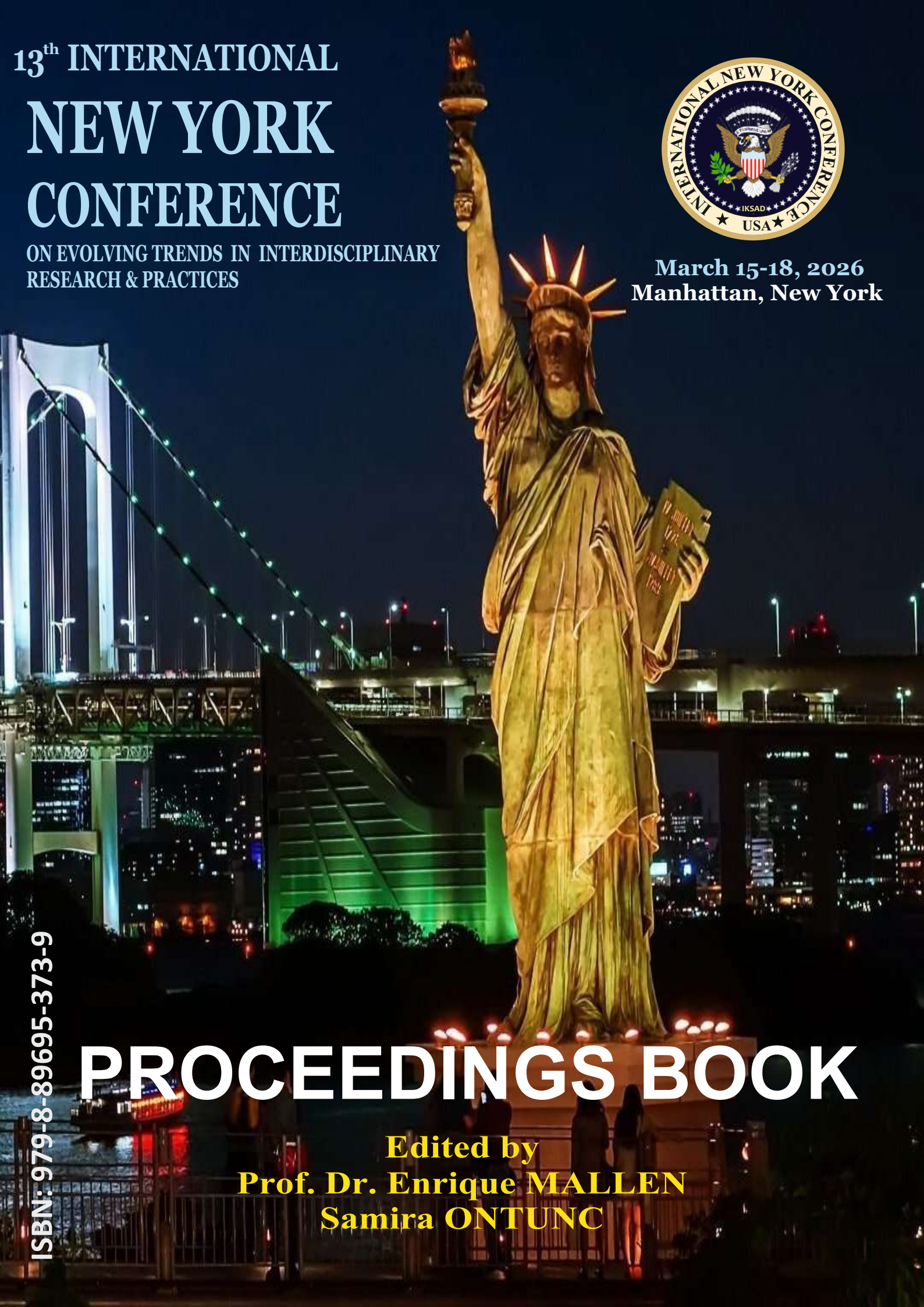


13th INTERNATIONAL

NEW YORK CONFERENCE

ON EVOLVING TRENDS IN INTERDISCIPLINARY RESEARCH & PRACTICES

March 15-18, 2026
Manhattan, New York

PROCEEDINGS BOOK

Edited by
Prof. Dr. Enrique MALLEN
Samira ONTUNC

ISBN: 979-8-89695-373-9

CONFERENCE ID

CONFERENCE TITLE

13th INTERNATIONAL NEW YORK CONFERENCE ON EVOLVING TRENDS IN INTERDISCIPLINARY RESEARCH & PRACTICES

DATE AND PLACE

March 15-18, 2026 / Manhattan, New York City

ORGANIZATION

EDITORS

Prof. Dr. Enrique MALLEN

Samira ONTUNC

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Accepted Article (Türkiye): 76

Accepted Article (Other Countries): 90

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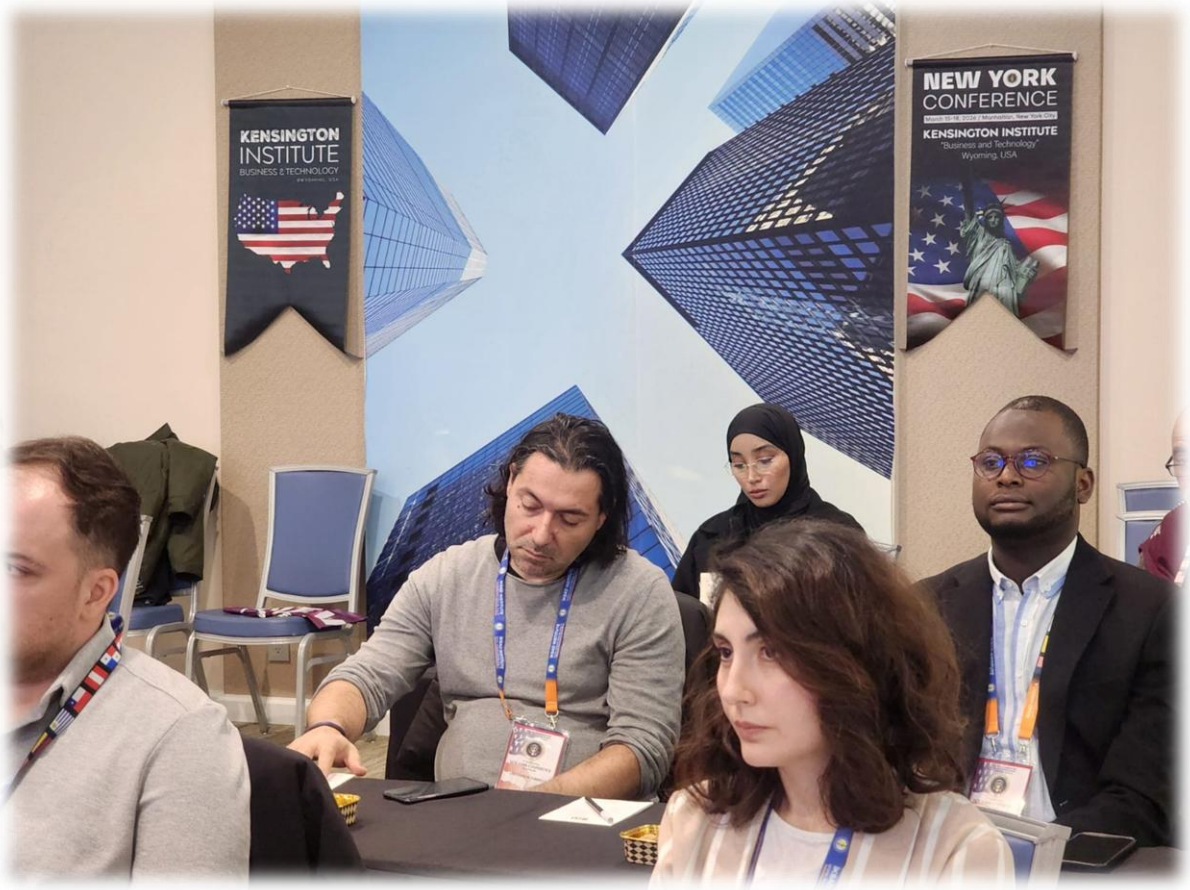




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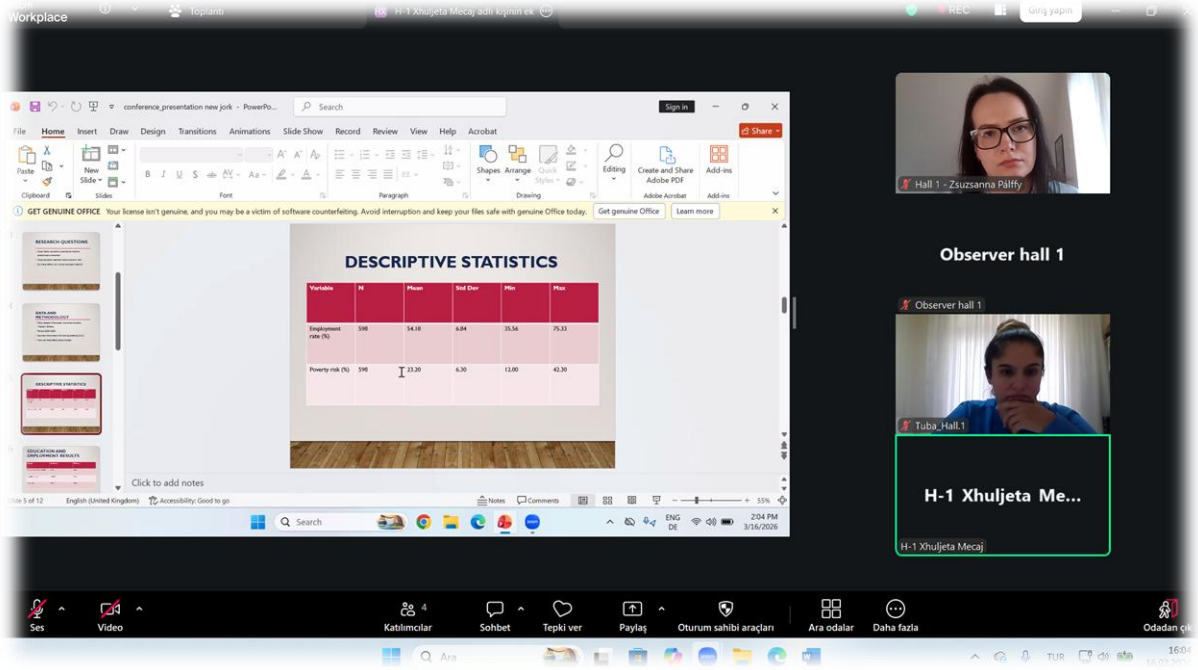


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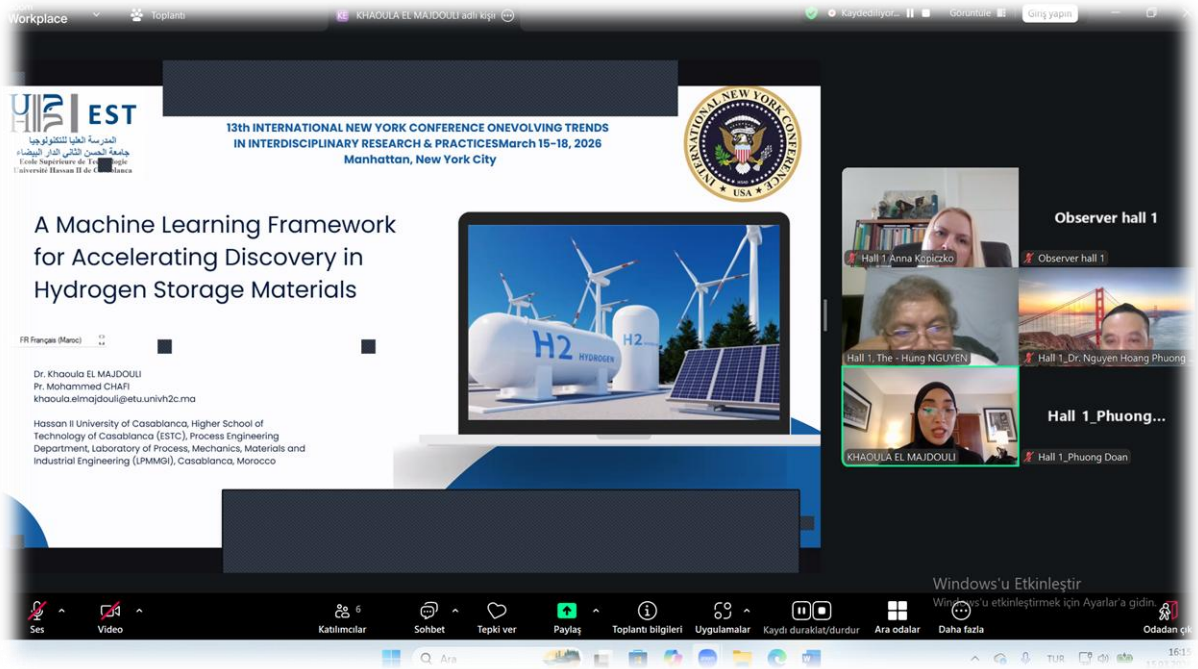
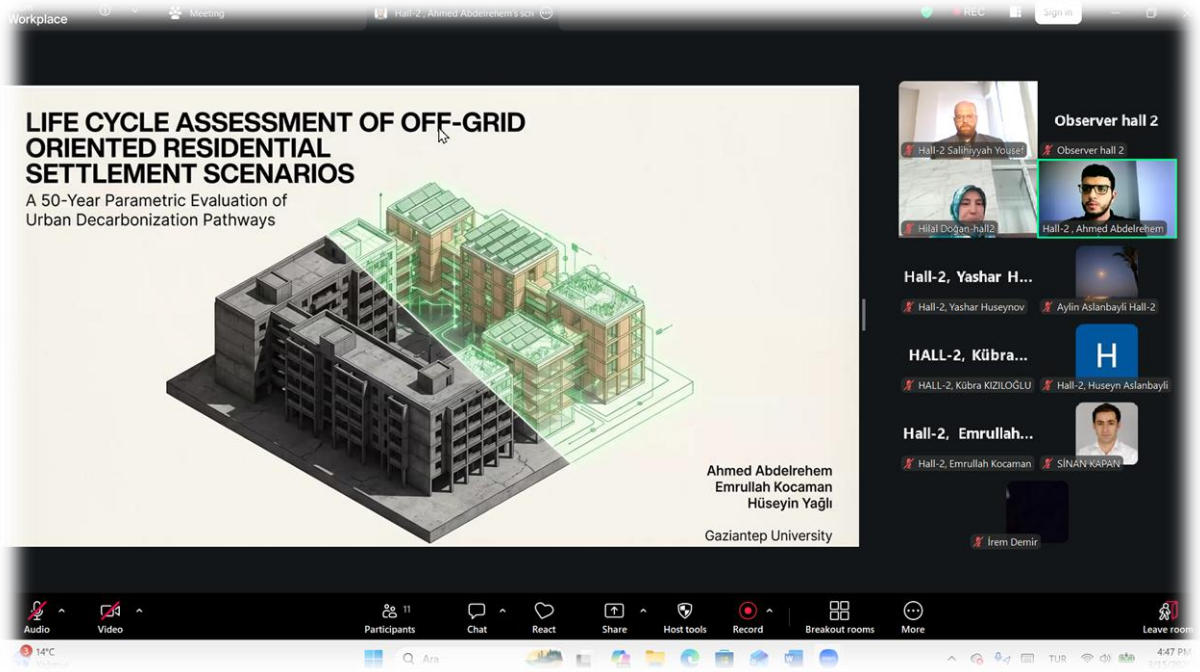


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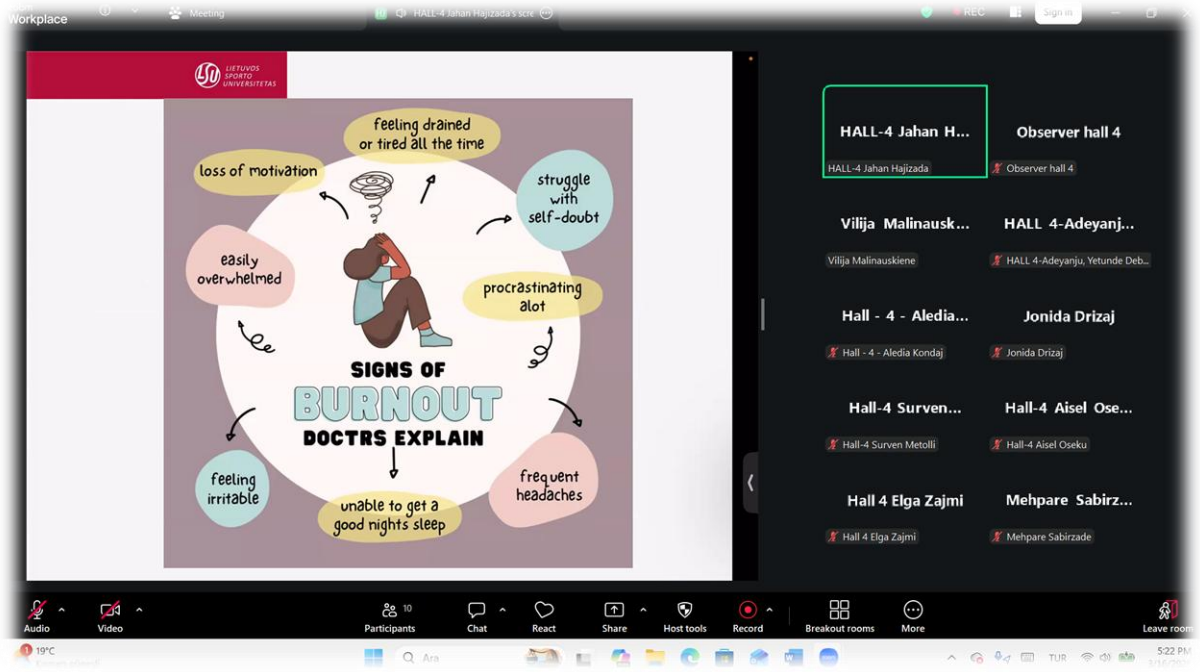
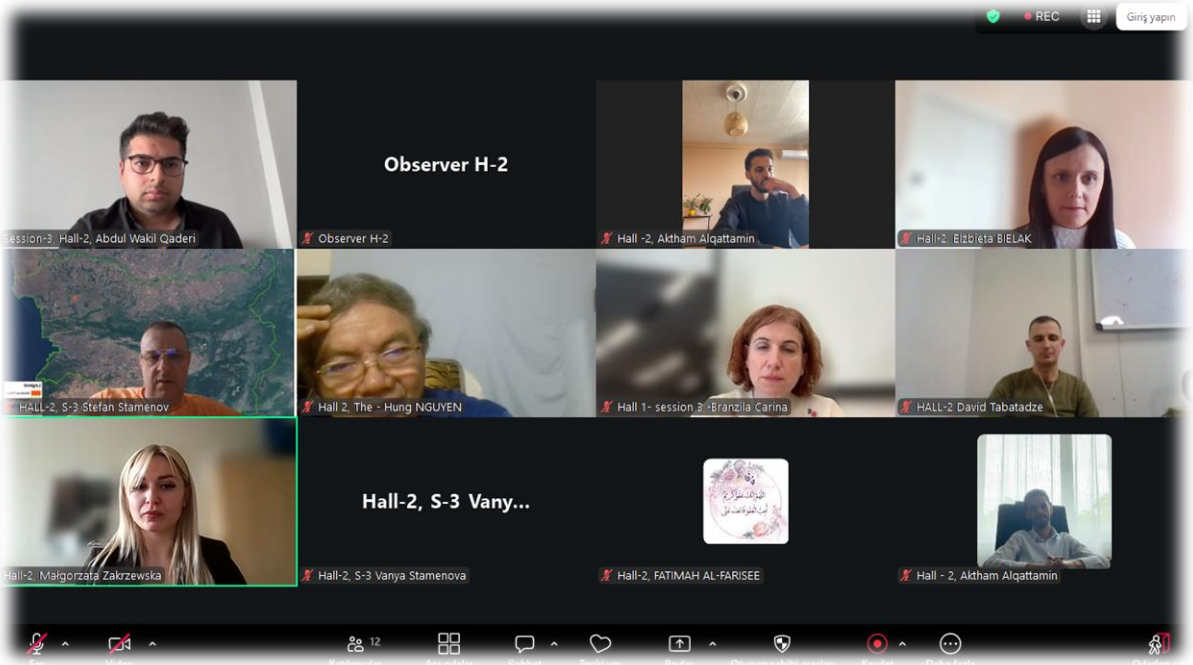


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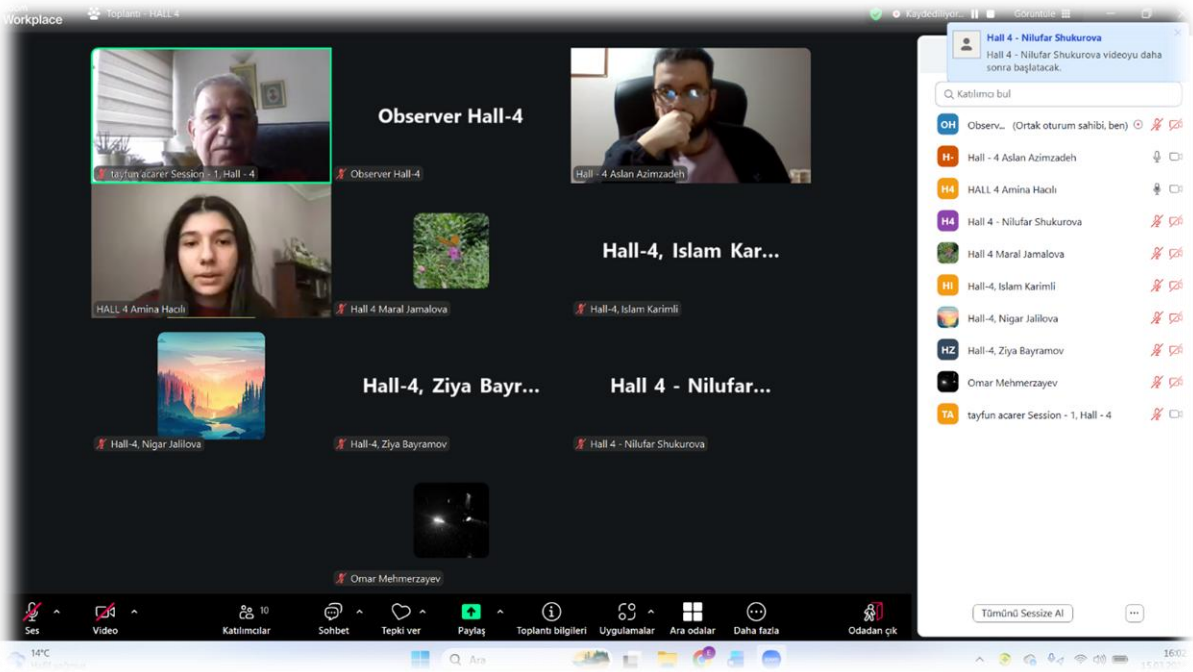


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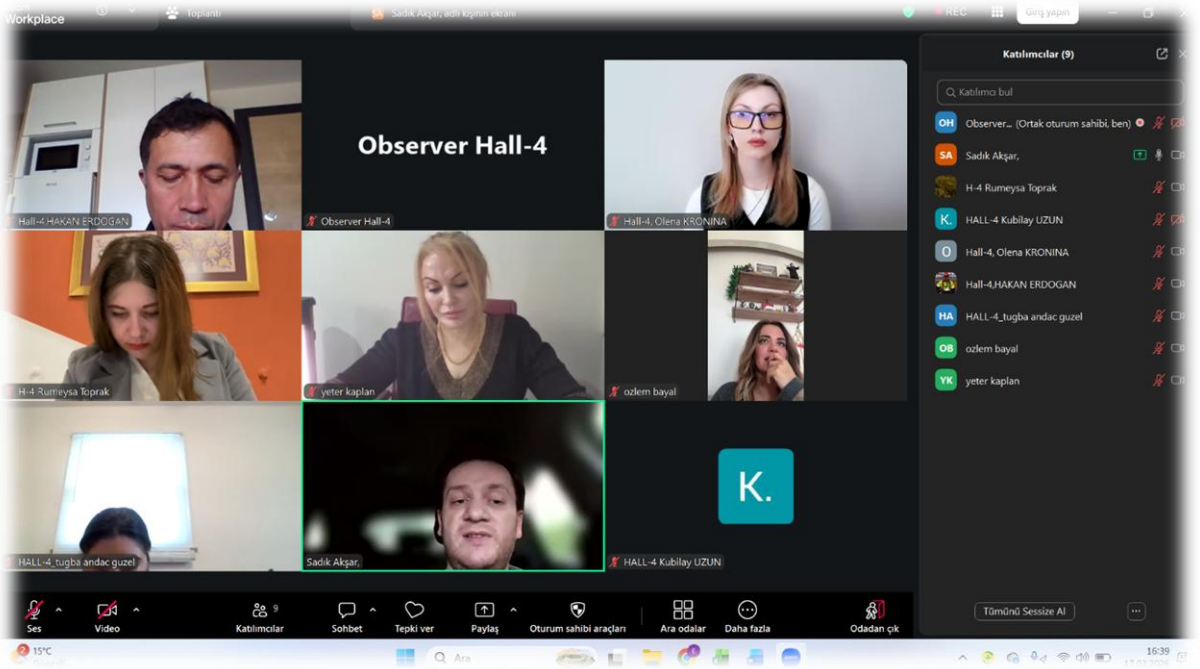


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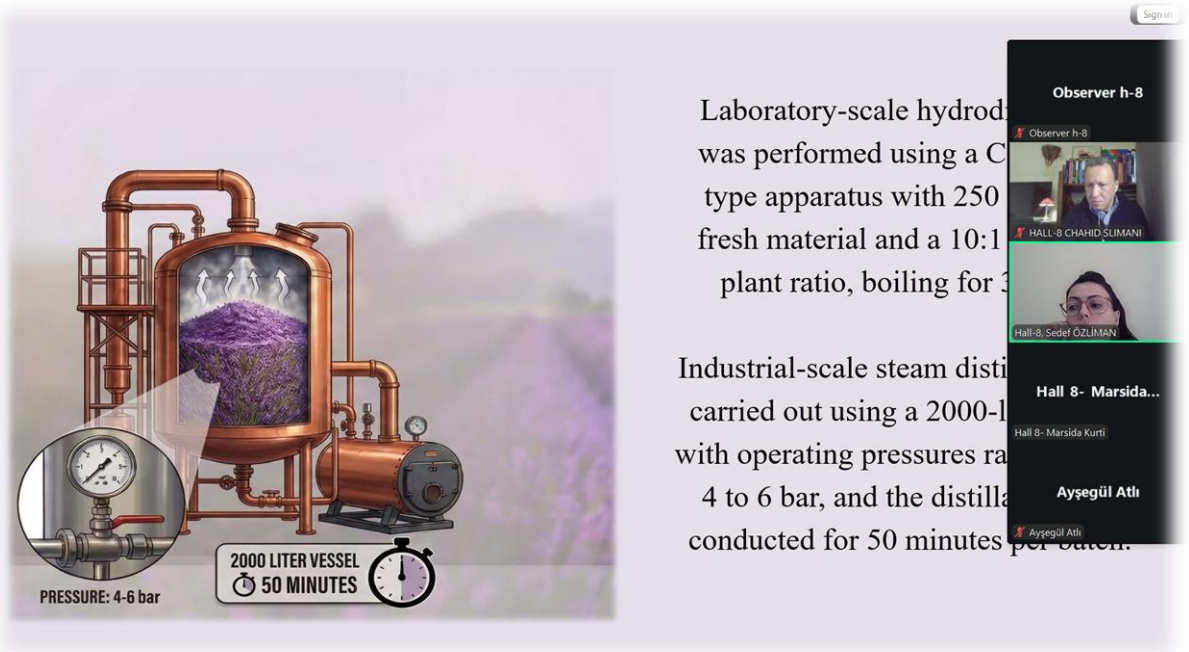




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13th INTERNATIONAL NEW YORK CONFERENCE ON EVOLVING TRENDS IN INTERDISCIPLINARY RESEARCH & PRACTICES

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March 15-18, 2026
Manhattan, New York City

OPENING CEREMONY

March 17, 2026
New York Local Time: 13:^{00}
Riu Plaza Times Square, New York City

Prof. Dr. Enrique Mallen

Sam Houston State University, USA
"ENHANCING KNOWLEDGE OF HISTORY THROUGH VISUAL ARTS"

Ms. Leslie Robinson

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Dr. Mustafa Latif EMEK

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IN PERSON SESSION

March 17, 2026

New York Local Time: 13:^{30}–16:^{00}

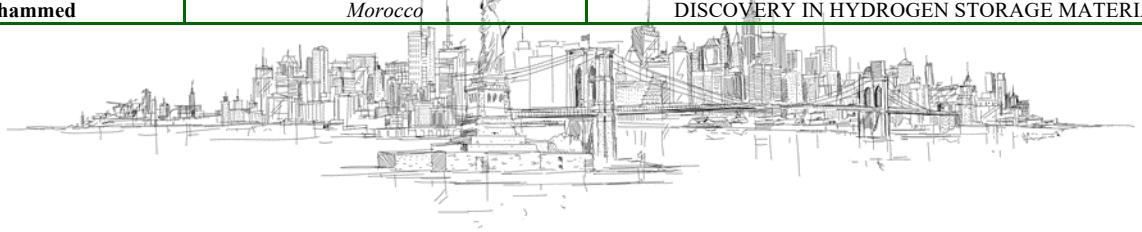
Riu Plaza Times Square, New York City

HEAD OF SESSION: Prof. Dr. Enrique Mallen

Authors	Affiliation	Presentation title
Abdul Tarrick Aziz **Cagri Karaman** **Aydin Gezer**	*Ataturk University, Türkiye*	ON BI-PARA-COMPLEX STRUCTURES ON WALKER-4 MANIFOLDS
Aliona Ghendov-Mosanu **Viorica Bulgaru** **Iurie Rumeus** **Georgiana Gabriela Codină**	*Technical University of Moldova, Republic of Moldova* *Ştefan cel Mare University of Suceava, Romania*	EVALUATION OF TEXTURE PROFILE IN BREAD FROM INGEN TRITICALE VARIETIES FROM THE REPUBLIC OF MOLDOVA WITH FERMENTED BREWERS' SPENT GRAIN ADDITION
Ehud Spanier	*University of Haifa, Israel*	PROTECTION AND CONSERVATION OF THE MEDITERRANEAN SLIPPER LOBSTER: A CONTEMPORARY PRACTICAL APPROACH TO SAFEGUARDING A THREATENED SPECIES
Dr. Anisa Potka **Prof. Numila Kuneshka** **Dr. Flora Korumi** **Dr. Armand Shehu** **Dr. Marsida Kurti**	*Mother Teresa University Hospital Centre in Tirana, Albania*	STURGE-WEBER SYNDROME: A RARE CASE REPORT
Assoc. Prof. Dr. Serkan YORGANCILAR	*Independent Researcher, Ankara, Türkiye*	THE SOCIOLOGY OF ALGORITHMIC GOVERNANCE: POWER, DATA, AND CONTROL IN DIGITAL SOCIETIES

Refreshment Break & Networking

Gamze Maden Müftüoğlu **Mehmet Baysan** **Nizamettin Aydın**	*National Defence University, Türkiye* *Istanbul Technical University, Türkiye*	TOWARD INTERPRETABLE EVALUATION OF STRUCTURAL VARIANT BENCHMARKING TOOLS
Cristiano Maria Verrelli **Lucio Caprioli** **Cristian Romagnoli** **Maciej Ryszczuk** **Marco Iosa**	*University of Rome Tor Vergata, Italy* *San Raffaele Open University, Italy* *Sapienza University of Rome, Italy* *IRCCS Santa Lucia Foundation, Italy*	TWO-DIMENSIONAL HARMONIC PATTERNS IN CYCLIC HUMAN MOVEMENTS
Tevfik Denizhan Muftuoglu	*Istanbul Aydin University, Türkiye*	DECODING RAINFALL DRIVERS: A SHAP-SUPPORTED MACHINE LEARNING APPROACH
Assist. Prof. Dr. Özlem ÖZKAN ÖNÜR **Assoc. Prof. Dr. Ethem İLHAN ŞAHİN**	*İstanbul Nişantaşı University, Türkiye* *Adana Alparslan Türkeş University, Türkiye*	NATURAL STONE AND ARCHITECTURAL FACADE TECHNOLOGIES: GEOLOGICAL ORIGIN, PERFORMANCE ANALYSIS, AND SUSTAINABLE APPLICATION STRATEGIES
Prof. Dr. Sedat Cereci	*Hatay Mustafa Kemal University, Türkiye*	ARTIFICIAL INTELLIGENCE as A CONTEMPORARY MASS COMMUNICATION TOOL
Peter Brečka **Alena Hašková**	*Constantine the Philosopher University, Slovakia*	TEACHERS' READINESS TO IMPLEMENT INTEGRATED TEACHING IN SLOVAKIA
El majdouli khaoula **Chafi Mohammed**	*Hassan II University of Casablanca, Morocco*	A MACHINE LEARNING FRAMEWORK FOR ACCELERATING DISCOVERY IN HYDROGEN STORAGE MATERIALS



13th INTERNATIONAL NEW YORK CONFERENCE ON

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15.03.2026 | SESSION-1 | HALL-1

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Asst. Prof. Elza Bitsadze

Authors	Affiliation	Presentation title
Van-Bao Nguyen **The-Hung Nguyen** **Phuong T.K Doan** **Hoang-Phuong Luong Nguyen** **My-Linh Nguyen Thi**	*Department of Agriculture and Rural Development, Vietnam* *Nam Can Tho University, Vietnam* *The University of Danang, Vietnam*	INVESTIGATION OF RIVER TRAINING SOLUTIONS FOR THE KHANH TRACH REACH OF THE LAI GIANG RIVER, BINH DINH PROVINCE
A.Bazit **L. Adlani** **D. Benmessaoud left** **H. Zarrok** **A. Zarrouk** **M. El Hezzat**	*Ibn Tofail University, Morocco* *Hassan II University, Morocco* *Mohammed V University in Rabat, Morocco*	ECO-FRIENDLY VALORIZATION OF EXPIRED ESCO FOR THE CORROSION PROTECTION OF C38 CARBON STEEL IN 1M HCL: EXPERIMENTAL ASSESSMENT SUPPORTED BY QUANTUM CHEMICAL CALCULATIONS AND MOLECULAR DYNAMICS SIMULATIONS
Asst. Prof. Elza Bitsadze **Lia janadze**	*Akaki Tsereteli State University, Georgia*	LEVERAGING CLOUD INFRASTRUCTURE FOR THE DIGITAL TRANSFORMATION OF BUSINESS
Sergiu Paiu **Olga Boeştean** **Georgiana Gabriela Codină** **Aliona Ghendov-Mosanu**	*Technical University of Moldova, Republic of Moldova* *Ştefan cel Mare University of Suceava, Romania*	COMPARATIVE EVALUATION OF TRITICALE BREADS WITH BLONDE AND DARK FERMENTED BREWERS' SPENT GRAIN
Olga Smerea **Viorica Bulgaru** **Olga Boeştean** **Aliona Ghendov-Moşanu**	*Technical University of Moldova, Republic of Moldova*	UTILIZATION OF JOSTABERRY EXTRACT AS A NATURAL PIGMENT FOR ENHANCING THE QUALITY OF CONFECTIONERY PRODUCTS
Prof. (Assoc.) PhD. Karol Gryko **Prof. (Assoc.) PhD. Anna Kopiczko** **Prof. Jakub Grzegorz Adamczyk** **PhD Damian Worchacz** **MD Michał Harasymczuk**	*Józef Piłsudski University of Physical Education in Warsaw, Poland* *University of Zielona Góra, Poland* *Poznań University of Medical Sciences, Poland*	INTEGRATING BIOBANDING INTO YOUTH BASKETBALL: SKELETAL AGE, BIOLOGICAL MATURATION, AND TRAINING IMPLICATIONS

(All speakers required to be connected to the session 10 min before the session starts)
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15.03.2026 | SESSION-1 | HALL-2

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Samet KUŞKIRAN

Authors	Affiliation	Presentation title
Jalil Nuraliyev **Huseyn Aslanbayli**	*Gas Research and Design Institute, Azerbaijan* *Landau School, Azerbaijan*	DYNAMIC ANALYSIS OF KINETIC AND POTENTIAL ENERGY CONVERSION IN ELEVATOR COUNTERWEIGHT SYSTEMS
Jalil Nuraliyev **Aylin Aslanbayli**	*Oil and Gas Research and Design Institute, Azerbaijan* *Secondary School No. 176, Azerbaijan*	ANALYSIS OF MECHANICAL ENERGY TRANSFORMATIONS AND LOSSES IN ROLLER COASTERS: MODELING, SIMULATION, AND EFFICIENCY IMPROVEMENT PROPOSALS
YASHAR HUSEYNOV	*National Defense University, Azerbaijan*	APPLICATION OF MATHEMATICAL AND SIMULATION MODELS FOR CALCULATING THE EFFECTIVENESS OF ARTILLERY FIRE
Yousef Salihiyyah **Emrullah Kocaman** **Hüseyin Yağlı**	*Gaziantep University, Türkiye*	CLEAN ENERGY TRANSITIONS: A COMPARATIVE ANALYSIS OF OFF-GRID SOLUTIONS FOR A LOW-CARBON FUTURE
Ahmed Abdelrehem **Emrullah Kocaman** **Hüseyin Yağlı**	*Gaziantep University, Türkiye*	LIFE CYCLE ASSESSMENT OF OFF-GRID ORIENTED RESIDENTIAL SETTLEMENT SCENARIOS
Sinan Kapan	*Firat University, Türkiye*	ENERGY EFFICIENCY ASSESSMENT OF A PUBLIC BUILDING
Dr. Kübra KIZILOĞLU **Prof. Dr. Ümit Sami SAKALLI**	*Kırıkkale University, Türkiye*	EXTENDING AIRLINE OPERATIONS PLANNING WITH CREW FEASIBILITY CONSIDERATIONS: A PENALTY-BASED ASSESSMENT
Hilal Doğan	*Health Sciences University, Türkiye*	ASSESSMENT OF RADIATION DOSE LEVELS TO PRISON GUARDS DURING MYOCARDIAL PERFUSION SCINTIGRAPHY IN NUCLEAR MEDICINE UNITS

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15.03.2026 | SESSION-1 | HALL-3

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Dr. Sandra Trzcińska

Authors	Affiliation	Presentation title
Ayat Roushdy Ahmed **Amr Mohamed Allama** **Tayseer Mohamed Mansour** **Marwa Mohamed Zalat**	*Menoufia University, Egypt* *Suez Canal University, Egypt* *Taibah University, Saudi Arabia*	VALIDATION OF A CLINICAL COMPETENCY LOGBOOK INVENTORY FOR WORKPLACE-BASED ASSESSMENT IN UNDERGRADUATE MEDICAL EDUCATION
Andrei Felicia **Iana Andreea** **Atyim Laura** **Hum Ivona** **Gurgus Daniela** **Folescu Roxana**	*University of Medicine and Pharmacy "Victor Babes" Timisoara, Romania* *University Clinic of Family Medicine, Romania*	BRIDGING COMMUNITY HEALTH AND CLINICAL INNOVATION: THE EVOLVING ROLE OF FAMILY MEDICINE IN MODERN HEALTHCARE SYSTEMS
Klejda TANI **Aisel OSEKU**	Sport University of Tirana, Albania	DIGITAL TRANSFORMATION OF PHYSIOTHERAPY EDUCATION: INSIGHTS FROM THE E-PHYSIO PROJECT
Dr. Sandra Trzcińska	*The Maria Grzegorzewska University, Poland*	COMPENSATORY THERAPY OF SCOLIOSIS – FROM THE KTS CONCEPT TO THE CTS METHOD
Silvije Šegulja **Mateja Sabolek** **Bojan Miletić** **Anja Šegulja Perić**	*University of Rijeka, Croatia*	PARENTAL BURNOUT AND STRESS OF PARENTS OF CHILDREN WITH AUTISM SPECTRUM DISORDER
Gulfem Unsal	*Ankara Gaziler Physical Therapy and Rehabilitation Training and Research Hospital, Türkiye*	IMPACT OF DERMATOLOGICAL HEALTH ON THE QUALITY OF LIFE IN LOWER LIMB AMPUTEES: A SPECIALIZED FOCUS ON PROSTHETIC INTEGRATION AND PSYCHOSOCIAL WELL-BEING
Catia Cristina Janjacomo Martini **Artur Rocha Martini** **Julia Carrer Hallak** **Martina Salviano Martini** **Jaime Eduardo Cecilio Hallak** **Laís Valencise Magri** **Jardel Francisco Mazzi-Chaves** **Selma Siéssere** **Marcelo Palinkas** **Simone Cecilio Hallak Regalo**	*University of São Paulo, Brazil* *National Institute for Translational Medicine, Brazil*	EFFECTS OF CANNABIDIOL AND OCCLUSAL SPLINT ON BITE FORCE AND OROFACIAL PRESSURE IN WOMEN WITH PAINFUL MYOFASCIAL TMD
Prof. Assoc. Dr. LEDI NEÇAJ	*Medical University of Tirana, Albania*	PATIENT RECOGNITION AND SELF-MANAGEMENT OF HEART FAILURE SYMPTOMS: A VIGNETTE-BASED PILOT STUDY
G. O. Tona	*Ladoke Akintola University of Technology, Nigeria*	DIAGNOSIS, CONTROL AND THERAPEUTIC TREATMENT PRACTICES OF MASTITIS IN LACTATING COWS – A REVIEW

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15.03.2026 | SESSION-1 | HALL-4

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Assoc. Prof. Dr. Tayfun ACARER

Authors	Affiliation	Presentation title
Aslan Azimzadeh **Amina Hajili**	*Azerbaijan State University of Economics, Azerbaijan* *Landau School, Azerbaijan*	ICOR-BASED ASSESSMENT OF THE INVESTMENT–GDP PROPORTION IN AZERBAIJAN
Aslan Azimzadeh **Islam Karimli**	*Azerbaijan State University of Economics, Azerbaijan* *Idrak Lyceum, Azerbaijan*	EXPLORING INNOVATION TRENDS IN AZERBAIJANI BUSINESSES: CURRENT STATE AND COVID-19 IMPLICATIONS
Maral Jamalova **Nilufar Shukurova**	*Azerbaijan State University of Economics* *Secondary School named after Afgan Gadashov, Azerbaijan*	THE ROLE OF INFLUENCER TRUST, VALUE, AND PERCEIVED INFLUENCE IN SHAPING REPURCHASE INTENTION: EVIDENCE FROM TRENDYOL USERS IN AZERBAIJAN
Hilala Jafarova **Nigar Jalilova**	*Azerbaijan State University of Economics, Azerbaijan*	INTEGRATION OF LOG ANALYSIS AND ARTIFICIAL INTELLIGENCE METHODS IN CYBERSECURITY ANALYTICS
Jalil Nuraliyev **Nasha Khalil**	*Oil and Gas Research and Design Institute, Azerbaijan* *Secondary School No. 176, Azerbaijan*	ANALYSIS OF POTENTIAL ENERGY CONVERSION AND POWER GENERATION EFFICIENCY AT HOOVER DAM HYDROELECTRIC PLANT
Assoc. Prof. Dr. Tayfun ACARER	*Piri Reis University, Türkiye*	A MEASUREMENT SYSTEM PLANNED TO BE DEVELOPED FOR THE REAL-TIME MONITORING OF SHIP-GENERATED AIR POLLUTION IN NARROW WATER CHANNELS WITH HIGH MARITIME TRAFFIC

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15.03.2026 | SESSION-1 | HALL-5

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Assist. Prof. Arif Gezer

Authors	Affiliation	Presentation title
Assist. Prof. Arif Gezer	*Çankırı Karatekin University, Türkiye*	CIRCASSIAN PROVERBS AND THEIR EQUIVALENTS IN TURKISH IV
Assist. Prof. Arif Gezer	*Çankırı Karatekin University, Türkiye*	HADITH LITERATURE IN THE REPUBLICAN PERIOD IN TURKEY
Res. Asst. Esra Gamze Uğur Ekşi **Burak Güngüneş**	*Yildiz Technical University, Türkiye*	A DOORWAY TO CHILDHOOD: VIRTUAL CHILDHOOD MUSEUM
Mustafa KAHYA **Ayşe Handan DÖKMECİ**	*Tekirdağ Namık Kemal University, Türkiye*	INTERAGENCY STANDARDIZATION IN CHEMICAL INCIDENT MANAGEMENT: STRATEGIES FOR ESTABLISHING A COMMON LANGUAGE IN TRIAGE ALGORITHMS
Sibel Aksahin	*Gaziantep University, Türkiye*	CLIMATE DISPLACEMENT AND THE STRUTURAL LIMITS OF THE 1951 REFUGEE CONVENTION
Sibel TOPUZ **Şeyda TAŞAR**	*Fırat University, Türkiye*	CHEMICAL AND THERMOCHEMICAL PATHWAYS FOR THE SUSTAINABLE TRANSFORMATION OF RUBBER-BASED WASTE BRIQUETTES

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15.03.2026 | SESSION-1 | HALL-6

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Asst. Prof. Dr. Ferhat Atik

Authors	Affiliation	Presentation title
Asst. Prof. Dr. Ferhat Atik	*Girne American University, Cyprus*	THE SOCIAL SCHEMAS THEORY IN COMMUNICATION: NORMS, IDENTITY AND DISCOURSE
Kenan Novruzov	*Baku State University, Azerbaijan*	WHY SPECIALIZATION IN MEDIA IS IMPORTANT?
Mine DEMİRTAŞ **Nizam Kaan DEMİRTAŞ** **Mahmut YAVAŞ**	*İstanbul Beykent University, Türkiye* *Marmara University, Türkiye*	AN EXAMINATION OF TWIPLOMACY, THE NEW TREND IN THE DIGITAL WORLD
Fatma Defne Ilgaz	*Düzce University, Türkiye*	TURKISH AUDIENCES FRAMING DOGVILLE: A SEXIST TEXT OR A RECIPROCAL MORAL NARRATIVE?
Furkan Daziroğlu	*Ankara Yildirim Beyazit University, Türkiye*	THE IMPACT OF ERP USE ON ENVIRONMENTAL AND ECONOMIC PERFORMANCE IN TÜRKIYE'S NON-METALLIC MINERAL PRODUCTS INDUSTRY: THE MEDIATING ROLE OF WAREHOUSE MANAGEMENT PERFORMANCE AND THE MODERATING ROLE OF USER COMPETENCE
Prof. Dr. Emet Gürel **Assist. Prof. Dr. İlkay Burak Taşkıran**	*Ege University, Türkiye* *İstanbul Aydın University, Türkiye*	COMMUNICATIVE HEALTH LITERACY IN DIGITAL ENVIRONMENTS: A THEORETICAL MODEL PROPOSAL
Yüksel Balaban	*Istanbul University, Türkiye*	THE REFLECTIONS OF CHANGING TECHNOLOGIES IN ANIMATION CINEMA ON FILM AESTHETICS
Md Ashraful Amin **Abdul Kader Jelane** **Ishrat Jahan Mousumi** **Md Anwar Hossain Pathan** **Nadia Akter Toma**	*Tokyo International University, Japan* *International Islamic University, Malaysia* *University Collage MAIWP International, Malaysia* *International University, Malaysia*	NORTH KOREA'S WEAPONS DEVELOPMENT: A GROWING CHALLENGE TO JAPAN'S NATIONAL SECURITY FRAMEWORK

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15.03.2026 | SESSION-1 | HALL-7

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Mehmet İNCEBIYIK

Authors	Affiliation	Presentation title
Medine ARSLAN ALCAN **Fatih Mehmet FINDIK**	*Dicle University, Türkiye*	COMPLETE UTERINE RUPTURE DURING CESAREAN SECTION: CASE REPORT
Hasan Basri ÇOLAK **Nurcihan TAN ERKOÇ**	*Istanbul Gelisim University, Türkiye*	GREEN VALORIZATION OF FOOD WASTES: ANTIOXIDANT POTENTIAL OF DEEP EUTECTIC SOLVENT EXTRACTS
Işıl Yağmur **Ergül Belge Kurutaş**	*Necip Fazıl City Hospital, Türkiye* *Kahramanmaraş Sütçü İmam University, Türkiye*	THE ROLE OF OXIDATIVE STRESS IN MALE REPRODUCTIVE HEALTH: A COMPARATIVE ANALYSIS OF 8-ISOPROSTAGLANDIN AND RAFTLIN LEVELS
Mehmet İNCEBIYIK	*Harran University Research and Application Hospital, Türkiye*	EMERGENCY MANAGEMENT OF A RUPTURED PLACENTA PERCRETA WITH CRITICAL ANEMIA (HGB: 3 MG/DL): A RACE AGAINST TIME
Mehmet İNCEBIYIK	*Harran University Research and Application Hospital, Türkiye*	ADVANCED MINIMALLY INVASIVE APPROACH: A COMPARATIVE ANALYSIS OF V-NOTES AND CONVENTIONAL LAPAROSCOPY IN BENIGN GYNECOLOGICAL PROCEDURES
PhD Gulnar Atakishiyeva **PhD Sevinc Mukhtarova** **Assoc. Prof. Shukufa Eyvazova** **Assoc. Prof. Naila Veysova** **Assoc. Prof. Sima Musayeva** **Assoc. Prof. Ilhama Hamdullayeva** **Dr. Namiq Shikhaliyev**	*Baku State University, Azerbaijan* *Azerbaijan Technical University* *Baku Engineering University, Azerbaijan*	IN SILICO EVALUATION OF BLOOD–BRAIN BARRIER PERMEABILITY AND NEUROLOGICAL DRUG POTENTIAL OF A NOVEL MOLECULE
Onur Toprak	*Erciyes University, Türkiye*	THE USE OF AI-SUPPORTED HYBRID APPROACHES IN THE PRODUCTION PROCESS OF MEDICAL ILLUSTRATION
Zümre DEMİR **Görkem KIRMIZIKAYA ÖZMEN** **Ökkeş YILMAZ**	*Fırat University, Türkiye*	THE EFFECT OF NEEM (STYRAX OFFICINALIS L.) SEED AND PHYTOSTEROL SUPPLEMENTATION ON WEIGHT GAINS IN RATS WITH EXPERIMENTALLY INDUCED BENIGN PROSTATIC HYPERPLASIA
Fatma Genç	*İstanbul Yeni Yüzyıl University, Türkiye*	RECENT ADVANCES IN QUANTUM CHEMICAL CALCULATIONS

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15.03.2026 | SESSION-1 | HALL-8

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Prof. Dr. Chahid SLIMANI

Authors	Affiliation	Presentation title
Prof. Dr. Chahid SLIMANI **Abdellah BAHTAT**	*Sidi Mohamed Ben Abdellah University, Morocco*	THE ETHICAL CHALLENGES POSED BY THE INTEGRATION OF ARTIFICIAL INTELLIGENCE IN THE MEDICAL FIELD IN MOROCCO
Donika Mema **Albana Fico** **Alban Ylli**	*Institute of Public Health, Albania* *University of Medicine, Albania*	TRENDS AND SEASONALITY OF TUBERCULOSIS IN ALBANIA: A 10-YEAR ANALYSIS (2015–2024)
Ayşegül ATLI **Zümra Betül SARIOĞLU**	*Ankara University, Türkiye*	EVALUATION OF DYSMENORRHEA-RELATED AWARENESS LEVELS AND PAIN INTENSITY IN YOUNG WOMEN WITH PRIMARY DYSMENORRHEA
Ayşegül ATLI **Zümra Betül SARIOĞLU**	*Ankara University, Türkiye*	THE EFFECTS OF A YOGA PROGRAM ON SYMPTOMS IN YOUNG WOMEN WITH PRIMARY DYSMENORRHEA: PARTICIPANT EXPERIENCES
Emir Soltanbeigi **Sedef Özliman**	*Afyonkarahisar Health Sciences University, Türkiye*	FROM LABORATORY TO INDUSTRIAL DISTILLATION: VARIATIONS IN THE ESSENTIAL OIL COMPOSITION OF TWO Lavandula SPECIES
Marsida Kurti **Sokol Buba**	*University of Medicine Tirana, Albania*	WHEN ABDOMINAL PAIN MASKS TESTICULAR TORSION: A CASE SERIES FOR PEDIATRIC EMERGENCY CARE
Dogun Ojochogu **Ogenyi Ruth Ajibola** **Dinchi P. Telzin** **Longchi Satkat Zacchaeus**	*Federal College of Forestry Jos, Nigeria* *University of Jos, Nigeria*	OCCURRENCE OF STORAGE FUNGI AND ASSOCIATED AFLATOXIN CONTAMINATION IN PHASEOLUS VULGARIS SOLD IN SELECTED MARKETS IN JOS NORTH, NIGERIA
Albana Fico **Donika Mema**	*University of Medicine, Albania*	IDENTIFICATION OF AT - RISK GROUPS AMONG TUBERCULOSIS PATIENTS IN ALBANIA, 2015–2024

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16.03.2026 | SESSION-2 | HALL-1

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Dr. Atabek MOVILYANOV

Authors	Affiliation	Presentation title
Amal Hasan Ibrahim	*The University of Jordan, Jordan*	EXPLORING THE IMPACT OF TECHNOLOGY INTEGRATION ON JOB SATISFACTION: PERSPECTIVES OF SPECIAL EDUCATION TEACHERS FOR CHILDREN WITH AUTISM SPECTRUM DISORDER
Dr. Xhuljeta MEÇAJ	*Aleksandër Moisiu' University of Durrës, Albania*	EDUCATION, LABOR MARKETS, AND SOCIAL INEQUALITY IN EUROPE: AN INTERDISCIPLINARY PERSPECTIVE
Imane Laframe	Hassan II University of Casablanca, Morocco	THE ACTION-ORIENTED APPROACH AS A FOUNDATION FOR SOFT SKILLS DEVELOPMENT IN HIGHER EDUCATION
Zsuzsanna Pálffy	*Széchenyi István University, Hungary*	THE FOURTH MISSION: A SYSTEMATIC LITERATURE REVIEW ON HOW EMBEDDED HIGHER EDUCATION INSTITUTIONS SHAPE SOCIETY
Dr. Tuba YILDIRIM SARIKAYA **Prof. Dr. Uğur BÜYÜK**	*Erciyes University, Türkiye*	BEYOND THE CLASSROOM: THE USE OF EDUCATIONAL ROBOTICS IN SCIENCE EDUCATION FROM PARENTS' PERSPECTIVES
Adam Andani Mohammed **Mpawenimana Abdallah Saidi**	*University for Development Studies Tamale, Department of Sociology and Social Work, Ghana* *Zanzibar University, Tanzania*	WOMEN'S RIGHTS ARE HUMAN RIGHTS: LITERACY OF VIOLENCE AGAINST WOMEN AMONG SOCIAL WORK STUDENTS

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16.03.2026 | SESSION-2 | HALL-2

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Assoc. Prof. Dr. Hilal Kazu

Authors	Affiliation	Presentation title
Gürbüz OCAK **Busenur ÇAY** **Fatma Nurcan PINAR**	*Afyon Kocatepe University, Türkiye* *Sakarya Uygulamalı Bilimler University, Türkiye*	EXAMINING THE ENVIRONMENTAL LITERACY LEVELS OF TEACHERS AND TEACHER CANDIDATES IN TERMS OF VARIOUS VARIABLES
Gürbüz OCAK **Huriye AKÇAY** **Fatma Nurcan PINAR**	*Afyon Kocatepe University, Türkiye* *Sakarya Uygulamalı Bilimler University, Türkiye*	LEVELS OF LIFELONG LEARNING SKILLS OF MIDDLE SCHOOL STUDENTS
Assoc. Prof. Dr. Hilal Kazu **Prof. Dr. İbrahim Yaşar Kazu** **Enes Ulukaya**	*Firat University, Türkiye*	DETERMINING FACTORS IN K-12 TEACHERS' ACCEPTANCE OF ARTIFICIAL INTELLIGENCE: AN INTEGRATED ANALYSIS OF TAM AND DOI THEORIES
Assoc. Prof. Dr. Hilal Kazu **Prof. Dr. İbrahim Yaşar Kazu** **Enes Ulukaya**	*Firat University, Türkiye*	THE BLACK BOX IN THE CLASSROOM: A SYSTEMATIC REVIEW OF AI ETHICS IN K-12
Firdevs Nur Uykun **Büşra Zeynep Temoçin**	*Middle East Technical University, Türkiye*	RISK-AVERSION ADJUSTED PORTFOLIO OPTIMIZATION WITH MACHINE LEARNING AND EXPLAINABLE AI
Mustafa Karabulut	*Adıyaman University, Türkiye*	MEHMET AKIF ERSOY'S POEM 'ACEM ŞAHI' CRITICIZES OPPRESSION AND TYRANNY
Mustafa Karabulut	*Adıyaman University, Türkiye*	GROTESQUE STRUCTURE IN İHSAN OKTAY ANAR'S NOVEL 'PUSLU KITALAR ATLASI'
Prof. Dr. Serhat SÜRAL **İrem DEMİR**	*Pamukkale University, Türkiye*	CONCEPTUAL REPRESENTATIONS OF THE TEACHER'S ROLE IN THE LESSON PLANNING LITERATURE

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16.03.2026 | SESSION-2 | HALL-3

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: İsmail Hakkı Tarhan

Authors	Affiliation	Presentation title
Res. Asst. Dr. Onur Kaya **Prof. Dr. Ahmet Sinan Öktem**	*Gebze Technical University, Türkiye*	BENDING BEHAVIOR OF SIMPLY SUPPORTED NANOPLATES WITH DEFECTIVE ELASTIC FOUNDATION
Zana Özdemir **Murat Serdar Almali** **Assist. Prof. Dr. Ferhat Ekin**	*Van Yuzuncu Yil University, Türkiye*	RSM-BASED METAMODELING OF UAV THRUST AND POWER UNDER HIGH-ALTITUDE AND VARIABLE ENVIRONMENTAL CONDITIONS
Seher AKYÜZ **Nisanur TANRITANIR** **Melike Tekin** **Jindanur ZENGİN** **Aykut ÇETİN**	*Adana Alparslan Türkeş Science and Technology University, Türkiye*	EXPERIMENTAL ANALYSIS OF THE EFFECT OF SURFACE GEOMETRY MODIFICATIONS ON AIRFOIL AERODYNAMIC PERFORMANCE
Burak FIRTINA **Aykut ÇETİN** **Ahmet Refah TORUN**	*Adana Alparslan Türkeş Science and Technology University, Türkiye*	VIBRATIONAL ANALYSIS OF GLASS FIBER–REINFORCED COMPOSITE BEAMS CONTAINING DIFFERENT PROPORTIONS OF MILLED CARBON ADDITIVES
Aleyna ÇUBUK **Aykut ÇETİN**	*Adana Alparslan Türkeş Science and Technology University, Türkiye*	INVESTIGATION OF THE MECHANICAL PROPERTIES AND IMPACT STRENGTH OF SAMPLES PRODUCED WITH MILLED CARBON FIBER AND SLA RESIN
İsmail Hakkı Tarhan	*Tokat Gaziosmanpaşa University, Türkiye*	NONLINEAR BEHAVIOUR OF TOPOLOGY-OPTIMISED GFRP-STRENGTHENED MASONRY ARCHES
Mahmut ÖĞ	*National Education Ministry, Türkiye*	TEACHING THE PHONEME /B/ IN PRIMARY EDUCATION THROUGH INTERACTIVE, MULTISENSORY, AND CULTURALLY RESPONSIVE ACTIVITIES
Mahmut ÖĞ	*National Education Ministry, Türkiye*	EFFECTIVE CLASSROOM MANAGEMENT IN PRIMARY EDUCATION: A LITERATURE REVIEW

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16.03.2026 | SESSION-2 | HALL-4

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Assoc. Prof. Malinauskiene Vilija

Authors	Affiliation	Presentation title
PhD(c) Elga Zajmi **Prof. Dr. Bardhyl Misja**	*Sports University of Tirana, Albania*	COMPARISON OF PERCEPTIONS OF PHYSICAL ACTIVITY DURING PREGNANCY ACROSS TWO DIFFERENT TIME PERIODS
PhD(c) Elga Zajmi **Prof. Dr. Bardhyl Misja**	*Sports University of Tirana, Albania*	EFFECTS OF A 3-MONTH STRUCTURED EXERCISE PROGRAM ON QUALITY OF LIFE (QOL) IN POSTPARTUM WOMEN
Aisel Oseku **Klejda Tani**	*Sport University of Tirana, Albania*	COMPARING MANUAL THERAPY AND THERAPEUTIC EXERCISE FOR CHRONIC NECK PAIN: RESULTS FROM A RANDOMIZED TRIAL
Surven Metolli **Aisel Oseku**	*Sport University of Tirana, Albania*	COMPARATIVE EFFECTS OF KINESIOTAPING AND PROPRIOCEPTIVE STABILIZATION EXERCISES IN THE MANAGEMENT OF CHRONIC NON-SPECIFIC LOW BACK PAIN
Aledia Kondaj	*Sport University of Tirana, Albania*	EVALUATING THE EFFECTIVENESS OF DANCE MOVEMENT THERAPY IN IMPROVING BALANCE AND POSTURAL STABILITY IN ADULTS AGED 30–50 YEARS
Assoc. Prof. Malinauskiene Vilija **Yetunde Deborah Adeyanju**	*Lithuania Sport University, Lithuania*	ASSOCIATIONS BETWEEN HEALTH ENHANCING PHYSICAL ACTIVITY AND MENTAL HEALTH IN RELATION TO SENSE OF COHERENCE AMONG UNIVERSITY STUDENT
Jahan Hajizada **Assoc professor Malinauskiene Vilija**	*Lithuanian Sports University, Lithuania*	ASSOCIATIONS OF BURNOUT WITH ADVERSE PSYCHOSOCIAL FACTORS AT WORK IN AZERBAIJAN
Mehpara SABİRZADA **Tehnegul QURBANOVA** **Lamiya HUSEYNOVA**	*Azerbaijan Sports Academy, Azerbaijan*	THE ECONOMIC FUNCTIONS OF SPORT IN ENHANCING SOCIAL WELFARE
Jonida Drizaj **Robert Çina**	*Sport University of Tirana, Albania*	REHABILITATION APPROACHES FOR SHOULDER INJURIES IN OVERHEAD ATHLETES

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16.03.2026 | SESSION-2 | HALL-5

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Samira ONTUNÇ

Authors	Affiliation	Presentation title
Bogdan-Catalin Serban Matei-Gabriel Ursachescu Vlad Diaconescu Caterina Zetu Maria Ruxandra Salagean Diana Dumitrașcu Octavian Buiu Marius Bumbac	*National Institute for Research and Development in Microtechnologies–IMT Bucharest, Romania National College "B. P. Hasdeu", Romania University of Medicine and Pharmacy "Carol Davila", Romania International Theoretical High School of Computer Science, Romania National College "Saint Sava", Romania National Institute for Research and Development in Microtechnologies–IMT Bucharest, Romania Valahia University of Târgoviște, Romania*	INSIGHTS IN SUPRAMOLECULAR CHEMISTRY: FROM PRINCIPLES TO APPLICATIONS
Vlad Diaconescu Bogdan-Catalin Serban Matei-Gabriel Ursachescu Caterina-Maria Zetu Octavian Buiu Marius Bumbac Diana Dumitrașcu Maria Ruxandra Salagean	*National Institute for Research and Development in Microtechnologies–IMT Bucharest, Romania National College "B. P. Hasdeu", Romania University of Medicine and Pharmacy "Carol Davila", Romania International Theoretical High School of Computer Science, Romania National College "Saint Sava", Romania National Institute for Research and Development in Microtechnologies–IMT Bucharest, Romania Valahia University of Târgoviște, Romania*	THE BIOCHEMICAL ROLE OF PLANT-DERIVED POLYPHENOLS IN MODULATING OXIDATIVE STRESS AND CELLULAR HOMEOSTASIS
Vlad Diaconescu Bogdan-Catalin Serban Matei-Gabriel Ursachescu Caterina-Maria Zetu Octavian Buiu Marius Bumbac Diana Dumitrașcu Maria Ruxandra Salagean	*National Institute for Research and Development in Microtechnologies–IMT Bucharest, Romania National College "B. P. Hasdeu", Romania University of Medicine and Pharmacy "Carol Davila", Romania International Theoretical High School of Computer Science, Romania National College "Saint Sava", Romania National Institute for Research and Development in Microtechnologies–IMT Bucharest, Romania Valahia University of Târgoviște, Romania*	DETECTION OF NITRATES IN MARKET VEGETABLES AND THEIR IMPACT ON HUMAN HEALTH: CHEMICAL ANALYSIS AND TOXICOLOGICAL RISKS
Bogdan-Catalin Serban Matei-Gabriel Ursachescu Vlad Diaconescu Caterina Zetu Diana Dumitrașcu Maria Ruxandra Salagean Octavian Buiu Marius Bumbac	*National Institute for Research and Development in Microtechnologies–IMT Bucharest, Romania National College "B. P. Hasdeu", Romania University of Medicine and Pharmacy "Carol Davila", Romania International Theoretical High School of Computer Science, Romania National College "Saint Sava", Romania National Institute for Research and Development in Microtechnologies–IMT Bucharest, Romania Valahia University of Târgoviște, Romania*	INVISIBLE CHEMISTRY OF SWIMMING POOL DISINFECTION: BENEFITS AND RISK
Matei-Gabriel Ursachescu Bogdan-Catalin Serban Vlad Diaconescu Maria Ruxandra Salagean Caterina Zetu Diana Dumitrașcu Octavian Buiu Marius Bumbac	*National Institute for Research and Development in Microtechnologies–IMT Bucharest, Romania National College "B. P. Hasdeu", Romania University of Medicine and Pharmacy "Carol Davila", Romania International Theoretical High School of Computer Science, Romania National College "Saint Sava", Romania National Institute for Research and Development in Microtechnologies–IMT Bucharest, Romania Valahia University of Târgoviște, Romania*	FROM CHEMISTRY TO MEDICINE: DIMETHYL SULFOXIDE (DMSO) AS A POPULAR CHEMICAL WITH UNEXPECTED MEDICAL APPLICATIONS
Armela Mazrreku Belinda Hoxha Marilda Osmani	*University of Elbasan "Aleksander Xhuvani" Albania*	Valorization of Waste Cooking Oils into Biodiesel. Process Performance Compared with Virgin Vegetable Oils
Ravana Guliyeva Ulker Mahmudova Khayala Abdinova	*Baku State University, Azerbaijan*	PRODUCTIVITY OF NATURAL FORAGE VEGETATION IN THE CASPIAN COASTAL ZONE

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16.03.2026 | SESSION-2 | HALL-6

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Dr. Atabek MOVILYANOV

Authors	Affiliation	Presentation title
Željka Nikitović	*Institute of Physics University of Belgrade, Serbia*	APPLICATION OF PLASMA IN NANOTECHNOLOGIES
Soukaina El Mekkaoui **Faouzi Lakrad**	*Hassan II University of Casablanca, Morocco*	NONLINEAR VIBRATIONS OF AN ATOMIC FORCE MICROSCOPE UNDER DMT INTERACTION WITH MOVING CANTILEVER AND SAMPLE
Bogdan-Catalin Serban **Matei-Gabriel Ursachescu** **Vlad Diaconescu** **Caterina Zetu** **Diana Dumitrașcu** **Maria Ruxandra Salagean** **Octavian Buiu** **Marius Bumbac**	*National Institute for Research and Development in Microtechnologies–IMT Bucharest, Romania* *National College "B. P. Hasdeu", Romania* *University of Medicine and Pharmacy "Carol Davila", Romania* *International Theoretical High School of Computer Science, Romania* *National College "Saint Sava", Romania* *National Institute for Research and Development in Microtechnologies–IMT Bucharest, Romania* *Valahia University of Târgoviște, Romania*	HYDROGEN-BONDED ORGANIC FRAMEWORKS: A SHORT REVIEW
Bogdan-Catalin Serban **Matei-Gabriel Ursachescu** **Vlad Diaconescu** **Caterina Zetu** **Maria Ruxandra Salagean** **Diana Dumitrașcu** **Octavian Buiu** **Marius Bumbac**	*National Institute for Research and Development in Microtechnologies–IMT Bucharest, Romania* *National College "B. P. Hasdeu", Romania* *University of Medicine and Pharmacy "Carol Davila", Romania* *International Theoretical High School of Computer Science, Romania* *National College "Saint Sava", Romania* *National Institute for Research and Development in Microtechnologies–IMT Bucharest, Romania* *Valahia University of Târgoviște, Romania*	FROM APPROVAL TO WITHDRAWAL: A CONCISE REVIEW OF PHARMACEUTICALS WITHDRAWN AFTER WIDESPREAD USE
Anar Ismailov **Alekper Ismailov** **Leila Ismayılzada** **Farhad Mammadov** **Mehman Shirinov** **Lala Rustamova** **Melek Nadjaf-zade** **SevinjAghaliyeva**	*Azerbaijan Technical University* *National Aviation Academy, Azerbaijan* *Ministry of Science and Education of Azerbaijan*	ELEKTICAL PROPERTIES OF STRONGLY COMPENSATED CRYSTALS In 0.95 Sm 0.05 Se
Hind Maaghloud	*Hassan II University, Morocco*	OCCURRENCE OF HEAVY METALS AND MICROPLASTICS IN THE STOMACH CONTENT OF TWO FISH SPECIES IN THE NORTH AND CENTRAL ATLANTIC COAST OF MOROCCO
Jamila BOUCHGL **Ossama BENAISSA** **Khadija OUAISSA** **Moaad CHAAIRI**	*Higher Institute of Marine Fisheries-Agadir, Morocco* *Materials and Systems, ENSA, Morocco* *University Sultan Moulay Slimane, Morocco*	COMBUSTION EFFICIENCY ENHANCEMENT AND CARBON DEPOSIT CONTROL IN MARINE DIESEL ENGINES USING AN AUTOMATED FUEL TREATMENT SYSTEM
Ravana Guliyeva **Ulker Mahmudova** **Khayala Abdinova**	Baku State University, Azerbaijan	PRODUCTIVITY OF NATURAL FORAGE VEGETATION IN THE CASPIAN COASTAL ZONE

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16.03.2026 | SESSION-2 | HALL-7

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Md. Nazmul Hasan Arfin

Authors	Affiliation	Presentation title
Md. Golam Kibria **Tanjia Shormin** **Md. Ali Ahson Bhouiyan**	*University of Chittagong, Bangladesh* *Georg-August Universitat, Germany*	GROWTH, YIELD AND QUALITY OF WHEAT AND POST-HARVEST SOIL PROPERTIES AS INFLUENCED BY BIOGAS DIGESTATE FROM COW DUNG AND POULTRY MANURE
Aliona Ghendov-Mosanu **Viorica Bulgaru** **Iurie Rumeus** **Georgiana Gabriela Codină**	*Technical University of Moldova, Republic of Moldova* *Ştefan cel Mare University of Suceava, Romania*	EVALUATION OF TEXTURE PROFILE IN BREAD FROM INGEN TRITICALE VARIETIES FROM THE REPUBLIC OF MOLDOVA WITH FERMENTED BREWERS' SPENT GRAIN ADDITION
Md. Nazmul Hasan Arfin **Nabiha Tasnim Ruhi** **MD.Rakibul Islam**	Sylhet Agricultural University, Bangladesh International University of Business Agriculture and Technology, Bangladesh	EFFECT OF SEAWEED ENRICHED HUMIC ACID ON GROWTH AND YIELD OF BT. BRINJAL (SOLANUM MELONGENA L.)
Benkirane Kawtar	*Cadi Ayyad University, Morocco*	COMPLIANCE VS. INTEGRATION: EVALUATING THE DIVERGENT IMPACT OF DIFFERENT RISK MANAGEMENT PRACTICES ON ORGANIZATIONAL PERFORMANCE IN MOROCCAN SOES.
Ilham Allam **Ilham Essaket** **Omar Cherkaoui** **Mohamed Tahiri**	*Laboratoire REMTEX, ESITH, Morocco* *Université Hassan II, Morocco* *Laboratoire LM2I, ENSEM, Morocco*	BIO-BASED WOOL POWDER AS A FLAME-RETARDANT ADDITIVE IN ACRYLATE COATINGS FOR TEXTILES

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16.03.2026 | SESSION-2 | HALL-8

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Miroslav Dechev

Authors	Affiliation	Presentation title
Miroslav Dechev	*Institute of Robotics Bulgarian Academy of Science, Bulgaria*	INFLUENCE OF ELECTRONIC SCREEN AND AUDIO-VISUAL DEVICES ON THE COGNITIVE, VISUAL, NEUROPSYCHOLOGICAL FUNCTIONS OF THE HUMAN BRAIN AND THE CARDIOVASCULAR SYSTEM DURING OUR CONTINUOUS EXPOSURE
Kunnur Aitbayeva **Kamila Batkuldinova** **Satzhan Askarov**	*Kazakh National Women's Teacher Traning University, Kazakhstan* *Astana IT University, Kazakhstan* *Nazarbayev University, Kazakhstan*	AI-ENHANCED PEDAGOGICAL APPROACHES IN MODERN EDUCATION
Ulzhan Urazaliyeva **Xeniya Bogdanova** **Arkhat Baimukhanov**	University, School of Education and Humanities, Kazakstan Amanzholov University, Kazakstan Zhetysu University named after I.Zhansugurov, Kazakstan	AI-POWERED FORMATIVE ASSESSMENT AND REAL-TIME FEEDBACK MECHANISMS
John Samuel **Jael Hephzibah**	*Vellore Institute of Technology, India* *Karunya Institute of Technology and Sciences, India*	DRIVING QUALITY EDUCATION THROUGH AI AND DATA SCIENCE
Jamila BOUCHGL **Mustapha LAMINE** **Abderrahim BOUFTOU** **Sanaa MAJID**	*Higher Institute of Marine Fisheries-Agadir, Morocco* *Laboratory of energy Engineering, Materials and Systems, Morocco* *Hassan II University of Casablanca, Morocco*	NATURAL CLAY-BASED REGENERATION PROCESS FOR USED MARINE OILS

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17.03.2026 | SESSION-3 | HALL-1

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Assoc. Prof. Dr. Hasan Selçuk ETİ

Authors	Affiliation	Presentation title
Elane Suleyman Soltanova **Aynur Ikhtiyar Hashimova** **Garanfil Abdul Shahsivarova**	*Sumgait State University, Azerbaijan*	THE IMPLEMENTATION OF AN INTERDISCIPLINARY UNIFIED VIRTUAL LABORATORY MODEL IN SECONDARY SCHOOLS AND A COMPARATIVE ANALYSIS OF ITS ECONOMIC EFFICIENCY
Ebru Erbudak	*Independant Researcher, Türkiye*	FROM ART' S AURA TO SHARING VALUE: THE COMMODIFICATION OF MUSEUM SPACE IN THE EXPERIENCE ECONOMY
Arda Toygar	*Ordu University, Türkiye*	CAREER CONSTRUCTION BEHAVIORS OF DECK CADETS: A COMPARATIVE ANALYSIS BASED ON SEAGOING PHASE TRAINING COMPLETION
Tolga Türköz	*Istanbul Aydin University, Türkiye*	AI-AUGMENTED LEADERSHIP, EMPLOYEE ADAPTATION, AND WORK ENGAGEMENT IN WHITE-COLLAR WORK SETTINGS
Res. Assist. Dr. Yeliz Neslihan AKIN BASA	*Istanbul University, Türkiye*	TAXATION TECHNIQUE IN THE INDIVIDUAL PENSION SYSTEM
Assoc. Prof. Dr. Hasan Selçuk ETİ **Güvenç KURUL**	*Tekirdag Namik Kemal University, Türkiye*	THE DIGITAL ARCHITECTURE OF MODERN CONSUMPTION: A COMPREHENSIVE INVESTIGATION INTO MARKETING PARADIGMS AND CONSUMER DECISION-MAKING
Assoc. Prof. Dr. Hasan Selçuk ETİ	*Tekirdag Namik Kemal University, Türkiye*	TRUST BUILDING IN DIGITAL MARKETING: THE RISE OF MICRO-INFLUENCERS AND USER-GENERATED CONTENT (UGC)
Sergün Kurtoğlu	*Istanbul University, Türkiye*	UNDER CHAOTIC CONDITIONS THE DEGRADATION OF THE VALIDITY–CREDIBILITY AXIS AND THE TRANSFORMATION OF INFORMATION UNDER CHAOTIC CONDITIONS

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17.03.2026 | SESSION-3 | HALL-2

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: David Tabatadze

Authors	Affiliation	Presentation title
Fatimah Abdulridha Haji Al-Farisee **Yazan Naser Mahmoud Albesbes**	*Karabuk University, Türkiye* *Western Union in Jordan*	THE USE OF ARTIFICIAL INTELLIGENCE IN DETECTING MONEY LAUNDERING ACTIVITIES: A COMPARATIVE STUDY BETWEEN TURKISH ISLAMIC BANKS AND INTERNATIONAL MONEY TRANSFER COMPANIES
Elżbieta Bielak **Małgorzata Zakrzewska**	*Krakow University of Economics, Poland*	SUSTAINABILITY-ORIENTED MANAGEMENT IN POLISH TANNERIES
Khadija OUAISSA **Jamila BOUCHGL** **M'Hamed HMAMOU** **Mustapha HASNAOUI**	*Higher institute of maritime Fisheries, Morocco* *University Sultan Moulay Slimane, Morocco* *Ibn Zohr University, Morocco*	AQUACULTURE IN MOROCCO: CHALLENGES, SUSTAINABILITY, AND FUTURE PROSPECTS FOR THE BLUE ECONOMY
Aktham Raed Ahmad Alqattamin	*University of Miskolc, Hungary*	INTERNATIONAL LAW AND STRUCTURAL INEQUALITY
Carina BRANZILA	*'Al. I.Cuza' University, Romania*	URBAN RESILIENCE IN ROMANIA'S SMART CITIES
Stefan Stamenov **Vanya Stamenova**	*Space Research and Technology Institute at the Bulgarian Academy of Sciences, Bulgaria*	LANDSCAPE MANAGEMENT OF NATURAL AND CULTURAL HERITAGE, MEDIEVAL ARCHAEOLOGICAL SITES IN BULGARIA
David Tabatadze	*Caucasus International University, Georgia*	THE IMPORTANCE OF RENEWABLE ENERGY SOURCES FOR NATIONAL SECURITY: THE CASE OF COUNTRY GEORGIA
Abdul Wakil Qaderi **Prof. Dr. Meltem Gürünlü**	*Istanbul Arel University, Türkiye*	DEVELOPMENT OF THE LOGISTICS SECTOR IN TURKIYE AND ITS IMPACT ON FOREIGN TRADE
Prof. Dr. Anita Boros	*Ludovika University of Public Service, Hungary*	FROM POLICY AMBITION TO BUSINESS PRACTICE: EMPIRICAL EVIDENCE ON CIRCULAR ECONOMY IMPLEMENTATION IN THE EUROPEAN UNION

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17.03.2026 | SESSION-3 | HALL-3

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Irina-Ana DROBOT

Authors	Affiliation	Presentation title
Kris Herbert	*University of Szeged, Hungary*	SPY LITERATURE AS A PROPAGANDA DEVICE ACROSS THE EAST-WEST DIVIDE: A COMPARISON OF HUNGARIAN AND AMERICAN COLD WAR SPY NOVELS
Simranjit Kaur **Dr Sharan Pal Singh**	*Lovely Professional University, India* *Lovely Professional University, India*	TEXT BEYOND WORDS: HOW MEANING IS CREATED THROUGH GAPS AND SILENCE IN CONTEMPORARY WRITING
Irina-Ana DROBOT	*Technical University of Civil Engineering Bucharest, Romania*	INDIVIDUALISM IN THE NOVEL LAST ORDERS AND IN THE SHORT STORY CHOCOLATE BY GRAHAM SWIFT
Bibigul Muratbekova	*Narxoz University, Kazakhstan*	DATA-DRIVEN APPROACHES IN CONTEMPORARY LANGUAGE PEDAGOGY
Mas'ud Hamdan	*University of Haifa, Israel/Palestine*	"THE REPORT": A SMALL TAP IN THE BIG REALM OF THE SERIO-COMICAL
Prof. Elizabeta Dimitrova, PhD	*Ss Cyril and Methodius University, Macedonia*	HEAVENLY CREATURES: HOW BYZANTINE PAINTERS DEPICTED MALE AND FEMALE BEAUTY

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17.03.2026 | SESSION-3 | HALL-4

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Dr. Hakan ERDOĞAN

Authors	Affiliation	Presentation title
Rumeysa Toprak	*Niğde Ömer Halisdemir University, Türkiye*	THE CULT OF THE SUN IN MESOPOTAMIAN SYRIAC AND ANDEAN INCA ARCHITECTURE
Dr. Hakan ERDOĞAN **Gökhan TİMUR** **Dr. Pelin ŞAHİNOĞLU** **Dr. Gökçe SÖNMEZ**	*Omer Halisdemir University, Türkiye* *Yıldız Technical University, Türkiye*	LONE WORKERS' RISK PERCEPTION AND SOCIAL INTEREST: AN ADLERIAN PSYCHOLOGICAL PERSPECTIVE
Sadık AKŞAR **Rengin BECEREN ÖZTÜRK**	*Bursa Uludağ University, Türkiye*	TRADITIONAL CONSTRUCTION TECHNIQUES AS DRIVERS OF SUSTAINABLE ARCHITECTURE: A RURAL HERITAGE–BASED MODEL FOR TURKEY
Sadık AKŞAR **Rengin BECEREN ÖZTÜRK**	*Bursa Uludağ University, Türkiye*	BRIDGING PAST AND FUTURE: INTEGRATING TRADITIONAL CONSTRUCTION TECHNIQUES INTO SUSTAINABLE ARCHITECTURE
Olena Kronina	*İstanbul University, Türkiye*	PECULIARITIES OF THE POETICS IN ETHEM BARAN'S SHORT STORY COLLECTION 'I FEEL LIKE CRYING WHENEVER I SEE YOUR BEAUTY' ('GÜZELLIĞINI GÖRDÜKÇE AĞLAYASıM GELIYOR') - THE ALIENATION, THE PROVINCE, AND THE MODERN PERSON
Tugba Andac Guzel **Eva Haviarova**	*Kayseri University, Türkiye* *Purdue University, USA*	A REVIEW OF CONTEMPORARY FURNITURE TRENDS AND EDUCATIONAL CONCEPTS FOR FURNITURE DESIGN
Özlem Bayal	*Gazi University, Türkiye*	**Structural Analysis of Graded and Standart $Al_{\Delta x}Ga_{1-\Delta x}N$ HEMT Devices by Williamson-Hall Method**

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17.03.2026 | SESSION-3 | HALL-5

New York Local Time: 08:^{00}–10:^{30}

Ankara Local Time: 16:^{00}–18:^{30}

HEAD OF SESSION: Ayşe KOÇAK SEZGİN

Authors	Affiliation	Presentation title
Yasemin Özel	*Kastamonu University, Türkiye*	GOVERNING THE MIND: PANOPTICON, AUTONOMY, AND PSYCHIATRIC NURSING
Yasemin Özel	*Kastamonu University, Türkiye*	THE PANOPTICON IN PSYCHIATRIC NURSING: SURVEILLANCE, POWER AND TRANSFORMATION CARE
Aydan Babayeva **Gülsüm Akdeniz**	Ankara Yıldırım Beyazıt University, Türkiye	A NEUROSCIENTIFIC APPROACH TO THE DIGITAL ASSESSMENT OF FACIAL PAREIDOLIA IN THE HEALTHY ADULT BRAIN
Ayşe KOÇAK SEZGİN **Elif AYDIN**	*Kütahya Health Sciences University, Türkiye* *Ağrı İbrahim Çeçen University, Türkiye*	EXOSOMES IN IDIOPATHIC PULMONARY FIBROSIS
Ayşe KOÇAK SEZGİN **Elif AYDIN**	*Kütahya Health Sciences University, Türkiye* *Ağrı İbrahim Çeçen University, Türkiye*	EXOSOME-RELATED NON-CODING RNAS AND ATHEROSCLEROSIS
Süleyman Ciddi **Prof. Handan Ertas**	*Selcuk University, Türkiye*	INVESTIGATION OF THE LEVELS OF ATTITUDES OF HEALTHCARE WORKERS TOWARDS XENOPHOBIA AND IMMIGRANTS IN SERVICE DELIVERY
Süleyman Ciddi **Assoc. Prof. Emel Filiz** **Prof. Handan Ertas**	*Selcuk University, Türkiye*	DETERMINIG THE OCCUPATIONAL HEALTH LITERACY LEVEL OF NURSES WORKING IN THE İNTENSIVE CARE UNIT
Zeynep Yonar **Beyza Mendeş**	*Bezmialem University, Türkiye*	GUT MICROBIOTA AND DEPRESSION: CURRENT APPROACHES THROUGH THE MICROBIOTA–GUT–BRAIN AXIS
Kadriye Buse CEYLAN **Ayşe Handan DÖKMECİ**	*Institute of Health Sciences, Türkiye*	LEAVING NO ONE BEHIND IN CBRN CRISIS MANAGEMENT: INCLUSIVE COMMUNICATION STRATEGIES FOR THE ELDERLY AND CHILD POPULATIONS

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• FROM LABORATORY TO INDUSTRIAL DISTILLATION: VARIATIONS IN THE ESSENTIAL OIL COMPOSITION OF TWO *Lavandula* SPECIES

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Abstract

Essential oil (EO) composition in medicinal and aromatic plants is shaped by multiple interacting factors, including genetic background, climatic conditions, agronomic practices, harvest timing, and post-harvest operations—particularly extraction. In this study, variations in the EO composition of *Lavandula* × *intermedia* L. and *Lavandula angustifolia* Mill. were examined by comparing laboratory-scale hydrodistillation and industrial-scale steam distillation. Fresh inflorescences were harvested at full flowering stage from cultivated plants in Afyonkarahisar, Türkiye. EOs obtained under each distillation condition were analyzed using GC/FID–MSD, and relative abundances were reported as percent total peak area, providing a descriptive comparison of compositional profiles. For *L.* × *intermedia*, both distillation methods produced EOs dominated by oxygenated monoterpenes, with linalool as the principal constituent (43.44% in laboratory distillation and 38.56% in industrial distillation). Industrial distillation was associated with a lower proportional contribution of key monoterpene alcohols (including terpinen-4-ol and borneol) and a concomitant increase in linalyl acetate. A notable shift was the increased representation of sesquiterpene hydrocarbons under industrial conditions, exemplified by *trans*-β-farnesene, which rose from a minor constituent (0.84%) in laboratory EO to a major constituent (5.40%) in industrial EO. These changes suggest that industrial processing conditions may favor the recovery of less volatile or later-eluting fractions relative to laboratory hydrodistillation. In *L. angustifolia*, laboratory distillation yielded a strongly linalool-driven profile (48.78%) with moderate linalyl acetate (15.83%), whereas industrial distillation produced a more balanced distribution between linalool (30.14%) and linalyl acetate (28.17%). In parallel, sesquiterpene hydrocarbons were proportionally enriched in industrial EO, with caryophyllene (10.15%) and trans-β-farnesene (7.25%) increasing relative to laboratory values. At the class level, industrial distillation tended to reduce the proportional contribution of oxygenated monoterpenes while increasing esters and sesquiterpene hydrocarbons. Overall, both *Lavandula* taxa retained their characteristic EO frameworks across distillation scales, centered on linalool and related oxygenated constituents; however, industrial-scale distillation consistently shifted relative profiles toward greater ester and sesquiterpene representation. These findings emphasize extraction scale as a key post-harvest driver of EO composition and should be considered when defining quality targets for cultivated *Lavandula* EOs intended for industrial use.

Keywords: Essential oil, GC-MS, Industrial distillation, *Lavandula* × *intermedia*, *L. angustifolia*

Introduction

The genus *Lavandula* (Lamiaceae) comprises aromatic taxa native from Macaronesia across the Mediterranean Basin and extending eastward toward parts of Southwest Asia (Salehi et al., 2018). Across its cultivated representatives, *Lavandula* is valued not only as an ornamental but also as a major source of fragrant products, with essential oil (EO) production underpinning much of its commercial relevance (Habán et al., 2023). *Lavandula*-derived EOs are widely used in perfumery and personal-care formulations and are also present in pharmaceutical- and food-related applications, which sustains a persistent global demand for lavender products (Wells et al., 2018). Among the most prominent cultivated taxa, *Lavandula angustifolia* (often referred to as "true" or "English" lavender) is commonly treated as a benchmark species for high-value aromatic oil (Habán et al., 2023). By contrast, *Lavandula* × *intermedia* (lavandin), a sterile hybrid of *L. angustifolia* and *L. latifolia*, is widely grown in commercial settings, frequently linked to higher biomass and EO yield under cultivation (Pokajewicz et al., 2023).

In ISO terminology, an EO is defined as a product obtained from plant raw material by processes such as steam distillation, mechanical processes applied to citrus pericarps, or dry distillation, followed—when present—by physical separation of an aqueous phase (ISO 9235:2021). Chemically, EOs are typically composed of volatile organic constituents, and terpene hydrocarbons together with their oxygenated derivatives are routinely reported as dominant classes in many plant EOs (Nabi et al., 2025). Within *Lavandula*, the EO profile varies by taxon and growing conditions, and shifts in the relative abundance of key constituents (including linalool and linalyl acetate) have been documented across varieties and between production years (Détár et al., 2020). At the same time, genotype remains a primary driver of EO composition in lavender, while environmental conditions and cultivation practices can measurably modulate the resulting chemical pattern (Habán et al., 2023). Beyond genetics, plant developmental status, local climate, and agronomic management are repeatedly identified as important determinants of both biomass accumulation and EO yield and composition in medicinal and aromatic crops (Najar et al., 2021). Postharvest handling can further shape outcomes, and long-term storage of dried *L. angustifolia* flowers has been shown to reduce EO content and to alter the proportions of some constituents over time (Dušková et al., 2016).

EOs can be obtained by several extraction routes, including hydrodistillation and steam distillation alongside solvent-based and emerging assisted techniques, with method choice often driven by the intended use and feasibility at scale (Nabi et al., 2025). In industrial production, steam distillation is frequently emphasized as a practical and widely adopted approach, in part because it can be implemented as a relatively straightforward unit operation in processing lines (Machado et al., 2022). From a process standpoint, distillation-based methods rely on volatilization and co-distillation phenomena, and these principles are commonly invoked to explain their suitability for recovering aroma constituents from aromatic plant matrices (Akdağ and Öztürk, 2019). At laboratory scale, hydrodistillation is often carried out using a Clevenger-type apparatus, where plant material is heated in an aqueous environment and volatile constituents are recovered after condensation and phase separation (Fagbemi et al., 2021). In steam distillation, by contrast, steam is passed through the plant bed, and the process configuration typically avoids the same extent of direct boiling-water contact that characterizes classical hydrodistillation, a distinction that is repeatedly highlighted in methodological discussions (Nabi et al., 2025). Because such differences in scale and operating conditions can influence both yield and apparent composition, approaches have been developed to better align laboratory experiments with industrial practice, including the downscaling of turbo-distillation concepts to laboratory-compatible set-ups (Périno et al., 2019).

In this study, EO from *L.* × *intermedia* and *L. angustifolia* were obtained using two distillation regimes—laboratory-scale hydrodistillation (Clevenger apparatus) and industrial-scale steam distillation—and then characterized by GC/FID–MSD based analysis to describe and compare

their relative chemical profiles. The work is presented as a descriptive comparison of the apparent proportions of major and minor constituents across the two production scales, with the aim of highlighting compositional patterns that may be associated with differences in distillation configuration and scale.

Materials and Methods

Plant material, location, and treatments

The plant material used in this study consisted of three-year-old *Lavandula* × *intermedia* L. and *Lavandula angustifolia* Mill. plants, and the work was carried out in 2021. Harvesting was carried out at full flowering stage. Inflorescences were manually cut by field workers approximately 10–20 cm below the spike using hand tools. Plant material was obtained from Sorkun Nursery, Sandıklı Forestry Nursery Directorate, Afyonkarahisar, Türkiye (38°25′ N, 30°02′ E; 1008 m above sea level). The cultivation area is geographically surrounded by mountainous terrain. The region is characterized by a continental climate, with an annual mean temperature of 13.2 °C. Recorded extreme temperatures range from 39.6 °C (maximum) to −16.7 °C (minimum). Winters are cold and snowy, spring seasons are mild and rainy, and summers are hot and dry. The plants were cultivated in accordance with sustainable agricultural practices. Essential oils (EOs) from both species were obtained using two distillation methods: laboratory-scale hydrodistillation (LD; Clevenger apparatus) and industrial-scale steam distillation (ID). The extracted EOs were subsequently subjected to GC/FID–MSD analysis for compositional characterization.

Because the plant material was not harvested in a standardized and homogeneous manner, determining EO yield under these conditions was not considered reliable. Each sample was distilled only once, and a single GC/FID–MSD analysis was performed per EO. Consequently, the study was conducted on a descriptive basis, and no statistical comparisons were undertaken.

Laboratory scale hydrodistillation

EOs were extracted by hydrodistillation using a Clevenger-type apparatus. Freshly harvested spike material (250 g) was subjected to hydrodistillation. Distilled water was added at a 10:1 ratio (water:plant material, v/v). After reaching the boiling point, distillation was continued for 3 h under standard atmospheric conditions. The obtained EO was dried over anhydrous sodium sulfate, filtered, and stored in amber glass vials at 4 °C until GC/FID–MSD analysis.

Industrial scale steam distillation

Industrial-scale steam distillation was carried out using a dedicated distillation line equipped with a 2000 L distillation vessel. The system included a gas-fired steam boiler, and the distillation vessel was manufactured from 2-mm-thick stainless steel with external thermal insulation. Steam was supplied to the distillation vessel under operating pressures ranging from 4 to 6 bar, and distillation was conducted for 50 min per batch. The vapour stream was directed to a stainless-steel cooling and condensation unit (2-mm-thick), consisting of a tubular heat-exchanger section followed by a coil-type condensation section. Condensed distillate was collected in a hydrosol tank positioned beneath the condenser. Phase separation was performed using a Florentine-type separator fitted with a borosilicate glass decanter, allowing separation of the EO from the aqueous phase. After completion of distillation, the separated EO was withdrawn, dried over anhydrous sodium sulfate as described for LD, and stored in amber glass vials at 4 °C until GC/FID–MSD analysis.

GC/FID–MSD identification of essential oil compounds

Volatile constituents of the EOs were characterized using GC/FID–MSD. Sample preparation procedures, column characteristics, and the main instrumental settings (including injection mode and parameters) are summarized in Table 1.

Table 1. GC/FID–MSD parameters used for essential oils characterization

Analytical parameter	Operating condition
Stationary phase	GC/FID (Agilent Technologies, 7890B) MSD (Agilent Technologies, 5977A)
Stationary phase specifications	Agilent HP–Innowax (19091N–116): 60 m × 0.320 mm i.d., 0.25 μm film thickness
Carrier gas / Flow	Helium (99.999%) / 1.3 mL min^{-1}
Sample preparation	EO diluted 1:50 (v/v) in n–hexane
Injection volume	1 μl (split mode, 40:1)
Initial oven temperature	70 °C, 5 min hold
1st stage temp. planning & gradient	70 → 160 °C, 3 °C min^{-1}, 5 min hold
2nd stage temp. planning & gradient	160 → 250 °C, 6 °C min^{-1}, 5 min hold
Injector temperature	250 °C
Detector temperature	270 °C
Ion source temperature	230 °C
MS scan range	m/z 35–550
Ionization mode	EI (70 eV)

Identification of compounds

Retention indices (RIs) were calculated using a C7–C30 n-alkane series under the same chromatographic conditions applied for EO analysis. Identification was based on RI agreement and comparison of mass spectra with reference spectra from the NIST and Wiley libraries, published data (Adams, 2017), and available in-house reference information. Relative abundance was reported as % total peak area (area normalization), obtained by dividing the peak area of each peak by the sum of all integrated peak areas. These values are semi-quantitative and reflect relative proportions within each EO, rather than absolute concentrations.

Results

Lavandula × *intermedia* L.

Based on GC/FID–MSD analysis, the EO of *L.* × *intermedia* obtained by laboratory-scale hydrodistillation / Clevenger (LD) showed a volatile composition comprising 40 identified volatiles, accounting for 99.38% of the total peak area. Under industrial-scale steam distillation (ID), the volatile composition comprised 43 identified volatiles, representing 99.17% of the total peak area (Table 2).

Table 2. Essential oil composition of *L.* × *intermedia* obtained by laboratory hydrodistillation and industrial steam distillation

Laboratory Scale Hydrodistillation (Clevenger)					Industrial Scale Steam Distillation				
No	**RT[1]**	**RI[2]**	**Composition**	**Area %[3]**	**No**	**RT[1]**	**RI[2]**	**Composition**	**Area %[3]**
1	8.796	1031	α-Pinene	0.67	1	8.796	1031	α-Pinene	0.91
2	9.809	1077	Camphene	0.37	2	9.803	1077	Camphene	0.44
3	10.873	1118	β-Pinene	0.17	3	10.873	1118	β-Pinene	0.24
4	11.194	1129	Sabinene	0.13	4	11.194	1129	Sabinene	0.17
5	12.023	1155	δ-3-carene	0.14	5	12.023	1155	δ-3-carene	0.2
6	12.338	1165	β-Myrcene	0.5	6	12.338	1165	β-Myrcene	0.52
7	12.55	1172	α-Phellandrene	0.13	7	12.55	1172	α-Phellandrene	0.15
8	13.03	1188	α-Terpinene	0.12	8	13.683	1207	Limonene	1.25
9	13.683	1207	Limonene	1.21	9	14.077	1217	1,8-Cineole	6.46
10	14.078	1217	1,8-Cineole	6.12	10	14.821	1237	*cis*-Ocimene	3.32
11	14.821	1237	*cis*-Ocimene	2.79	11	15.359	1251	γ-Terpinene	0.34
12	15.359	1251	γ-Terpinene	0.4	12	15.479	1254	*trans*-β-Ocimene	0.62
13	15.479	1254	*trans*-β-Ocimene	0.69	13	16.275	1275	Hexyl acetate	0.19
14	16.275	1275	Hexyl acetate	0.08	14	16.349	1277	m-Cymene	0.15
15	16.79	1289	α-Terpinolene	0.47	15	16.79	1289	α-Terpinolene	0.46
16	19.056	1345	Hexyl isobutyrate	0.21	16	19.056	1345	Hexyl isobutyrate	0.21
17	19.285	1351	Hexanol	0.24	17	19.279	1351	Hexanol	0.17
18	22.06	1419	Hexyl butanoate	0.93	18	22.06	1419	Hexyl butanoate	0.96
19	22.535	1430	Hexyl 2-methylbutyrate	0.41	19	22.534	1430	Hexyl 2-methylbutyrate	0.46
20	23.278	1449	Morillol	0.64	20	23.273	1448	Morillol	0.59
21	24.022	1467	*trans*-Sabinene hydrate	0.22	21	24.022	1467	*trans*-Sabinene hydrate	0.43
22	26.426	1526	Camphor	8.21	22	26.425	1526	Camphor	8.5
23	27.301	1548	Linalool	43.44	23	26.963	1540	β-Cubebene	0.22
24	27.393	1551	*cis*-β-Terpineol	0.19	24	27.295	1548	Linalool	38.56
25	27.61	1556	Octanol	0.14	25	27.398	1551	*cis*-β-Terpineol	0.26
26	27.747	1560	Linalyl acetate	2.66	26	27.61	1556	Octanol	0.12
27	28.703	1584	Bornyl formate	0.14	27	27.747	1560	Linalyl acetate	4.96
28	29.59	1606	Terpinen-4-ol	11.75	28	28.462	1578	α-Santalene	0.18
29	29.676	1609	Lavendulyl acetate	0.85	29	28.697	1584	Bornyl formate	0.16
30	29.83	1613	Hexyl hexanoate	0.18	30	29.584	1606	Terpinen-4-ol	9.77
31	30.288	1625	Hexyl tiglate	0.25	31	29.676	1609	Lavendulyl acetate	0.84
32	31.913	1667	*trans*-β-Farnesene	0.84	32	29.83	1613	Hexyl hexanoate	0.3
33	32.273	1677	Lavandulol	0.97	33	30.288	1625	Hexyl tiglate	0.3
34	33.103	1699	α-Terpineol	0.86	34	31.919	1668	*trans*-β-Farnesene	5.4
35	33.303	1704	Borneol	10.43	35	32.279	1677	Lavandulol	0.88
36	33.75	1716	Germacrene D	0.16	36	33.103	1699	α-Terpineol	0.29
37	34.167	1727	Nerol acetate	0.14	37	33.297	1704	Borneol	7.3
38	35.329	1758	Geranyl acetate	0.56	38	33.75	1716	Germacrene D	0.9
39	38.756	1842	Geraniol	0.25	39	34.854	1745	Carvone	0.14
40	50.464	2218	α-Bisabolol	0.72	40	34.968	1748	α-Farnesene	0.2
					41	35.329	1758	Geranyl acetate	0.92
					42	44.581	1991	Caryophyllene oxide	0.18
					43	50.463	2217	α-Bisabolol	0.55
Total (%)				99.38	Total (%)				99.17
Identified Compositions (n)				40	Identified Compositions (n)				43

[1]: Retention Time; [2]: Retention indices calculated against n-alkanes (C7-C30) on polar column; [3]: Data are reported as % total peak area (GC/FID–MSD)

In the EO of *L.* × *intermedia* obtained by LD, the major constituents (defined as compositions occurring at >1% of the total peak area) were dominated by oxygenated monoterpenes. Linalool represented the predominant constituent, accounting for 43.44% of the total peak area, and thus constituted the central feature of the EO composition. Other oxygenated monoterpenes were also present at appreciable levels, notably terpinen-4-ol (11.75%) and borneol (10.43%). Together with linalool, these major constituents formed the principal structural backbone of the volatile fraction. Camphor (8.21%) and 1,8-cineole (6.12%) further contributed to the oxygenated fraction, indicating a chemically diversified oxygenated profile rather than the dominance of a single functional group. In contrast, monoterpene hydrocarbons appeared at comparatively lower

proportions. *cis*-Ocimene (2.79%) and limonene (1.21%) were the only hydrocarbons exceeding 1%, suggesting a more limited representation of non-oxygenated monoterpenes in this EO. Linalyl acetate (2.66%) was the sole ester present above 1%, occurring at a substantially lower level than linalool.

Under ID, the major constituents of *L.* × *intermedia* were still largely composed of oxygenated monoterpenes. Linalool remained the predominant constituent (38.56%), retaining a central position within the EO composition. An oxygenated fraction was also recorded at substantial proportions, with terpinen-4-ol (9.77%), camphor (8.50%), borneol (7.30%), and 1,8-cineole (6.46%) occurring at relatively high levels, supporting the continued dominance of oxygenated monoterpenes under industrial conditions.

Notably, *trans*-β-farnesene (5.40%) was detected among the major constituents, reflecting a measurable contribution from sesquiterpene hydrocarbons in this distillate. In addition, linalyl acetate (4.96%) showed an increased contribution under ID, while remaining lower than linalool in the EO composition. Among monoterpene hydrocarbons exceeding 1%, *cis*-ocimene (3.32%) and limonene (1.25%) were present at modest levels, suggesting a limited but discernible hydrocarbon fraction within the major constituents. Overall, the ID-derived EO showed a profile centered on oxygenated monoterpenes, with an accompanying sesquiterpene hydrocarbon and moderate contributions from an acetate ester and selected monoterpene hydrocarbons.

Compared with LD EO, the EO composition of *L.* × *intermedia* obtained under ID showed several shifts within the major fraction (>1%). Linalool remained the dominant constituent in both distillation conditions, although its relative proportion was lower in ID EO. The same downward pattern was observed for terpinen-4-ol and borneol, both occurring at reduced levels under ID relative to LD. In contrast, camphor exhibited a slight increase under industrial steam distillation, whereas 1,8-cineole was broadly comparable between LD and ID, showing only minor variation. A more noticeable change was associated with linalyl acetate, which occurred at a higher level in ID EO and therefore contributed more substantially to the EO composition under industrial conditions. Among monoterpene hydrocarbons, *cis*-ocimene was recorded at a somewhat higher proportion under ID, while limonene remained essentially similar between the two distillation conditions. Overall, the EO composition under ID tended toward lower relative proportions of the major monoterpene alcohols alongside a greater contribution of the acetate ester within the major fraction, while retaining the same principal constituents as LD EO. A noticeable difference was observed for *trans*-β-farnesene, which was present below 1% in the LD EO (0.84%) but appeared among the major compositions in the ID EO, reaching 5.40% of the total peak area.

Among the minor compositions (<1%), 32 were recorded in LD EO and 34 in ID EO. Of these, 28 compositions were common to both distillation conditions, indicating a substantial overlap within the minor fraction of the EO composition. A limited number of minor entries within the EO composition were detected exclusively under one distillation condition. In LD EO, geraniol, nerol acetate, and α-terpinene were observed but were not recorded in ID EO; *trans*-β-farnesene was detected in both distillates, with a higher relative area percentage in ID. Conversely, β-cubebene, α-farnesene, α-santalene, caryophyllene oxide, m-cymene, and carvone were recorded only in ID EO.

Based on the classification presented in Table 3, the EO composition of *L.* × *intermedia* was clearly dominated by oxygenated monoterpenes under both distillation conditions. In LD EO, this class accounted for 82.44% of the total composition, whereas a lower, though still predominant, proportion was observed in ID EO (72.59%). Despite this decrease, oxygenated monoterpenes remained the principal chemical class in both cases, reflecting their central contribution to the overall EO composition. Monoterpene hydrocarbons represented a comparatively minor fraction under both conditions, though their proportion was slightly higher in ID EO (8.77%) than in LD

EO (7.79%), while the number of identified entries within this class remained the same. A more pronounced difference was associated with sesquiterpene hydrocarbons. Although limited in LD EO (1.00% with two entries), this class showed a noticeable increase in ID EO, both in relative proportion (6.90%) and in the number of recorded entries (five), indicating a greater representation of higher-molecular-weight hydrocarbons under industrial steam distillation. Oxygenated sesquiterpenes were present at low and comparable levels in both distillation methods, with only minor variation in relative proportion and a slight increase in the number of entries under ID. Ester content also differed between the two conditions: while LD EO contained a slightly higher number of ester-related entries, ID EO exhibited a higher overall percentage within this class. Finally, the alcohol class represented a small fraction of the EO composition in both cases, with similar counts and only marginal quantitative differences.

Overall, although both LD and ID EOs share a broadly similar framework dominated by oxygenated monoterpenes, the ID-derived EO exhibited a lower relative area percentage for this class and higher relative area percentages for sesquiterpene hydrocarbons and esters in this comparison.

Table 3. Chemical classes of *L.* × *intermedia* essential oil obtained by laboratory hydrodistillation and industrial steam distillation

Chemical class	**Laboratory Scale Hydrodistillation (Clevenger)**		**Industrial Scale Steam Distillation**	
	Compositions (n)	**%**	**Compositions (n)**	**%**
Monoterpene hydrocarbon	13	7.79	13	8.77
Oxygenated monoterpene	10	82.44	10	72.59
Sesquiterpene hydrocarbon	2	1	5	6.9
Oxygenated sesquiterpene	2	1.36	3	1.32
Ester	11	6.41	10	9.3
Alcohol	2	0.38	2	0.29

Lavandula angustifolia Mill.

Based on GC/FID–MSD analysis, the EO of *L. angustifolia* comprised 37 identified constituents under LD, representing 98.80% of the total peak area (Table 4). Under ID, 40 constituents were recorded, accounting for 98.85% of the total EO composition. The overall identification coverage was therefore comparable between the two distillation conditions, with both LD EO and ID EO showing a high level of representation of the volatile fraction. The slightly higher number of identified constituents under ID suggests a broader compositional profile in the industrially obtained EO, although the total percentage of the identified fraction remained essentially similar between LD and ID.

Table 4. Essential oil composition of *L. angustifolia* obtained by laboratory hydrodistillation and industrial steam distillation

Laboratory Scale Hydrodistillation (Clevenger)					**Industrial Scale Steam Distillation**				
No	**RT[1]**	**RI[2]**	**Composition**	**Area %[3]**	**No**	**RT[1]**	**RI[2]**	**Composition**	**Area %[3]**
1	8.796	1031	α-Pinene	0.19	1	8.796	1031	α-Pinene	0.37
2	12.338	1165	β-Myrcene	0.51	2	9.803	1077	Camphene	0.16
3	13.683	1207	Limonene	0.33	3	12.029	1155	3-Carene	0.17
4	14.072	1217	1,8-Cineole	0.98	4	12.338	1165	β-Myrcene	0.36
5	14.249	1222	n-Butyl butyrate	0.13	5	13.683	1207	Limonene	0.4
6	14.821	1237	*cis*-Ocimene	1.85	6	14.072	1217	1,8-Cineole	1.56
7	15.359	1251	γ-Terpinene	0.13	7	14.255	1222	n-Butyl butyrate	0.1
8	15.485	1254	*trans*-β-Ocimene	1.49	8	14.821	1237	*cis*-Ocimene	3.39
9	15.68	1260	3-Octanone	1.84	9	15.359	1251	γ-Terpinene	0.18
10	16.28	1275	Hexyl acetate	0.62	10	15.491	1255	*trans*-β-Ocimene	2.08
11	16.36	1278	p-Cymene	0.15	11	15.685	1260	3-Octanone	1.04
12	16.801	1289	α-Terpinolene	0.14	12	16.28	1275	Hexyl acetate	0.52
13	20.509	1381	1-Octen-3-yl-acetate	0.54	13	16.361	1278	p-Cymene	0.17
14	20.967	1392	3-Octanol	0.48	14	20.509	1381	1-Octen-3-yl-acetate	0.53
15	22.065	1419	Hexyl butanoate	0.58	15	20.967	1392	3-Octanol	0.3
16	23.21	1447	*cis*-Linalool oxide	0.34	16	21.15	1396	*cis,trans*-1,3,5-Undecatriene	0.16
17	23.29	1449	1-Octen-3-ol	0.31	17	22.065	1419	Hexyl butanoate	0.51
18	24.028	1467	*trans*-Sabinene hydrate	0.15	18	23.215	1447	*cis*-Linalool oxide	0.13
19	24.365	1475	Linalool oxide	0.28	19	23.29	1449	1-Octen-3-ol	0.2
20	26.425	1526	Camphor	0.41	20	24.028	1467	*trans*-Sabinene hydrate	0.2
21	27.312	1549	Linalool	48.78	21	26.42	1526	Camphor	0.35
22	27.398	1551	*cis*-β-Terpineol	0.15	22	26.969	1540	*trans*-α-Bergamotene	0.16
23	27.776	1560	Linalyl acetate	15.83	23	27.289	1548	Linalool	30.14
24	29.59	1606	Caryophyllene	6.64	24	27.404	1551	*cis*-β-Terpineol	0.14
25	29.687	1609	Lavandulyl acetate	3.41	25	27.787	1561	Linalyl acetate	28.17
26	29.841	1613	Hexyl hexanoate	0.17	26	28.485	1578	α-Santalene	0.62
27	31.918	1668	*trans*-β-Farnesene	1.06	27	28.926	1589	α-Bergamotene	0.2

28	32.285	1677	Lavandulol	1.77	28	29.561	1606	Caryophyllene	10.15
29	32.393	1680	Cryptone	0.25	29	29.693	1609	Lavandulyl acetate	3.65
30	33.114	1699	α-Terpineol	3.68	30	29.841	1613	Hexyl hexanoate	0.29
31	33.303	1704	Borneol	1.12	31	31.93	1668	*trans*-β-Farnesene	7.25
32	33.755	1716	Germacrene D	0.17	32	32.285	1677	Lavandulol	1.4
33	34.179	1727	Nerol acetate	0.74	33	32.393	1680	Cryptone	0.24
34	35.277	1756	Geranyl acetate	1.2	34	33.114	1699	α-Terpineol	0.62
35	36.874	1799	Nerol	0.51	35	33.303	1704	Borneol	0.81
36	38.779	1843	Geraniol	1.23	36	33.755	1716	Germacrene D	0.92
37	44.587	1991	Caryophyllene oxide	0.64	37	34.179	1727	Nerol acetate	0.22
					38	35.277	1756	Geranyl acetate	0.2
					39	35.541	1763	α-Amorphene	0.26
					40	44.593	1991	Caryophyllene oxide	0.53
Total (%)				98.8	Total (%)				98.85
Identified Compositions (n)				37	Identified Compositions (n)				40

[1]: Retention Time; [2]: Retention indices calculated against n-alkanes (C7-C30) on polar column; [3]: Data are reported as % total peak area (GC/FID–MSD)

In LD EO of *L. angustifolia*, the major fraction (>1%) was characterized by a strong predominance of oxygenated monoterpenes and their corresponding esters (Table 4). Linalool was clearly the leading constituent, accounting for nearly half of the total peak area (48.78%), thereby defining the overall character of the EO composition. Linalyl acetate followed as the second most abundant constituent (15.83%), indicating a substantial ester contribution alongside the dominant alcohol. Beyond these two principal constituents, several additional oxygenated monoterpenes were present at moderate levels. α-Terpineol (3.68%), lavandulol (1.77%), geraniol (1.23%), and borneol (1.12%) collectively reinforced the alcohol-rich nature of the EO composition. Lavandulyl acetate (3.41%) and geranyl acetate (1.20%) further contributed to the ester fraction, supporting a balanced distribution between free alcohols and their acetate derivatives within the major fraction. In contrast, hydrocarbon constituents were represented by comparatively lower proportions. Caryophyllene (6.64%) stood out as the most prominent sesquiterpene hydrocarbon, while cis-ocimene (1.85%) and trans-β-ocimene (1.49%) accounted for the principal monoterpene hydrocarbons above 1%. In addition, 3-octanone (1.84%) introduced a ketone component into the major fraction, and trans-β-farnesene (1.06%) reflected a modest contribution from sesquiterpene hydrocarbons. Overall, the LD EO of *L. angustifolia* displayed a composition dominated by linalool and linalyl acetate, supported by secondary alcohols, esters, and a limited hydrocarbon fraction.

In ID EO of *L. angustifolia*, the distribution within the major fraction (>1%) showed a more balanced relationship between alcohol and ester constituents than that observed under LD. Although linalool remained the most abundant constituent (30.14%), its dominance was less pronounced. Linalyl acetate reached a comparable level (28.17%), indicating a marked enrichment of the ester relative to LD and contributing substantially to the overall EO composition.

Sesquiterpene hydrocarbons were more prominently represented under ID. Caryophyllene (10.15%) and trans-β-farnesene (7.25%) together formed a considerable portion of the major fraction, suggesting an increased contribution of higher-molecular-weight hydrocarbons in the industrially obtained EO. Among monoterpene hydrocarbons, cis-ocimene (3.39%) and trans-β-ocimene (2.08%) occurred at moderate levels, further shaping the hydrocarbon profile. The oxygenated monoterpene fraction also included lavandulyl acetate (3.65%) and lavandulol (1.40%), while 1,8-cineole (1.56%) and 3-octanone (1.04%) introduced additional oxygenated functionality into the composition. Taken together, the ID EO of *L. angustifolia* displayed a composition in which linalool and linalyl acetate were present at nearly equivalent proportions, accompanied by a comparatively stronger representation of sesquiterpene hydrocarbons relative to LD.

Compared with LD EO, the major fraction of ID EO in *L. angustifolia* showed a redistribution within the oxygenated monoterpene pool, particularly between the dominant oxygenated monoterpene alcohol (linalool) and its corresponding oxygenated monoterpene ester (linalyl acetate). Linalool remained the leading constituent under both conditions, but its relative contribution was lower under ID, whereas linalyl acetate contributed more prominently and approached a near co-dominant position. In parallel, the sesquiterpene hydrocarbon contribution was more pronounced under ID, with both caryophyllene and trans-β-farnesene occurring at higher levels than in LD EO. Differences were also evident within the monoterpene hydrocarbon portion of the major fraction. Both cis-ocimene and trans-β-ocimene were recorded at higher relative proportions under ID. Lavandulyl acetate, lavandulol, and 3-octanone were detected under both conditions; lavandulol and 3-octanone tended to contribute less under industrial distillation, whereas lavandulyl acetate remained comparable or showed a slight increase. Overall, LD EO was characterized by a more strongly linalool-driven oxygenated monoterpene composition, whereas ID EO displayed a more balanced distribution between oxygenated monoterpene alcohol and ester constituents, accompanied by an enhanced sesquiterpene hydrocarbon and ocimene contribution within the major fraction.

The comparison of the major fraction between LD EO and ID EO of *L. angustifolia* also revealed several shifts around the 1% threshold. α-Terpineol, geraniol, geranyl acetate, and borneol were present within the major fraction under LD, yet their representation declined under ID, falling below 1% or, in the case of geraniol, no longer being detected. This pattern suggests a reduced contribution of several oxygenated monoterpene alcohols and related esters under industrial distillation conditions. Conversely, 1,8-cineole was recorded above 1% under ID, while remaining below this threshold in LD EO. Its emergence within the major fraction under industrial distillation indicates a relative enhancement of this oxide-type oxygenated monoterpene compared with laboratory conditions. Together, these threshold shifts highlight subtle yet distinct differences in the oxygenated monoterpene distribution between LD and ID EOs.

Within the minor fraction (<1%), a set of entries was recorded for both LD EO and ID EO of *L. angustifolia*, with a substantial overlap between the two distillation conditions. In total, twenty minor constituents were common to both profiles, indicating that much of the low-abundance portion of the EO composition was shared between LD and ID. A smaller group of minor constituents was observed exclusively under LD. These included nerol, linalool oxide, and α-terpinolene, which were recorded in LD EO but were not recorded in the ID EO composition. Notably, 1,8-cineole was detected in both distillates, remaining below 1% in LD EO but occurring above 1% in ID EO. Conversely, several minor constituents appeared only under ID, including α-santalene, α-amorphene, α-bergamotene, *trans*-α-bergamotene, 3-carene, camphene, and *cis*,*trans*-1,3,5-undecatriene. Borneol was detected in both distillates; however, it occurred within the major fraction in LD EO but fell below the 1% threshold in ID EO. Collectively, these exclusive entries

highlight modest differences in the minor portion of the EO composition between laboratory and industrial distillation conditions.

Table 5 reveals a marked redistribution in the class-level composition of *L. angustifolia* EO between LD and ID. Under LD, oxygenated monoterpenes clearly dominated the EO composition, accounting for 59.40% of the total peak area with 12 identified entries. In ID EO, this class decreased to 35.35% with 9 entries, indicating a substantial reduction in its overall contribution under industrial distillation. In contrast, the ester fraction increased under ID. While both LD and ID showed the same number of ester entries (9), their relative contribution rose from 23.22% in LD to 34.19% in ID, reflecting a pronounced enrichment of this class in the industrially obtained EO. A similar upward trend was observed for sesquiterpene hydrocarbons, which increased from 7.87% (3 entries) in LD to 19.56% (7 entries) in ID, demonstrating both quantitative and numerical expansion of this class under ID conditions. The monoterpene hydrocarbon fraction also showed a moderate increase, rising from 4.79% (8 entries) in LD to 7.28% (9 entries) in ID. By comparison, oxygenated sesquiterpenes remained relatively stable, contributing 0.64% (1 entry) in LD and 0.53% (1 entry) in ID.

Minor classes exhibited limited variation. The aliphatic ketone fraction decreased from 1.84% in LD to 1.04% in ID, while the simple ketone class remained nearly unchanged (0.25% in LD and 0.24% in ID). The aliphatic hydrocarbon class was not represented in LD but appeared at 0.16% in ID. Finally, the alcohol class showed a slight reduction from 0.79% in LD to 0.50% in ID, although the number of entries remained constant. Taken together, the class-level distribution indicates that LD EO is primarily driven by oxygenated monoterpenes, whereas ID EO reflects a compositional shift toward greater contributions from esters and sesquiterpene hydrocarbons, accompanied by a relative decline in oxygenated monoterpenes.

Table 5. Chemical classes of *L. angustifolia* essential oil obtained by laboratory hydrodistillation and industrial steam distillation

Chemical class	Laboratory Scale Hydrodistillation (Clevenger)		Industrial Scale Steam Distillation	
	Compositions (n)	%	Compositions (n)	%
Monoterpene hydrocarbon	8	4.79	9	7.28
Oxygenated monoterpene	12	59.4	9	35.35
Sesquiterpene hydrocarbon	3	7.87	7	19.56
Oxygenated sesquiterpene	1	0.64	1	0.53
Aliphatic hydrocarbon	-	-	1	0.16
Aliphatic ketone	1	1.84	1	1.04
Ester	9	23.22	9	34.19
Alcohol	2	0.79	2	0.5
Ketone	1	0.25	1	0.24

Discussion

According to ISO 8902:2009, the normative chromatographic profile of *L.* × *intermedia* (Grosso type) EO is characterized by linalool (24.0–37.0%) and linalyl acetate (25.0–38.0%) as the principal constituents, accompanied by comparatively higher oxygenated monoterpenes such as camphor (6.0–8.5%), 1,8-cineole (4.0–8.0%), borneol (1.5–3.5%), and terpinen-4-ol (1.5–5.0%). Additional components occur within narrower limits, including myrcene (0.3–1.0%), limonene (0.5–1.5%), cis-β-ocimene (0.5–1.5%), trans-β-ocimene (not detectable–1.0%), lavandulol (0.2–

1.0%), α-terpineol (0.3–1.3%), hexyl butyrate (0.3–0.5%), and lavandulyl acetate (1.5–3.5%), reflecting the standardized compositional framework defined for lavandin EO (ISO 8902:2009). Compared with the ISO 8902:2009 compositional framework for *L.* × *intermedia* (Grosso type) EO, the LD sample departs notably from the expected dual dominance of linalool and linalyl acetate. Linalool is higher than the ISO range, whereas linalyl acetate is substantially lower than the specified limits, indicating a pronounced imbalance relative to the normative Grosso-type profile. Among the principal oxygenated monoterpenes used in the standard, 1,8-cineole and camphor fall within the ISO intervals, while borneol and terpinen-4-ol are clearly elevated beyond the ISO limits. For the secondary markers, myrcene, limonene, *trans*-β-ocimene, lavandulol, and α-terpineol remain within the ISO ranges, but cis-β-ocimene exceeds the upper limit. In addition, hexyl butyrate is higher than the ISO range, and lavandulyl acetate is lower than the standardized limits. Relative to the reference profile reported above for *L.* × *intermedia* (ISO 8902:2009), the ID EO displayed a pronounced deviation in the expected dominance of the two principal markers. Linalool was above the reference range, whereas linalyl acetate was far below the stipulated limits, pointing to a clear shift away from the characteristic linalyl acetate–rich pattern. Among the oxygenated monoterpenes emphasized in the reference, 1,8-cineole remained within range and camphor aligned with the upper boundary, while borneol and terpinen-4-ol were distinctly higher than the allowed limits. Regarding the secondary markers, β-myrcene, limonene, trans-β-ocimene, and lavandulol fell within the reported ranges, but *cis*-β-ocimene exceeded the upper limit. In addition, α-terpineol was slightly below the lower threshold, whereas hexyl butyrate was above range and lavandulyl acetate was below the specified limits.

The EMA assessment report similarly describes *L. angustifolia* EO as being largely composed of monoterpene alcohols (about 60–65%), with linalool (20–50% of that fraction) and linalyl acetate (25–46% of that fraction) as principal components, and it additionally notes other constituents commonly encountered in the EO, such as cis-ocimene (3–7%) and terpinene-4-ol (3–5%), together with limonene, cineole, camphor, lavandulyl acetate, lavandulol, α-terpineol, β-caryophyllene, geraniol, and α-pinene. In the same EMA document, a group of non-terpenoid aliphatic constituents is also reported in *L. angustifolia* EO, including 3-octanone, 1-octen-3-ol, 1-octen-3-yl acetate, and 3-octanol, underscoring that the profile is not limited to terpenoids even though monoterpene derivatives dominate (EMA, 2012). Relative to the reference profile outlined above for *L. angustifolia* EO, the LD sample retained a monoterpene-derivative–dominated character, with linalool falling within the broadly reported range. In contrast, linalyl acetate was lower than the indicative interval, suggesting a reduced contribution of acetate esters compared with the typical profile. Among the other highlighted constituents, cis-ocimene was below the reported range, and terpinen-4-ol was not evident in the LD profile. Compounds including limonene, 1,8-cineole, camphor, lavandulyl acetate, lavandulol, α-terpineol, β-caryophyllene (caryophyllene), and geraniol were all detected, consistent with the expected qualitative composition, and α-pinene was likewise present. In addition, the non-terpenoid aliphatic constituents commonly reported for this EO—3-octanone, 1-octen-3-ol, 1-octen-3-yl acetate, and 3-octanol—were also identified, supporting the view that the profile extended beyond terpenoids despite the predominance of monoterpene derivatives. In the ID EO of *L. angustifolia*, the compositional pattern largely matched the reference profile summarized above (EMA, 2012), maintaining the typical monoterpene-derivative–dominated character. Linalool fell within the reported range, and linalyl acetate likewise remained within the indicated interval, supporting the expected prominence of these two markers. Among the accompanying constituents highlighted in the reference, cis-ocimene was within range, whereas terpinen-4-ol was not evident in the ID profile. Several other commonly cited components—α-pinene, limonene, 1,8-cineole, camphor, lavandulyl acetate, lavandulol, α-terpineol, and β-caryophyllene (caryophyllene)—were detected, consistent with the anticipated qualitative composition; however, geraniol was not detected. In addition, the non-terpenoid aliphatic constituents frequently reported for this EO—3-octanone, 1-

octen-3-ol, 1-octen-3-yl acetate, and 3-octanol—were also present, confirming that the industrially obtained EO retained these characteristic non-terpenoid volatiles alongside the dominant monoterpene fraction.

The compositional differences observed between LD (Clevenger-type hydrodistillation) and ID (industrial steam distillation) can primarily be interpreted in light of the intrinsic differences between the two extraction processes. In hydrodistillation, plant material remains in direct contact with boiling water, whereas in steam distillation the separation process largely occurs through the passage of steam across the plant matrix, a distinction that may alter mass transfer pathways and the release behavior of volatile constituents (Wainer et al., 2022). Moreover, conventional distillation techniques, including both HD and SD, commonly involve prolonged heating periods, which have been associated with thermal degradation or transformation of heat-sensitive compounds and, consequently, shifts in the resulting chemical profile. In this context, direct contact with hot aqueous phases during HD may facilitate water-mediated reactions; notably, the conversion or partial degradation of linalyl acetate under heat and aqueous conditions, accompanied by a relative increase in the corresponding alcohol (linalool), has been proposed as a plausible transformation pathway during extraction (Périno-Issartier et al., 2013). This mechanistic framework is consistent with the findings of the present study, in which both species showed a tendency under ID conditions toward relatively higher proportions of certain esters, particularly linalyl acetate, alongside comparatively lower levels of some oxygenated monoterpene alcohols, such as linalool, compared with LD.

Although the primary objective of the current investigation was to compare extraction methods, the role of effective distillation time may reasonably be considered an accompanying methodological factor embedded within these operational differences. EO composition has been shown to depend strongly on extraction kinetics and temporal fractionation, whereby individual constituents reach their maxima at different stages of distillation. Specifically, compounds such as 1,8-cineole have been reported to predominate during the early stages and subsequently decline with extended distillation, whereas compounds described as linalool acetate in that study tend to approach maximum levels at later stages, and camphor may exhibit intermediate maxima (Zheljazkov et al., 2013). Consequently, differences in steam flow rate, plant bed loading, and heating intensity or effective extraction duration between industrial and laboratory settings may lead to unequal accumulation patterns of early- and late-eluting constituents, thereby contributing to the compositional divergence observed between LD and ID oils (Kara and Baydar, 2013; Zheljazkov et al., 2013). Experimental evidence has likewise demonstrated that the choice between HD and SD can influence both oil quality and composition; in certain comparisons, steam-distilled oils exhibited relatively higher camphor levels and perceptible differences in olfactory characteristics, although such trends appear to be species- and condition-dependent rather than universal (Wainer et al., 2022). Finally, the comparatively greater representation of certain sesquiterpenes under industrial conditions may also be interpreted in relation to process-related factors such as scale, mass transfer dynamics, and the extraction behavior of less volatile constituents, particularly where industrial distillation operates under distinct temporal and thermal regimes (Kara and Baydar, 2013; Zheljazkov et al., 2013).

Conclusion

Overall, the descriptive comparison conducted in the present study indicated that EO composition in both *L.* × *intermedia* and *L. angustifolia* remained anchored to their characteristic linalool-centered chemical frameworks across distillation scales, yet consistent compositional shifts accompanied the transition from laboratory scale hydrodistillation (Clevenger) to industrial scale steam distillation. Industrial processing tended to be associated with a relative redistribution within

the oxygenated monoterpene pool, reflected by reduced proportional contributions of selected oxygenated constituents alongside enhanced representation of acetate esters. In parallel, the increased occurrence of sesquiterpene hydrocarbons under industrial conditions suggests that scale-dependent operational factors may favor the recovery of less volatile or later-eluting fractions. These observations are compatible with process-related influences such as differences in plant–water contact, heating regime, and extraction kinetics rather than taxon-specific compositional instability. Because the study was conducted on a descriptive basis without replication or statistical inference, the observed patterns should be interpreted as indicative rather than definitive. Nevertheless, the findings highlight that laboratory-derived profiles may not directly translate to industrial production outcomes and emphasize extraction configuration as a critical post-harvest determinant when defining quality expectations or compositional benchmarks for cultivated *Lavandula* EOs.

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References

Adams, R. P. (2017). Identification of essential oil components by gas chromatography/mass spectrometry (4th ed.). Allured Publishing Corporation.

Akdağ, A., & Öztürk, E. (2019). Distillation methods of essential oils. S.Ü. Fen Fakültesi Fen Dergisi, 45(1), 22–31.

Détár, E., Zámboriné Németh, É., Gosztola, B., Demján, I., & Pluhár, Z. (2020). Effects of variety and growth year on the essential oil properties of lavender (*Lavandula angustifolia* Mill.) and lavandin (*Lavandula* × *intermedia* Emeric ex Loisel.). Biochemical Systematics and Ecology, 90, 104020. https://doi.org/10.1016/j.bse.2020.104020

Dušková, E., Dušek, K., Indrák, P., & Smékalová, K. (2016). Postharvest changes in essential oil content and quality of lavender flowers. Industrial Crops and Products, 79, 225–231. https://doi.org/10.1016/j.indcrop.2015.11.007

EMA (European Medicines Agency), Committee on Herbal Medicinal Products (HMPC). (2012, March 27). Assessment report on *Lavandula angustifolia* Miller, aetheroleum and *Lavandula angustifolia* Miller, flos (EMA/HMPC/143183/2010). European Medicines Agency.

Fagbemi, K. O., Aina, D. A., & Olajuyigbe, O. O. (2021). Soxhlet extraction versus hydrodistillation using the Clevenger apparatus: A comparative study on the extraction of a volatile compound from *Tamarindus indica* seeds. TheScientificWorldJournal, 2021, 5961586. https://doi.org/10.1155/2021/5961586

Habán, M., Korczyk-Szabó, J., Čerteková, S., & Ražná, K. (2023). *Lavandula* species, their bioactive phytochemicals, and their biosynthetic regulation. International Journal of Molecular Sciences, 24(10), 8831. https://doi.org/10.3390/ijms24108831

ISO (International Organization for Standardization). (2009). Oil of lavandin Grosso (French type) (ISO Standard No. 8902:2009). ISO.

ISO 9235. (2021). Aromatic natural raw materials — Vocabulary (definition of essential oil) (PDF). https://cdn.standards.iteh.ai/samples/78908/be6692eb830e47dfb845c358c10d0cbb/ISO-9235-2021.pdf

Kara, N., & Baydar, H. (2013). Influence of distillation time and fractions on essential oil content and composition of lavandin (*Lavandula* × *intermedia* Emeric ex Lois). Research on Crops, 14(4), 1128–1134.

Machado, C. A., Oliveira, F. O., de Andrade, M. A., Hodel, K. V. S., Lepikson, H., & Machado, B. A. S. (2022). Steam distillation for essential oil extraction: An evaluation of technological advances based on an analysis of patent documents. Sustainability, 14(12), 7119. https://doi.org/10.3390/su14127119

Nabi, M. H. B., Ahmed, M. M., Mia, M. S., Islam, S., & Zzaman, W. (2025). Essential oils: Advances in extraction techniques, chemical composition, bioactivities, and emerging applications. Food Chemistry Advances, 8, 101048. https://doi.org/10.1016/j.focha.2025.101048

Najar, B., Pistelli, L., Ferri, B., Angelini, L. G., & Tavarini, S. (2021). Crop yield and essential oil composition of two *Thymus vulgaris* chemotypes along three years of organic cultivation in a hilly area of central Italy. Molecules (Basel, Switzerland), 26(16), 5109. https://doi.org/10.3390/molecules26165109

Périno, S., Pierson, J.-T., Ruiz, K., Cravotto, G., & Chemat, F. (2019). Downscaling of industrial turbo-distillation to laboratory turbo-Clevenger for extraction of essential oils: Application of concepts of green analytical chemistry. Molecules, 24(15), 2734. https://doi.org/10.3390/molecules24152734

Périno-Issartier, S., Ginies, C., Cravotto, G., & Chemat, F. (2013). A comparison of essential oils obtained from lavandin via different extraction processes: Ultrasound, microwave, turbohydrodistillation, steam and hydrodistillation. Journal of chromatography. A, 1305, 41–47. https://doi.org/10.1016/j.chroma.2013.07.024

Pokajewicz, K., Czarniecka-Wiera, M., Krajewska, A., Maciejczyk, E., & Wieczorek, P. P. (2023). *Lavandula* × *intermedia*—A bastard lavender or a plant of many values? Part I. Biology and chemical composition of lavandin. Molecules, 28(7), 2943. https://doi.org/10.3390/molecules28072943

Salehi, B., Mnayer, D., Özçelik, B., et al. (2018). Plants of the genus *Lavandula*: From farm to pharmacy. Natural Product Communications, 13(10). https://doi.org/10.1177/1934578X1801301037

Wainer, J., Thomas, A., Chimhau, T., & Harding, K. G. (2022). Extraction of essential oils from *Lavandula* × *intermedia* 'Margaret Roberts' using steam distillation, hydrodistillation, and cellulase-assisted hydrodistillation: Experimentation and cost analysis. Plants, 11(24), 3479. https://doi.org/10.3390/plants11243479

Wells, R., Truong, F., Adal, A. M., Sarker, L. S., & Mahmoud, S. S. (2018). Lavandula essential oils: A current review of applications in medicinal, food, and cosmetic industries of lavender. Natural Product Communications, 13(10), 1403–1417. https://doi.org/10.1177/1934578X1801301038

Zheljazkov, V. D., Cantrell, C. L., Astatkie, T., & Jeliazkova, E. (2013). Distillation time effect on lavender essential oil yield and composition. Journal of Oleo Science, 62(4), 195–199. https://doi.org/10.5650/jos.62.195

INVISIBLE CHEMISTRY OF SWIMMING POOL DISINFECTION: BENEFITS AND RISK

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ABSTRACT

Swimming is a very popular form of recreation and is highly recommended because of its positive impact on health. Regular practice can help lower the risk of cardiovascular diseases, reduce stress, improve motor coordination, posture, and balance, improve respiratory function, and play a pivotal role in long-term body weight regulation. Swimming pool water typically contains a plethora of constituents, including natural organic matter coming from the source water, several microorganisms (some of which may be pathogenic), and different organic compounds introduced by swimmers. As a consequence, some risks need to be taken into account to ensure the safety of the swimmers.

This communication presents an overview of the most commonly used swimming pool disinfection methods and discusses their respective advantages and limitations as follows:

- chlorine-based systems: liquid chlorine (sodium hypochlorite), chlorine gas, Calcium hypochlorite, stabilized chlorine (dichloroisocyanuric acid, also known as dichlortrichloroisocyanuric acid (trichlor);
- salt water Pools (salt chlorination)- electrolysis converts salt into chlorine on-site;
- bromine;
- copper–Silver Ionization;
- advanced oxidation process (AOP);
- ultraviolet (UV) disinfection;
- ozone (O_3) disinfection;
- hydrogen peroxide (Biguanide systems);
- natural / bio pools (plant-based filtration);
- hybrid systems, chlorine + UV, chlorine + ozone, salt chlorination + UV, ionization + low-dose chlorine;

Swimming pool disinfection has a pivotal role for eliminating pathogens that cause skin infections and diarrhea, but it creates disinfection byproducts (DBPs) when chlorine or bromine reacts with contaminants like sweat, urine, and cosmetics.

The paper analyzes several disinfection byproducts such as chloroacetic acid, dichloroacetic acid, trichloroacetic acid, haloketones, haloacetaldehydes, haloacetonitriles, halonitromethanes, haloacetamides, both from the perspective of their formation mechanism and their toxicity. Mitigation strategies for reduce level of disinfection byproducts are also discussed.

Keywords: disinfection byproducts, chlorine, bromine, ozone.

ELECTRICAL PROPERTIES OF STRONGLY COMPENSATED CRYSTALS $IN_{0.95}SM_{0.05}SE$

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ABSTRACT

InSe layered crystals, which belong to the A^3B^6 group, are constantly in the focus of attention of researchers due to their unique properties. It is known that layered crystals . GaSe and InSe have large nonlinear susceptibility, strong anisotropy of physical properties, high exciton binding energy (~20MeV), small absorption coefficients of fundamental absorption (~$10^3 cm^{-1}$). Devices based on these crystals are used in various fields of industrial electronics. These include optical modulators, X-ray detectors, measuring devices for measuring radiation in nuclear reactors, zero-interference optical transistors, pressure sensors, switches, memory elements and other optoelectronic devices in which the electric current is replaced by a light beam, as well as for the study of nonlinear optical processes, etc. д. The main goal of conducting these studies is to expand the working range of devices based on $In_{0.95}Sm_{0.05}Se$ single crystals and control them. It is known that Rare Earth Elements are dissolved in small amounts in crystals. REEs increase the photosensitivity, photoluminescent and electrophysical properties of the crystal. The experiments were carried out at low temperatures. For this purpose, the electrical conductivity and volt-ampere characteristics of $In_{0.95}Sm_{0.05}Se$ single crystals were determined in this work. The experiments were conducted at low temperatures. The volt-ampere characteristics at temperatures of 117.65K, 133.3K, 166.67K,

200K, 250K, and 294K, respectively, and the temperature dependence of the electrical conductivity in the Sabin current in $In_{0.95}Sm_{0.05}Se$ single crystals were studied and graphs were drawn. It was determined from the experimental data that at low voltage, an Ohmic region is observed in the volt-ampere characteristic. The $I \sim U^{3/2}$ dependence observed in the volt-ampere characteristic after the Ohmic region arises as a result of the injection of charge carriers from point contacts or specially configured electrodes. When Ohm's law is satisfied, the carrier volume is located in a sphere with a radius of $r_x < 2r_s$. Thus, it was determined from the volt-ampere characteristic and the temperature dependence of the electrical conductivity that the mechanism of current conduction corresponds to the Limited Flow of Space Charges (TOPZ) theory. In the volt-ampere characteristic, the transition voltage from the ohmic region to the quadratic region depends on the temperature. This indicates that there is a strong compensation here. The activation energy of charge carriers E_a=0.018eV

Keywords: perfect crystals, charge carrier activation energy, compensated crystals, electrical conductivity, transition voltage, volt-ampere characteristic.

ELECTRICAL PROPERTIES OF HIGHLY COMPENSATED $IN_{0.95}SM_{0.05}SE$ CRYSTALS

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ABSTRACT

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photoluminescent and electrophysical properties of the crystal. The experiments were carried out at low temperatures. For this purpose, the electrical conductivity and volt-ampere characteristics of $In_{0.95}Sm_{0.05}Se$ single crystals were determined in this work. The experiments were conducted at low temperatures. The volt-ampere characteristics at temperatures of 117.65K, 133.3K, 166.67K, 200K, 250K, and 294K, respectively, and the temperature dependence of the electrical conductivity in the Sabin current in $In_{0.95}Sm_{0.05}Se$ single crystals were studied and graphs were drawn. It was determined from the experimental data that at low voltage, an Ohmic region is observed in the volt-ampere characteristic. The $I \sim U^{3/2}$ dependence observed in the volt-ampere characteristic after the Ohmic region arises as a result of the injection of charge carriers from point contacts or specially configured electrodes. When Ohm's law is satisfied, the carrier volume is located in a sphere with a radius of $r_x < 2r_s$. Thus, it was determined from the volt-ampere characteristic and the temperature dependence of the electrical conductivity that the mechanism of current conduction corresponds to the Limited Flow of Space Charges (SCLC) theory. In the volt-ampere characteristic, the transition voltage from the ohmic region to the quadratic region depends on the temperature. This indicates that there is a strong compensation here. The activation energy of charge carriers E_a=0.018eV

Introduction

The layered structure of indium monoselenide (InSe) crystals, the ease with which its ingots can be separated into layers ranging in thickness from a few nanometers to several millimeters, and the smooth and chemically stable surface of the separated layers at the atomic level [1-3] indicate that these crystals are promising materials for ultra-thin-layer electronics [4-7]. Undoubtedly, this property of InSe necessitates a detailed study of injection currents, as well as other physical phenomena in this semiconductor. Various methods are used to expand the operating range of devices based on InSe single crystals and control them. One such method is the partial replacement of In atoms in InSe single crystals with Sm atoms.

According to [8], rare earth elements (REEs) in semiconductors have low solubility and cleaning capacity, which is associated with a decrease in the concentration of uncontrolled impurities and an increase in charge carrier mobility. The replacement of indium atoms with rare earth atoms in crystals leads to an increase in the number of levels of the donor type, which creates conditions for the formation of n-type conductivity. The main goal of conducting these studies is to expand the operating range of devices based on $In_{0.95}Sm_{0.05}Se$ single crystals and to control them.

According to the data of work [9], the electrical conductivity of n- $In_{0.95}Sm_{0.05}Se$ single crystals at a temperature of 294 K was $\sigma=2.45\cdot10^{-2}$ $Ohm^{-1}\cdot cm^{-1}$, the Hall coefficient $Rx=3.55\cdot10^{2}$ cm^3/C, the mobility of charge carriers $\mu_n \approx 8.71$ $cm^2/V\cdot s$, and their equilibrium concentration $n_0=1.76\cdot10^{16}$ cm^{-3}.

At low temperatures, the main role in charge transport phenomena in semiconductors is played by traps generated by various defects. As an interesting and useful example of partially disordered crystalline semiconductors, we investigated space charge limited currents (SCLCs) in the unipolar injection regime in n-InSe and n- $In_{0.95}Sm_{0.05}Se$ crystals [10] in order to obtain additional information about the specific properties of injection currents in this type of semiconductors and to clarify their mechanism.

Samples and Experimental Conditions

The ampoules for compound synthesis were made of fused quartz. High-purity elements In 000, Se "OCh 17-3," and Sm CM-1 were used as starting components. The chemical elements were

weighed according to stoichiometry with an accuracy of 10^{-5} g and poured into an empty graphitized quartz ampoule.

The ampoule was then evacuated to a residual pressure of 10^{-4} mmHg, and its neck was then sealed. Initially, the ampoule filled with the compound was placed in the furnace at a slight angle. It should be noted that these compounds are sensitive to the volatile component Se, so selecting the correct mode is necessary to prevent explosions during synthesis. As the components melt and synthesis begins, selenium vapor collects at the cold end of the ampoule, which remains outside the furnace, and precipitates, reducing the risk of explosion. The remaining portion of the ampoule is then gradually inserted into the furnace. The substance inside the ampoule is mechanically stirred each time. After the synthesis is complete, the angle between the furnace and the floor is increased, and the temperature is raised by 10–20°C above the melting point of the compound. The ampoule is left in this position for 1–1.5 hours to allow the substances to diffuse into each other, mix, and form a homogeneous compound. The temperature is then lowered to room temperature at a rate of 200°C/hour, and the furnace is turned off. This produces a stoichiometrically homogeneous substance. One of the key features of layered A^3B^6 crystals is their stoichiometry deviation, regardless of their composition. This deviation is greater if selenium is used in powder form and less if it is used in granular form.

One of the most important problems in semiconductor physics is the production of chemically pure crystals with a sufficiently perfect crystalline structure. A modified Bridgman method was used to grow single crystals.

The ε-InSe space symmetry group is D_{3h}^1, belonging to the hexagonal syngony, and the crystal lattice parameters of the $In_{0.95}Sm_{0.05}Se$ solid solution under study (a = 4.12 Å, c = 16.98 Å, c/a = 4.12) are given in [11]. The samples used to study the electrical properties had a thickness of 100–300 μm, and the contact area was $2 \cdot 10^{-2}$ cm². Silver paste was used as the contact material. A constant electric field was applied perpendicular to the sample layers. When measuring the electrical properties in the temperature range of 80–300 K, the error was 3–4%. The configuration of the samples is shown in the frame of Fig. 1.

Experiments were carried out in the temperature range of 80–294 K using a UTREKS cryostat system. A stabilized V3-3 device was used to generate a constant electric field of up to $E \leq 1.5 \cdot 10^6$ V/m, and the current was measured using a V7-21A universal voltmeter.

Experimental Results and Discussion

Figure 1 shows the current-voltage characteristics (CVC) of the Ag- $In_{0.95}Sm_{0.05}Se$ -Ag system at temperatures of 117.65K, 133.3K, 166.67K, 200K, 250K, and 294K.

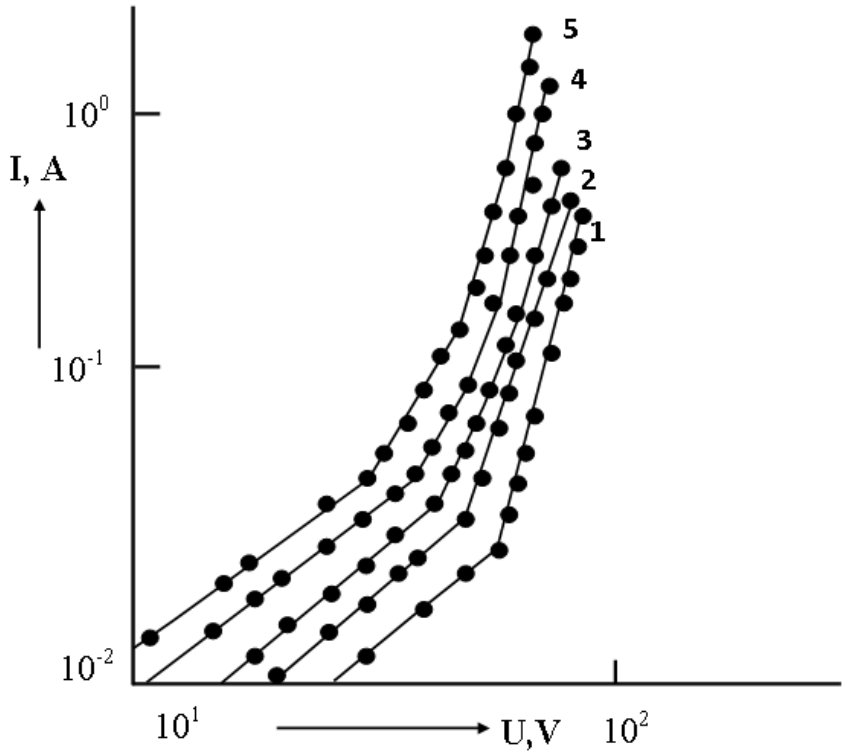


Fig.1 Temperature dependence of the volt-amper Characteristics in $In_{0.95}Sm_{0.05}Se$ single crystals. Curve T,K: 1-117,65; 2-133; 3-166,6; 4-200; 5-250; 6-294.

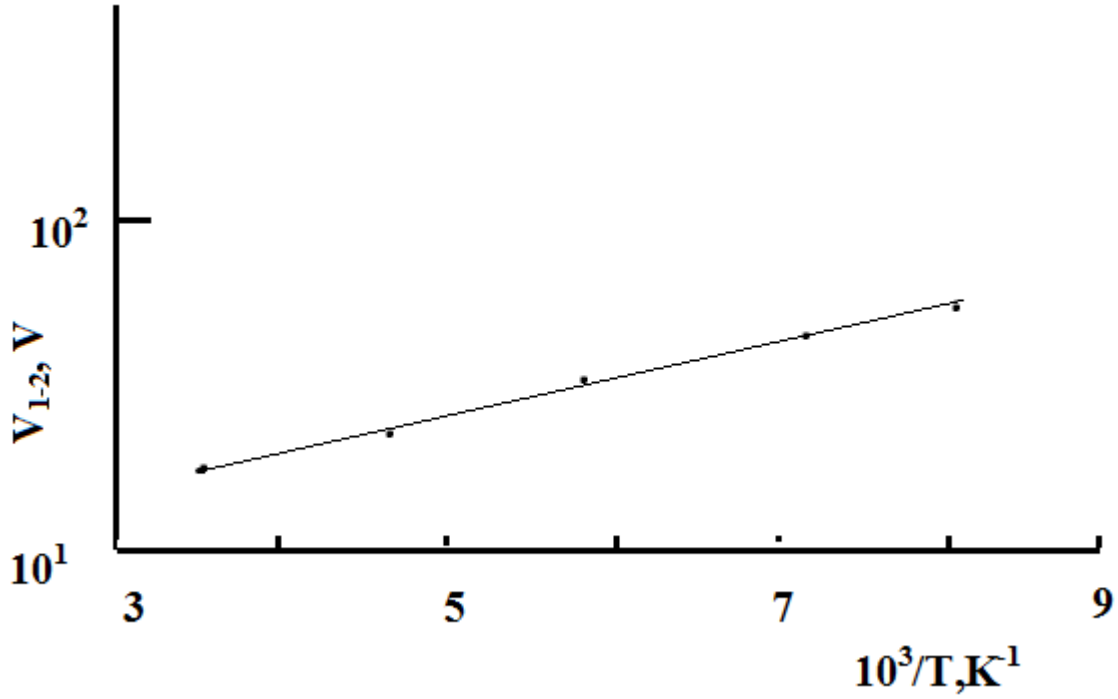


Fig.2. Temperature dependence of the voltage transition from the ohmic to the nonlinear region in $In_{0.95}Sm_{0.05}Se$ single crystals.

According to [12], if the voltage transition from the ohmic to the nonlinear region (Vx) is temperature-independent, then weak compensation occurs in these crystals; if it is temperature-dependent, then strong compensation occurs. Our temperature dependence of Vx indicates that $In_{0.95}Sm_{0.05}Se$ single crystals are highly compensated semiconductors.

Conclusion

Experimental measurements of the current-voltage characteristics and their temperature dependences were conducted at temperatures of 117.65 K, 133.3 K, 166.67 K, 200 K, 250 K, and 294 K, as well as the temperature dependence of the electrical conductivity of $In_{0.95}Sm_{0.05}Se$ single crystals in a constant electric field of up to $E \leq 1.5 \cdot 106$ V/m. Strong compensation was found in $In_{0.95}Sm_{0.05}Se$ single crystals, and the current flow mechanism is primarily unipolar injection. The energy of local levels in the band gap of $In_{0.95}Sm_{0.05}Se$ single crystals was determined to be Ea=0.018 eV.

It was demonstrated that the physical parameters of $In_{0.95}Sm_{0.05}Se$ single crystals can be controlled by adjusting the experimental conditions. Based on this material, it is possible to create measuring instruments in industrial electronics

REFERENCES

[1] A. Politano, G. Chiarello, R. Samnakay, G. Liu, B. Gurbulak, S. Duman, A.A. Balandin, D.W. Boukhvalov. NANOSCALE. 2016. т. 8, vol.16, p. 8474-8479.

[2] T. Ohta, A. Klast, Y.A. Adams, Q. Yu, M.A. Olmstead, F.S. Ohuchi. Phys. Rev., 2004, B 69, 125322.

[3] A.I. Dmitriev, V.V. Vishnyak, G.V. Lashkarev, V.L. Karbovsky, Z.D. Kovaluk, A.P. Bakhtinov. FTT, 2011, p. 53, Issue 3, p. 579-589.

[4] S.R. Tamalampudi, Y.Y. Lu, U.R. Kumar, R. Sankar, C.D. Liao, B.K. Moorthy, C.H. Cheng, F. Chou, Y.T. Chen. Nano letters, 2014, t.14, vol. 5, p. 2800-2806.

[5] W. Feng, J.B. Wu, X.L. Li, W. Zheng, X. Zhou, K. Xiao, W.W. Cao, B. Yang, J.C. Idrobo, L. Basile. Journal of Materials Chemistry C, 2015, t. 3, vol. 27, p. 7022-7028.

[6] A. Milutinovic, Z.Z. Lazarevic, M. Jakovljevic, B. Hadzic, M. Petrovic, M. Gilic, W.D. Dobrowolski, N.Z. Romcevic. Journal of Physics and Chemistry of Solids, 2016, t. 89, p.120-127.

[7] A.A.A. Darwish, T.A. Hanafy, A.A. Attia, D.M. Habashy, M.Y. El-Bakry, M.M. El-Nahass. Superlattices and microstructures, 2015, t. 83, p.299-309.

[8]. A.A. Ismailov, A.A. Ismailov, N.Z. Gasanov, P.G. Ismailova, L.A. Ismailzade Effect of γ-Irradiation on Low Temperature Hopping Conductivity in InSe Single Crystals Doped by Er. Semiconductors, 2025,v.59, N6, p.503-506.

9. G.I. Isakov, A.A.Ismailov, N.Z. Gasanov, A.A.Ismailov, P.G. Ismailova Electrophysical properties of $In_{1-x}Sm_xSe$ crystals at different doses of γ-irradiation Polish journal of science 2024, №71, p. 43-49.

[10] M. Lampert, P. Mark. Injection Currents in Solids. Moscow: Mir, 1973, 446 p.

[11] P.G. Rustamov, A.O. Khalilov, M.A. Alijanov, and O.M. Aliev. Study of Solid Solutions of Samarium Monoselenide in InSe. Inorganic Materials, 1978, Vol. 14, No. 7, pp. 1261–1264.

12. A.A.Ismailov, N.Z.Gasanov, Z.M.Nazrullaeva, A.A.Ismailov Influence of γ-irradiation on the elektrophysics of $In_{1-x}Sm_xSe$ crystals. American Journal of Social and Humanitarian Research. Global Rearch, Network, 5-in May 2022, V.3issue, p.120-122.

ANALYSIS OF MECHANICAL ENERGY TRANSFORMATIONS AND LOSSES IN ROLLER COASTERS: MODELING, SIMULATION, AND EFFICIENCY IMPROVEMENT PROPOSALS

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ABSTRACT

This research investigates the transformation of mechanical energy along roller-coaster tracks and quantifies losses due to rolling friction and aerodynamic drag. The objective is to model potential and kinetic energy variations, simulate energy dissipation and centripetal loads, and propose technical and design innovations that enhance ride efficiency and passenger safety.A quantitative modelling and simulation approach is adopted. The roller-coaster profile is discretised into segments (lift hill, first drop, vertical loop, camelback hills, and brake run), and the height function is used to compute potential energy ($PE=mgh$). Kinetic energy ($KE=mv^2$) and total mechanical energy ($TE=PE+KE$) are updated iteratively. Rolling friction ($F_f=mg$) and aerodynamic drag ($F_d=C_dA\ v^2$) are incorporated to model energy losses. Simulation parameters include a mass of 1000 kg, friction coefficient (), drag coefficient ($C_d=0.5$), air density 1.225 $kg \cdot m^{-3}$, and frontal area 2.5 m^2. Potential energy peaks at the top of the lift hill (≈1.36 MJ) and decreases during drops as it is converted into kinetic energy. Maximum speed (≈183 $km \cdot h^{-1}$) occurs at the lowest point of the first drop, while G-forces peak (≈6.56 G) in tight loops. Cumulative energy losses reach ≈1.36 MJ, indicating that friction and drag remove most of the initial mechanical energy. These losses concentrate in steep descents and high-speed loops. The results confirm that optimising track radius and employing aerodynamic shaping can reduce losses and keep G-forces within safety limits. Implementing regenerative braking during deceleration, adopting low-friction materials, and optimising loop radii and aerodynamics can substantially reduce energy losses, improve efficiency, and enhance rider comfort. The modelling framework provides designers with quantitative tools to evaluate design alternatives. The study integrates potential energy, kinetic energy, energy losses, and G-force profiles into a unified simulation model, bridging the gap between ideal energy-conservation theory and real-world roller-coaster dynamics. It offers data-driven design recommendations not widely addressed in existing literature.

Keywords: Roller Coaster; Mechanical Energy; Potential and Kinetic Energy; Rolling Friction; Aerodynamic Drag; Efficiency.

FROM CHEMISTRY TO MEDICINE: DIMETHYL SULFOXIDE (DMSO) AS A POPULAR CHEMICAL WITH UNEXPECTED MEDICAL APPLICATIONS

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ABSTRACT

Dimethyl sulfoxide (DMSO) is widely recognized as a laboratory solvent and industrial chemical, yet it has an unexpected second role in medicine. Its clinical relevance is not based on a single drug like identity, but on chemistry: polarity and hydrogen bonding capacity, exceptional membrane penetration, strong solvation power, and redox-related reactivity. Because DMSO is so familiar and accessible, it is often surrounded by exaggerated claims. Thus, a chemistry-focused analysis is desired to understand where the evidence supports therapeutic use and where it does not.

This paper focuses on the following main aspects:

- Structure–property relationships - the sulfoxide functional group, high dielectric constant and the ability to disrupt hydration shells and lipid packing: explaining both facile delivery and toxicity at higher dosages;
- Pharmacological actions beyond solvent effects - mechanistic hypotheses for anti inflammatory and analgesic activity;
- Controversies and safety - the gap between over-the-counter use and regulated indications, common adverse effects (odor, skin reactions) and possiblre interaction with other drugs potential.

Keywords: DMSO, solvent effect, membrane transport.

DYNAMIC ANALYSIS OF KINETIC AND POTENTIAL ENERGY CONVERSION IN ELEVATOR COUNTERWEIGHT SYSTEMS

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ABSTRACT

This study investigates the dynamic conversion of potential and kinetic energy in elevator counterweight systems with a focus on energy balance, efficiency, and loss minimization. Modern high-rise elevators are not only essential for vertical transportation but also significantly impact overall building energy consumption, accounting for approximately 3–10% of total electricity use. The research develops a simplified physical and mathematical model of the elevator–counterweight mechanism, incorporating mass balance, velocity profiles, and energy transfer equations. Three counterweight scenarios (lighter, balanced, and heavier relative to the nominal load) are simulated to analyze variations in power demand, regenerative potential, and energy efficiency. Results show that an optimally selected counterweight mass—approximately 40–50% of the cabin mass plus rated load—minimizes energy losses, balances motor workload, and enhances regenerative braking performance. Additionally, the integration of modern technologies such as variable voltage variable frequency (VVVF) drives, regenerative converters, and smart control systems is shown to improve overall efficiency by up to 30–40%. The findings provide a theoretical and simulation-based framework for designing energy-efficient elevator systems, contributing to sustainable building management and reduced operational costs.

Keywords: Elevator Systems, Counterweight Optimization, Potential and Kinetic Energy Conversion, Regenerative Braking, Energy Efficiency.

FROM APPROVAL TO WITHDRAWAL: A CONCISE REVIEW OF PHARMACEUTICALS WITHDRAWN AFTER WIDESPREAD USE

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ABSTRACT

Medicines play a cardinal role in the modern era, forming the foundation of healthcare and contributing to increased life expectancy. They not only treat and cure diseases but also prevent them, manage chronic conditions, and enhance overall quality of life on a population level. Pharmaceutical innovations have contributed significantly to the gains in life expectancy observed over recent decades. Drugs and vaccines approval include a rigorous, long- term process: discovery/development, pre-clinical testing, phased clinical trial and and ongoing safety monitoring after market entry. Despite rigorous regulatory control extending over many years, no medicine can ever be considered 100% safe.

The aim of this article is to review some of the most well-known cases of medicines and vaccines that were used for many years but were ultimately withdrawn from the market due to toxicity and pronounced adverse effects that clearly outweighed the benefits of their use. Thus, the article presents the history of each of the following drugs and vaccines, from its synthesis, to its marketing and withdrawal, as follows:

- Thalidomide (late 1950s–1961) – originally promoted as a sedative and treatment for morning sickness; it was later shown that use during early pregnancy caused severe congenital abnormalities.
- Diethylstilbestrol (1940s–1970s) – prescribed to reduce the risk of miscarriage; in 1971, prenatal exposure was linked to a rare form of vaginal and cervical cancer;
- Vioxx (withdrawn in 2004) – approved as a COX-2–selective analgesic; subsequent clinical trial data revealed an increased risk of thrombotic cardiovascular events;
- Bextra (withdrawn in 2005) – a COX-2 inhibitor used for pain management; concerns over cardiovascular safety led to its removal from the market.
- Fen-Phen (fenfluramine/phentermine, withdrawn in 1997) – a weight-loss drug combination; its use was associated with heart valve damage and pulmonary hypertension.

Keywords: drugs, safety, Diethylstilbestrol, Vioxx

HYDROGEN-BONDED ORGANIC FRAMEWORKS: A SHORT REVIEW

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ABSTRACT

In recent decades, porous solids have attracted increasing interest due to their numerous applications, such as gas separation and purification, gas storage, energy devices, adsorbents for pollution control, thermal management, catalysis and catalyst supports, sensing, etc. Zeolites, metal–organic frameworks (MOFs), covalent organic frameworks (COFs) are just a few examples of porous solids widely used in various applications due to their outstanding properties, such as exceptional porosity and surface area, tunable pore sizes, highly tailorable and designable functionalities, as well as ion-exchange capabilities and host–guest interactions.

The aim of this paper is to review hydrogen-bonded organic frameworks (HOFs), a recently developed class of synthetic porous solids self-assembled from organic molecular units through hydrogen-bonding interactions, often supported by π–π stacking along with other weak intermolecular interactions. Typical organic hydrogen-bonding units include species such as benzenedicarboxylic acids, extended aromatic polycarboxylates, pyridine / bipyridine / terpyridine derivatives, amide (urea / thiourea,) phenols, catechols, and other hydroxyl-rich aromatics, imidazole, triazole, tetrazole, pyrazine derivatives. The advantages of using HOFs - such as mild and simple synthesis (often solution-based), high crystallinity with well-defined structures, solution processability, regenerability, recyclability, self-healing behavior, structural flexibility and stimuli responsiveness, as well as chemical diversity and functional tenability - are discussed in detail. Moreover, this paper addresses the limitations of HOFs, including their comparatively lower thermal, chemical, and moisture stability relative to MOFs and COFs, potential loss of porosity upon guest removal, and mechanical fragility with limited robustness for shaping and processing. Last but not least, the most versatile applications of HOFs - such as gas storage and adsorption, membrane separations (including gas separation membranes), molecular separations, catalysis and electrocatalysis (including water splitting), photocatalysis and solar-to-chemical conversion, sensing and stimuli-responsive materials, ion/proton conduction and energy - and environment-related applications, as well as biomedical uses (drug delivery, biocomposites) - are discussed in detail.

Keywords: hydrogen-bonded organic frameworks, gas storage.

ADVANCED MINIMALLY INVASIVE APPROACH: A COMPARATIVE ANALYSIS OF V-NOTES AND CONVENTIONAL LAPAROSCOPY IN BENİGN GYNECOLOGICAL PROCEDURES

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ABSTRACT

Objective: Vaginal Natural Orifice Transluminal Endoscopic Surgery (v-NOTES) has emerged as an alternative minimally invasive surgical approach that enables access to the peritoneal cavity through a natural orifice without abdominal incisions. This study aimed to compare v-NOTES with conventional laparoscopy in benign gynecological procedures in terms of surgical ergonomics, postoperative pain, and recovery outcomes.

Materials and Methods: This prospective cohort study included 60 patients undergoing hysterectomy or adnexal surgery for benign gynecological indications. Patients were divided into v-NOTES and conventional laparoscopy groups. Postoperative pain was assessed using the Visual Analog Scale (VAS) from the first postoperative morning to the seventh postoperative evening. Analgesic requirements and functional recovery parameters were recorded. Statistical analyses were performed to compare postoperative outcomes between the two groups.

Results: The v-NOTES group demonstrated significantly lower postoperative pain scores at all evaluated time points compared with the conventional laparoscopy group. Pain scores in the laparoscopy group remained elevated (VAS > 4) during the first 48 hours, whereas patients undergoing v-NOTES reported consistently lower pain levels (VAS < 3) from the first postoperative day. Analgesic requirements were reduced by approximately 40% in the v-NOTES group due to the absence of abdominal wall trauma. Additionally, the transvaginal access provided stable instrument triangulation, enabling effective surgical dissection and hemostasis comparable to conventional laparoscopic techniques.

Conclusion: v-NOTES represents a promising advancement in minimally invasive gynecological surgery, offering reduced postoperative pain, improved recovery, and superior cosmetic outcomes without compromising surgical safety. As surgical experience increases, v-NOTES may become a preferred approach for benign gynecological procedures.

Keywords: v-NOTES; Vaginal Natural Orifice Transluminal Endoscopic Surgery; conventional laparoscopy; minimally invasive surgery; postoperative pain; benign gynecological surgery

DETECTION OF NITRATES IN MARKET VEGETABLES AND THEIR IMPACT ON HUMAN HEALTH: CHEMICAL ANALYSIS AND TOXICOLOGICAL RISKS

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ABSTRACT

Nitrate compounds, prevalent as essential nitrogen sources in plant physiology, primarily as nitrate ions (NO_3^-), exhibit a dual nature when introduced into the human metabolic system. While naturally occurring in many crops, the excessive use of nitrogen-based fertilizers in intensive agriculture has led to a significant accumulation of these salts in leafy vegetables such as spinach, lettuce, and root vegetables. The purpose of this paper is to examine the chemical detection methods of nitrates in market-sourced produce and to analyze the biochemical pathways that transform these relatively inert ions into hazardous species. We investigate the reduction of nitrates to nitrites (NO_2^-) by commensal oral bacteria and the subsequent formation of N-nitroso compounds, which are associated with increased carcinogenic potential and systemic toxicity.

These nitrogenous species act as precursors to oxidative stress, interacting with hemoglobin to form methemoglobin, thereby impairing the oxygen-carrying capacity of the blood, a condition particularly critical in pediatric medicine known as "blue baby syndrome." Furthermore, the paper explores the chemical kinetics of nitrate-protein interactions under the acidic conditions of the gastric environment. While most agricultural research focuses on crop yield, this study emphasizes the necessity of chemical monitoring to ensure food safety and prevent chronic exposure. Consequently, the development of rapid detection kits and the promotion of organic fertilization practices are valuable tools in the mitigation of "nitrate syndrome" and the preservation of public health.

Finally, the paper emphasizes the analytical techniques and the physiological mechanisms of the most common nitrogenous derivatives found in the food chain:

- The Griess teagent method **-** classic colorimetric assay used for the sensitive detection of nitrites, relying on a diazotization reaction to form a distinct magenta-colored azo dye.
- Methemoglobinemia (blue baby syndrome) - a pathological state where nitrites oxidize the iron in hemoglobin from Fe^{2+} to Fe^{3+}, rendering it incapable of binding oxygen.
- Nitrosamines **- p**otent pro-carcinogenic compounds formed by the reaction of nitrites with secondary amines, highlighting the critical link between dietary chemistry and long-term health risks.

Keywords: nitrate detection, food safety, methemoglobinemia, nitrosamines, chemical analysis, bublic health..

THE BIOCHEMICAL ROLE OF PLANT-DERIVED POLYPHENOLS IN MODULATING OXIDATIVE STRESS AND CELLULAR HOMEOSTASIS

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ABSTRACT

Polyphenolic antioxidants, a diverse group of secondary metabolites, including flavonoids, phenolic acids, and anthocyanins, exhibit outstanding protective, signaling, and anti-inflammatory properties. Thanks to these features, plant-derived antioxidants are unique molecules with a wide range of promising applications in preventive medicine, such as the regulation of oxidative stress, cellular repair, and the management of chronic degenerative diseases. Moreover, these compounds are vital in modulating the redox balance within the cellular environment. The purpose of this paper is to underscore the biochemical roles of polyphenols in neutralizing free radicals, encouraging greater interest in exploring them as natural therapeutic agents. We investigate a range

of antioxidant-mediated pathways, including the scavenging of reactive oxygen species (ROS), chelation of transition metals, and the activation of endogenous enzymatic defense, highlighting their distinctive reactivity via intracellular signaling cascades. These antioxidants often act as bioactive ligands, interacting with specific transcription factors like Nrf2, forming a defense bridge between dietary intake and cellular longevity. While most antioxidant research focuses on their direct radical-scavenging capacity, their systemic effects extend to the modulation of inflammatory cytokines and the protection of vascular integrity. In addition, their characteristic interaction with mitochondrial membranes underpins applications in neuro-protective therapy and metabolic health. Consequently, plant-derived antioxidants are valuable tools in the development of functional foods, nutraceuticals, and pharmacological interventions for oxidative syndrome.

Finally, the paper emphasizes the properties and uses of the most well-known botanical antioxidants and their mechanisms in metabolic synthesis:

- Quercetin - a potent flavonoid and enzyme inhibitor that enhances capillary stability and triggers anti-inflammatory responses.
- Resveratrol - a key regulator of sirtuin activation and mitochondrial biogenesis, often used to study longevity and cardioprotective effects.
- Polyphenolic-rich extracts - natural complexes designed to synergistically counteract lipid peroxidation and chronic damage associated with oxidative stress.

Keywords: polyphenolic antioxidants, oxidative stress, reactive oxygen species (ROS), flavonoids.

INSIGHTS IN SUPRAMOLECULAR CHEMISTRY: FROM PRINCIPLES TO APPLICATIONS

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ABSTRACT

Supramolecular chemistry is a field of chemistry that studies interactions between molecules without the formation of covalent bonds, relying instead on weak forces such as hydrogen bonding, electrostatic interactions, and van der Waals forces. Although a relatively new science, supramolecular chemistry has led to applications of great spectacularity as well as practical utility in a wide range of fields. The aim of this article is to discuss the principles underlying supramolecular chemistry, as well as their applications." Thus, the article focuses on key terms and concepts such as molecular recognition, dynamic adaptability, host–guest relationship, self-

assembly, hydrophobic effects, metal coordination, complementary shape, and complementary interactions.

Among the applications of supramolecular chemistry discussed in the article, we can mention:

- analytical applications - including separations using liquid membranes with macrocyclic carriers, separations by solvent extraction, masking processes, chromatographic separations, UV–VIS spectrophotometric analytical methods, and volumetric analysis methods.
- electrochemical applications - polarography, potentiometric, amperometric, and conductometric titrations;
- applications in organic synthesis -synthesis of cyclobutadiene in a semicarcerand matrix;
- applications in chemical catalysis -phase-transfer catalysis, triphase catalysis, and supramolecular catalysis.

Additional areas such as isotope separation, environmental remediation through water purification, and micro- and nanoelectronics increasingly take advantage of supramolecular approaches. A few of the most spectacular and highly interesting directions include reducing or eliminating unpleasant odors and tastes in foods generated by microbial contamination and hygroscopicity preventing precipitate formation in citrus products packaged in tin cans, in soft drinks, and preventing sweets from melting, conditioning tobacco-based products, conditioning cosmetic and washing products, conditioning medicines, conditioning pesticides, conditioning certain baking agents, uses in animal husbandry and fish farming.

Keywords: supramolecular chemistry, host-guest relationship, self-assembly

EMERGENCY MANAGEMENT OF A RUPTURED PLACENTA PERCRETA WITH CRITICAL ANEMIA (HGB: 3 MG/DL): A RACE AGAINST TIME

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ABSTRACT

Introduction: Placenta percreta is a life-threatening manifestation of the placenta accreta spectrum that can lead to spontaneous uterine rupture and catastrophic intraperitoneal hemorrhage. Managing such cases in an emergency setting is extremely challenging, especially when complicated by profound hemorrhagic shock and critical anemia.

Materials and Methods: We retrospectively analyzed the emergency surgical and medical management of a 31-year-old pregnant woman (G3P2) who presented to the emergency department at 28 weeks of gestation with acute abdominal pain and hypovolemic shock. Laboratory findings revealed a critical hemoglobin level of 3 mg/dL. An emergency exploratory laparotomy was performed immediately following rapid volume replacement and initiation of a massive transfusion protocol.

Case Presentation: Upon entering the abdominal cavity, approximately 3 liters of hemoperitoneum were evacuated. A ruptured uterine fundus was identified, with placental tissue (percreta) protruding through the serosa and invading the surrounding omentum. A rapid cesarean delivery was performed, followed by an emergency total hysterectomy to control the massive bleeding. The patient received 10 units of erythrocyte suspension and 8 units of fresh frozen plasma intraoperatively.

Results and Discussion: The patient was transferred to the intensive care unit postoperatively in stable condition and was discharged on the tenth postoperative day. This case demonstrates that even with a near-fatal hemoglobin level of 3 mg/dL, maternal survival is possible through immediate surgical intervention and aggressive blood product replacement. In cases of ruptured percreta, the "gold standard" of planned multidisciplinary care is often replaced by rapid surgical decision-making and damage control surgery. This report emphasizes the importance of high clinical suspicion for uterine rupture in patients with prior cesarean sections presenting with unexplained shock.

Keywords: Placenta Percreta, Uterine Rupture, Hemorrhagic Shock, Critical Anemia, Emergency Hysterectomy.

DEVELOPMENT OF THE LOGISTICS SECTOR IN TURKIYE AND ITS IMPACT ON FOREIGN TRADE

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ABSTRACT

This study empirically examines the impact of developments in the logistics sector on foreign trade performance in Türkiye over the period 2001–2023. To represent the level of logistics development, freight volumes transported by road, sea, and rail were utilized, and a composite Logistics Development Index (LOJIX) was constructed using Principal Component Analysis (PCA). Thus, the multidimensional structure of logistics was consolidated into a consistent indicator. Foreign trade performance was evaluated using two measures: total foreign trade volume and trade openness.

The short- and long-run relationships between LOJIX and foreign trade indicators were analyzed within the ARDL–ECM framework, which allows the inclusion of variables with different integration orders and provides reliable estimates in small samples. Two separate models were estimated. The results of Model 1, which employs total foreign trade volume as the dependent variable, reveal a long-run cointegration relationship and indicate that short-run deviations converge toward long-run equilibrium through an error correction mechanism. Furthermore, structural break tests indicate a statistically significant break in 2010. This finding suggests that the relationship between logistics capacity and foreign trade may have shifted to a different regime in the post-2010 period, highlighting the importance of accounting for temporal differentiation in the modeling process.

In Model 2, where trade openness is the dependent variable, evidence of a structural break is weaker, and the impact of LOJIX appears to operate mainly through short-run dynamics.

Overall, the findings confirm a positive and complementary relationship between logistics development and foreign trade in Türkiye. By constructing a composite logistics index and jointly examining short- and long-run effects, the study contributes to the literature. The results underscore the potential of logistics infrastructure investments to enhance foreign trade performance and emphasize the need to consider regime shifts in policy design.

Keywords: Logistics, Foreign Trade, Impact.

INTERNATIONAL LAW AND STRUCTURAL INEQUALITY

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ABSTRACT

International law is frequently portrayed as a framework that moderates power and ensures the formal equality of sovereign states. Yet the persistence of global stratification invites a deeper inquiry: does international law merely fail to eliminate inequality, or is inequality structurally embedded within its operation? The durability of geopolitical and economic hierarchies suggests that legality alone does not neutralize asymmetry and may instead interact with it in complex ways.

This study approaches international law not as an ABSTRACT normative ideal, but as a functional system situated within a stratified world order. Drawing on the Center–Periphery model, it argues that the distribution of legal authority, interpretative influence, and enforcement capacity reflects existing geopolitical hierarchies. Formal sovereignty conceals differentiated agency: while all states are legally equal, their capacity to shape norms, navigate ambiguity, influence institutional agendas, and withstand enforcement pressures varies significantly.

Rather than focusing solely on violations of international law, the analysis turns to the routine functioning of legal institutions in security and economic governance. It demonstrates how consent-based structures, decentralized enforcement, and institutional asymmetries generate uneven legal consequences across global actors. The issue is therefore not limited to exceptional breaches of legality, but concerns the patterned operation of international legal mechanisms themselves.

The study suggests that international law does not simply regulate inequality from the outside; it operates through structures that may normalize and stabilize it. Reassessing the function of international law, therefore, requires confronting not only its stated ideals but the systemic conditions under which it is produced, interpreted, and applied.

Keywords: International Law, Global Stratification, Center-Periphery, Legal Authority, Structural Inequality.

PATIENT RECOGNITION AND SELF-MANAGEMENT OF HEART FAILURE SYMPTOMS: A VIGNETTE-BASED PILOT STUDY

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ABSTRACT

Background: Heart failure is a condition marked by significant symptoms and high rates of hospitalization. Effective self-management, which involves recognizing symptoms and modifying behaviours, is essential yet often neglected in contemporary educational approaches. This study created heart failure self-care vignettes to assess understanding of both physical and psychological symptoms. However, the face validity and reliability of these vignettes have not been extensively evaluated.

Objective: The purpose of this study is to validate a novel tool aimed at measuring knowledge related to the identification of heart failure symptoms and self-management practices while also examining its inter-rater reliability among individuals diagnosed with heart failure.

Methods: Cognitive interviews were conducted with heart failure patients at a university hospital in the Tirana region of the Albania. The analysis included 74 items sourced from the vignette segments along with pertinent interview questions. Five participants were aged 65 years or older and did not have any cognitive, visual, or auditory impairments. Two independent raters utilized a cognitive interview coding guide to analyse the interviews. A qualitative evaluation of the vignettes was carried out using a 3-point Likert scale (1 = misunderstanding, 2 = partial understanding, 3 = full understanding). Inter-rater reliability was assessed through percent agreement and Cohen's kappa coefficient.

Results: Patients showed an understanding of 76% of the psychological vignette items and 83% of the physical vignette items, reflecting an overall satisfactory comprehension of the tasks. The inter-rater reliability was found to be moderate, with Cohen's kappa values reported at 0.39 for psychological items and 0.43 for physical items.

Conclusions: This preliminary assessment indicates that these vignettes may offer conceptual support for evaluating knowledge regarding symptom recognition as well as self-management strategies. Cognitive-level interviews aided in interpreting vignette segments prior to their use in future data collection initiatives.

Keywords: knowledge; symptom perception; symptom monitoring; symptom recognition; management; heart failure

EFFECT OF SEAWEED ENRICHED HUMIC ACID ON GROWTH AND YIELD OF BT. BRINJAL (*SOLANUM MELONGENA* L.)

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ABSTRACT

Bt. brinjal (*Solanum melongena* L.), a member of the Solanaceae family, is an economically important vegetable crop cultivated worldwide across tropical, subtropical, and warm temperate regions. It has been genetically developed to resist lepidopteran pests, particularly the Brinjal Fruit and Shoot Borer (*Leucinodes orbonalis*), through the expression of *Bacillus thuringiensis* (Bt) toxin that forms pores in the insect's digestive system. In Bangladesh, where brinjal is locally known as "Begoon," it ranks second only to potato in acreage and production. The present study evaluated the effect of seaweed-enriched humic acid on the growth and yield of Bt. brinjal using a Randomized Complete Block Design (RCBD) with three replications. Four treatments were applied: T_0 (control), T_1 (recommended fertilizer), T_2 (10 kg seaweed-enriched humic acid ha^{-1}), and T_3 (20 kg seaweed-enriched humic acid ha^{-1}). Humic acid enhances nutrient availability, stimulates seed germination and viability, and primarily promotes root growth. Growth parameters—plant height, leaf number, branch number, and flower number—were recorded at 30, 50, and 80 days after sowing (DAS). The highest values were observed at DAS 80, with plant height (119 cm), leaf number (130.33), branch number (26.67), and flower number (63.35). Yield performance revealed maximum production in T_2 (21.15 ton ha^{-1}), followed by T_3 (16 ton ha^{-1}), T_1 (12 ton ha^{-1}), and minimum in T_0 (12 ton ha^{-1}). The findings indicate that seaweed-enriched humic acid significantly enhances growth and yield attributes of Bt. brinjal. Therefore, its application can be regarded as an effective, eco-friendly, and sustainable supplement to improve productivity and promote sustainable agricultural systems in Bangladesh.

Key words : Bt brinjal, Fruit and Shoot Borer, Sea weed, Humic acid, Recommended fertilizer.

COMPENSATORY THERAPY OF SCOLIOSIS – FROM THE KTS CONCEPT TO THE CTS METHOD

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ABSTRACT

The KTS® (Compensatory Scoliosis Therapy) concept emerged from a multi-year research process focused on understanding and improving the treatment of scoliosis. It was based on an analysis of the effectiveness of the FED and FITS methods conducted between 2012 and 2017. During this period, clear differences between the mechanical-corrective and functional approaches were demonstrated, allowing for a better understanding of both the mechanics of deformation and the body's compensatory responses. This research also enabled the identification of the first compensatory mechanisms. A key step in the development of the concept was the defense of a doctoral dissertation in 2018, during which the results of treatment of patients with scoliosis using the FED and FITS methods were compared for the first time, introducing summary parameters allowing for a comprehensive analysis of treatment effects. These parameters became the basis for further, in-depth assessment of postural compensation disorders.

In subsequent years, the rapid development of modern diagnostic methods, including 3D ultrasound, enabled understanding of the multi-planar nature of spinal deformities and precise capture of global trunk rotation. These studies confirmed that scoliosis is a complex deformity involving compensation and adaptation of the entire trunk. This paradigm shift led to the emergence of a new therapeutic perspective, in which postural compensation became a central element of clinical assessment – the KTS® concept.

Between 2021 and 2024, a hybrid therapy model was developed, integrating mechanical, functional, and compensatory approaches. During this period, the SDR summation parameter for typical double-curve scoliosis was refined, enabling a synthetic postural assessment. This process led to the formalization of the KTS® concept and the granting of patent protection in 2023.

In 2025, a compensatory treatment method for scoliosis was developed based on this concept – the CTS method – as a three-dimensional treatment model focused on restoring proper trunk compensation, providing an alternative to approaches focused primarily on reducing the initial curvature angle. The CTS method offers a modern, holistic therapeutic approach, integrating compensation analysis and correction mechanics, and aims to stabilize posture by restoring proper rotational compensation.

Keywords: KTS® concept, CTS method, idiopathic scoliosis, compensation mechanism, 3D diagnostics, summative parameters. scoliosis therapy.

THE DEGRADATION OF THE VALIDITY–CREDIBILITY AXIS AND THE TRANSFORMATION OF INFORMATION UNDER CHAOTIC CONDITIONS

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ABSTRACT

In chaotic conditions, the value of information cannot be explained solely through accuracy or classical validity criteria. In this context, the determining problem is not whether information is true, but its capacity to disrupt the system's linear order and whether this disruption produces a new space for re-organization. In chaotic environments, information operates not only as content representing reality but also as a perturbation that reshapes decision pathways under limited energy conditions; therefore, the value attributed to knowledge shifts from a truth-centered verification logic to a functional regulation logic that enables sustainability. The study conceptualizes this shift as the degradation of the validity–credibility axis: when validity that prioritizes representational truth becomes insufficient, credibility criteria that enable action come to the fore. Within this framework, information gains value insofar as it is processed as usable risk in a consistent and traceable manner and supports sustainability (negentropy).

This approach distinguishes two strategic responses in the chaotic context: (i) repair aims to bring the disrupted linear structure closer to its former operating logic; (ii) generative pathway production aims to record inputs that disrupt linear order as usable risk and to develop alternative organizations capable of transforming entropic loss into negentropic gain. In chaos, the outcome of repair is often uncertain; moreover, the risk of cumulative damage and irreversibility renders linear reflexes such as "let us repair once more" strategically fragile. Under limited energy conditions, if the first solution (repair) fails, there may be insufficient resources to attempt the second solution. For this reason, the study argues that, although it involves risk, orienting toward generative pathway production from the outset (a move that postpones repair or redefines repair together with new pathway production) can be rationally justified in terms of the conservation of energy and the logic of sustainability.

Methodologically, the study is built on abductive inference. Abduction here does not mean merely deriving theory from data; rather, it is the mechanism-level recalibration of a previously established conceptual backbone (linear disruption; entropy/negentropy; the shift from validity to credibility; the repair–new pathway dilemma) by comparing it with the process observed in the field. This approach is operationalized through an explanatory single-case process reading based on chronologically compiled media sources on LEGO's crisis and recovery trajectory. In the LEGO case, the conceptual framework is refined by tracing the points at which truth-centered evaluation becomes insufficient and the points at which reliable/functional frames generate new organizational pathways. Thus, the study claims that the transition from an information understanding centered on truth to a transformative information understanding that prioritizes sustainability under chaotic conditions can be traced not only theoretically but also processually.

Keywords: Chaos, information value, validity, credibility, entropy, negentropy, linear disruption, abductive inference.

NORTH KOREA'S WEAPONS DEVELOPMENT: A GROWING CHALLENGE TO JAPAN'S NATIONAL SECURITY FRAMEWORK

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ABSTRACT

This paper explores the complex security challenges Japan faces in response to North Korea's advancing weapons program and the implications for regional stability in East Asia. North Korea's growing missile and nuclear capabilities pose significant threats, driving Japan to reconsider its security policies within the constraints of its pacifist constitution and longstanding U.S. alliance. This study analyzes Japan's adaptations to its Self-Defense Forces, increased defense spending, and enhanced missile defense systems as part of a strategic shift toward greater security autonomy. In a comparative analysis, Japan's approach is evaluated alongside the security frameworks of South Korea and the United States, while considering the roles of China and Russia as influential regional actors. The paper further suggests that Japan's evolving defense stance, particularly in building regional alliances, holds critical importance for countering North Korean threats. Policy recommendations emphasize the need for strategic flexibility, advancements in missile defense technology, and multilateral collaboration with allies. Long-term implications underscore how North Korea's militarization could reshape the geopolitical landscape, necessitating a proactive, cooperative approach to maintain regional stability and deter potential conflict. This analysis offers

insights into future directions for Japanese security policy and highlights areas for further research, including the impact of North Korea's internal policies on regional security dynamics.

Keywords: Japan, Risk, Weapons, Security.

GUT MICROBIOTA AND DEPRESSION: CURRENT APPROACHES THROUGH THE MICROBIOTA–GUT–BRAIN AXIS

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ABSTRACT

The bidirectional communication between the gut microbiota and the central nervous system plays a pivotal role in the regulation of mental health through the microbiota–gut–brain axis. Accumulating evidence indicates that alterations in gut microbiota composition are closely associated with the development and progression of depression. Dysbiosis has been shown to contribute to depressive symptoms through activation of the hypothalamic–pituitary–adrenal (HPA) axis, increased systemic inflammation, and disturbances in neurotransmitter synthesis and metabolism. Nutrition is recognized as one of the most important modifiable factors influencing gut microbiota composition and functionality. Recent research emphasizes the role of nutrition-based interventions in supporting mental health by promoting microbial balance. Fermented foods and psychobiotic approaches, including probiotics and prebiotics, have been reported to enhance the production of short-chain fatty acids, thereby supporting intestinal barrier integrity and modulating stress-related responses via immune and neural pathways. Moreover, adherence to the Mediterranean diet has been associated with increased gut microbiota diversity and reduced inflammatory markers due to its high content of bioactive compounds with antioxidant and anti-inflammatory properties. Clinical studies also suggest that omega-3 polyunsaturated fatty acids may exert antidepressant effects by attenuating neuroinflammation, regulating cytokine production, and supporting neuronal function and synaptic plasticity. Overall, nutrition-based strategies targeting the gut microbiota appear to be promising complementary approaches in the prevention and management of depression alongside conventional treatments. However, further well-designed, long-term randomized controlled trials are needed to clarify underlying mechanisms and establish standardized, evidence-based nutritional recommendations.

Keywords: Gut Microbiota, Depression, Nutrition, Psychobiotics, Mediterranean Diet

EFFECTS OF CANNABIDIOL AND OCCLUSAL SPLINT ON BITE FORCE AND OROFACIAL PRESSURE IN WOMEN WITH PAINFUL MYOFASCIAL TMD

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ABSTRACT

Muscular temporomandibular disorder is managed through conservative, pharmacological, physical, and behavioral strategies, in addition to interocclusal appliances and complementary therapies aimed at controlling pain, inflammation, and neuromuscular activity. Cannabidiol has been considered a therapeutic adjuvant due to its potential anti-inflammatory and antinociceptive effects. This triple-blind randomized clinical trial evaluated maximum molar bite force and orofacial tissue pressure in women with refractory painful muscular temporomandibular disorder treated with an occlusal splint combined with a transdermal gel applied to the masseter muscle region. Twenty adult women participated and were distributed into two groups: occlusal splint with cannabidiol gel (n = 10) and occlusal splint with placebo gel (n = 10). Temporomandibular disorder was diagnosed according to the Diagnostic Criteria for Temporomandibular Disorders criteria. Measurements of right and left molar bite force (Kratos dynamometer) and lip, tongue, and cheek pressure (PLL Pró-Fono) were obtained at three time points: pre-treatment, after 15 days, and after 30 days, with the gel (cannabidiol or placebo) being applied during the final 15 days. Data were analyzed using repeated-measures ANOVA with Bonferroni correction ($p < 0.05$) and effect size calculation. Functional improvement was observed over time in both groups. In the cannabidiol group, there was a significant increase in bite force ($p = 0.003$ right; $p = 0.001$ left), with medium effects on the right ($d = 0.58$) and medium-large effects on the left ($d = 0.70$), in addition to a significant increase in lip pressure ($p < 0.001$; $d = 1.99$). In the placebo group, bite force increased slightly without significance (d between 0.30 and 0.36), while lips ($p = 0.05$; $d = 0.70$) and cheeks ($p = 0.02$; d between 0.52 and 0.57) showed significant increases. The study demonstrated that the combination of occlusal splint and transdermal cannabidiol gel promoted clinically relevant gains in bite force and lip pressure, suggesting complementary therapeutic value for refractory cases. The study was approved by the Ethics Committee of the University of São Paulo, School of Dentistry at Ribeirão Preto, Brazil (process #76023223.5.0000.5419), and was registered in ReBEC (number RBR-6xfb4xs).

Keywords: Cannabidiol, TMD, myofascial pain, occlusal splint, bite force, orofacial

BIO-BASED WOOL POWDER AS A FLAME-RETARDANT ADDITIVE IN ACRYLATE COATINGS FOR TEXTILES

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ABSTRACT

The demand for sustainable flame-retardant (FR) technologies in textiles has grown due to environmental and health concerns surrounding halogenated and conventional phosphorus-based additives. In this work, keratin-derived wool powder was explored as a bio-based, nitrogen- and sulfur-rich additive incorporated into acrylate polymer coatings for cotton fabrics. The objective was to enhance flame retardancy while maintaining coating integrity and wash durability.

Fabric substrates were coated with acrylate formulations containing various loadings of wool powder, applied by knife coating and cured under controlled thermal conditions. The influence of wool powder incorporation on coating morphology, adhesion, and durability was assessed. Structural and chemical interactions were examined using Fourier-transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM). Thermal stability and degradation pathways were analyzed by thermogravimetric analysis (TGA). Flame retardancy was evaluated through vertical flame testing, with additional post-laundering flammability assessments to investigate long-term performance.

The results demonstrate that the introduction of wool powder into acrylate coatings significantly improves flame resistance by promoting char formation and reducing flame spread. TGA and FTIR analyses confirmed the contribution of keratin's nitrogen and sulfur functional groups to the stabilization of the polymer matrix during combustion. Importantly, the wool-modified coatings retained mechanical integrity and showed enhanced durability after repeated washing cycles compared to unmodified acrylate coatings.

This study highlights the potential of keratin-based waste materials as effective flame-retardant additives in polymer coatings, offering a renewable and environmentally responsible alternative to traditional synthetic FR systems. The approach provides a pathway toward integrating circular bio-resources into advanced textile finishing technologies while addressing both safety and sustainability challenges.

Keywords: Wool powder; Acrylate coating; Bio-based flame retardant; Cotton fabric; Wash durability; Sustainable textiles.

EVALUATION OF TEXTURE PROFILE IN BREAD FROM INGEN TRITICALE VARIETIES FROM THE REPUBLIC OF MOLDOVA WITH FERMENTED BREWERS' SPENT GRAIN ADDITION

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ABSTRACT

Bread texture represents a critical parameter in the sensory evaluation of baked products. In the case of triticale bread, texture plays a significant role in shaping consumer perception, due to the distinct physicochemical properties of triticale compared to common wheat. This study aimed to investigate the texture profile of bread samples produced from five Ingen triticale varieties (33, 35, 40, 54, and 90) cultivated in the Republic of Moldova, with the incorporation of fermented brewers' spent grain (FBSG) at levels of 10% and 17.5%. Control samples containing 0% FBSG were analyzed for comparison. Texture profile analysis was conducted using a TA.HD plus C texture analyzer, evaluating key parameters: hardness, adhesiveness, cohesiveness, resilience, gumminess, and chewiness. The results demonstrated that both the FBSG inclusion level and the specific triticale variety significantly influenced the texture characteristics of the bread samples. Hardness increased proportionally with the amount of FBSG added. The ranking of hardness values among the samples was as follows: Ingen 40 > Ingen 54 > Ingen 33 > Ingen 35 > Ingen 93. The observed increase in firmness is attributed to reduced moisture content and enhanced interactions between gluten and dietary fibers. Moreover, the variability in the protein–starch–pentosan complex inherent to each triticale variety may have further contributed to differences in

hardness. Adhesiveness also showed a marked increase with higher FBSG concentrations, influenced by both the compositional characteristics of the triticale flour - particularly protein and carbohydrate levels - and the substantial fiber content introduced by FBSG. Significant increases in adhesiveness were observed in samples Ingen 40, Ingen 93, and Ingen 35 as the FBSG level rose from 0% to 17.5%. Cohesiveness and resilience were mainly affected by the relatively low gluten content of the triticale flours, which ranged from 18.49% to 27.49% (wet gluten). An increase in cohesiveness accompanied by a decrease in resilience resulted in denser and stickier bread textures. Gumminess and chewiness followed similar patterns across the samples. These increases are attributed to the elevated dietary fiber content, particularly from FBSG, which collectively promote the development of a more compact and firm bread matrix.

Keywords: baked products, physicochemical properties, texture profile analysis, sensory evaluation.

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ABSTRACT

Bread texture represents a critical parameter in the sensory evaluation of baked products. In the case of triticale bread, texture plays a significant role in shaping consumer perception, due to the distinct physicochemical properties of triticale compared to common wheat. This study aimed to investigate the texture profile of bread samples produced from five Ingen triticale varieties (33, 35, 40, 54, and 90) cultivated in the Republic of Moldova, with the incorporation of fermented brewers' spent grain (FBSG) at levels of 10% and 17.5%. Control samples containing 0% FBSG were analyzed for comparison. Texture profile analysis was conducted using a TA.HD plus C texture analyzer, evaluating key parameters: hardness, adhesiveness, cohesiveness, resilience, gumminess, and chewiness. The results demonstrated that both the FBSG inclusion level and the specific triticale variety significantly influenced the texture characteristics of the bread samples. Hardness increased proportionally with the amount of FBSG added. The ranking of hardness values among the samples was as follows: Ingen 40 > Ingen 54 > Ingen 33 > Ingen 35 > Ingen 93. The observed increase in firmness is attributed to reduced moisture content and enhanced interactions between gluten and dietary fibers. Moreover, the variability in the protein–starch–pentosan complex inherent to each triticale variety may have further contributed to differences in

hardness. Adhesiveness also showed a marked increase with higher FBSG concentrations, influenced by both the compositional characteristics of the triticale flour - particularly protein and carbohydrate levels - and the substantial fiber content introduced by FBSG. Significant increases in adhesiveness were observed in samples Ingen 40, Ingen 93, and Ingen 35 as the FBSG level rose from 0% to 17.5%. Cohesiveness and resilience were mainly affected by the relatively low gluten content of the triticale flours, which ranged from 18.49% to 27.49% (wet gluten). An increase in cohesiveness accompanied by a decrease in resilience resulted in denser and stickier bread textures. Gumminess and chewiness followed similar patterns across the samples. These increases are attributed to the elevated dietary fiber content, particularly from FBSG, which collectively promote the development of a more compact and firm bread matrix.

Keywords: baked products, physicochemical properties, texture profile analysis, sensory evaluation.

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INTEGRATING BIOBANDING INTO YOUTH BASKETBALL: SKELETAL AGE, BIOLOGICAL MATURATION, AND TRAINING IMPLICATIONS

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ABSTRACT

This study aimed to evaluate biological maturation, somatic characteristics, and skeletal parameters in athletes of the Polish National U15 Basketball Teams. The sample consisted of 33 athletes: 16 female athletes (U15F) and 17 male athletes (U15M). Hand–wrist DXA scans (NORLAND EXCELL XR-46) were used to assess bone mineral density (BMD), bone mineral content (BMC), and skeletal age according to ISCD recommendations and Carpal Bone Age Standards. Biological age was additionally assessed using Cameron's questionnaire method. Kinanthropometric measurements were also performed. This work was supported by the Ministry of Sports and Tourism Republic of Poland, and the Polish Basketball Federation with the grant 2025.0521/0102/UDot/DSW "Assessment of biological age and optimization of the basketball

training process". Female athletes presented an endomorph–ectomorph somatotype (5.00–1.80–3.85), characterised by relatively high endomorphy and low mesomorphy. Both groups showed considerable variation in body height and mass, especially male athletes. DXA results indicated high values of BMD and BMC in both groups, with male athletes showing higher absolute mineralisation levels and narrower inter-individual variation. Female athletes demonstrated greater variability in wrist and metacarpal BMD/BMC. In both groups, skeletal age was accelerated by approximately 1.5–2.0 years compared to chronological age, confirming a faster biological maturation typical for youth athletes exposed to regular training loads. The menarche age among female athletes fell within the national population norm, and the timing of voice mutation among male athletes corresponded with the expected ranges for Polish adolescents. The findings confirm that basketball-specific loading frequently impacts ball handling, landings on the upper limbs, and repetitive weight-bearing actions, providing a strong osteogenic stimulus, especially for the wrist region. The biological development of both U15F and U15M national-level athletes appears accelerated yet harmonious, without signs of developmental disharmony. These results highlight the importance of considering biological age, rather than chronological age alone, in training load management and talent profiling. Systematic monitoring of bone parameters through DXA may support effective injury prevention and the optimisation of long-term athlete development pathways.

Keywords: carpal bone age standards, biological maturation, basketball, kinanthropometric profile

INVESTIGATION OF THE MECHANICAL PROPERTIES AND IMPACT STRENGTH OF SAMPLES PRODUCED WITH MILLED CARBON FIBER AND SLA RESIN

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ABSTRACT

Additive manufacturing technologies, particularly stereolithography (SLA), offer significant advantages for producing complex polymer components; however, the relatively limited mechanical performance of photopolymer-based parts restricts their use in load-bearing applications. In this study, the mechanical behavior of SLA-printed specimens produced with different infill ratios and reinforced with milled carbon fiber was experimentally investigated. A commercially available water-washable UV-curable photopolymer resin was modified by adding milled carbon fibers with an average particle size of 80 μm at weight fractions of 0, 0.4, and 0.8 wt%. Tensile and Charpy impact test specimens were fabricated at infill ratios of 60%, 80%, and 100% using an SLA 3D printer. Tensile tests were conducted according to ASTM D638 (Type V) and Charpy impact tests were performed in accordance with ASTM D256. All experiments were carried out at room temperature under controlled laboratory conditions. The results demonstrate that increasing the infill ratio significantly enhances both tensile strength and impact toughness of the printed specimens. The highest tensile strength and impact toughness were obtained for specimens printed with 100% infill and without carbon fiber reinforcement. Conversely, the addition of milled carbon fiber exhibited a detrimental effect on mechanical performance for all infill ratios. As the carbon fiber content increased, both tensile strength and impact toughness consistently decreased. This behavior is attributed to possible agglomeration of short fibers, reduced interlayer bonding, and increased stress concentration within the photopolymer matrix. Overall, the findings indicate that infill ratio is a dominant parameter governing the mechanical performance of SLA-printed photopolymer parts, while milled carbon fiber reinforcement, at the investigated particle size and weight fractions, does not provide mechanical enhancement. These results provide useful guidance for the design and optimization of SLA-fabricated polymer components where mechanical performance is critical.

Keywords: Stereolithography (SLA), Additive manufacturing, Infill ratio, Milled carbon fiber reinforcement, Charpy impact toughness

OCCURRENCE OF HEAVY METALS AND MICROPLASTICS IN THE STOMACH CONTENT OF TWO FISH SPECIES IN THE NORTH AND CENTRAL ATLANTIC COAST OF MOROCCO

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ABSTRACT

In the last decades, scientists have taken a keen interest in studying microplastics (MPs) that have invaded all aspects of marine life, namely abiotic and biotic. They are currently viewed as vector molecules of other types of pollution, due to their strong affinity to pollutants. The present study is designed to analyze heavy metals: Hg, Cd, and Zn, and the microplastics contained inside the stomach of 122 fish individuals, composed of, *Trachurus trachurus*, and *Zeus faber*, from the coast of the Moroccan Atlantic coast between Larache (35°30'N) and Sidi Ifni (29°30'N). Microplastics were detected using Fourier-transform infrared spectroscopy, and heavy metals were identified by atomic absorption spectroscopy. Out of 122 specimens analyzed, 46% ingested MPs, with fibers being the most common form. Three polymer types were identified: polyamide, polystyrene, and acrylic. HMs analysis revealed the presence of mercury, cadmium, and zinc in 97% of the samples, though concentrations remained below regulatory limits. The concentration hierarchy was Cd > Hg > Zn (mean in µg/kg dry weight: 3.24 > 2.75 > 2.73). Cd, Hg, and Zn contents were compared between fish individuals containing MPs in their stomach contents and those without. The results showed that individuals containing MPs in their stomachs recorded the highest values of heavy metals. These results therefore confirm the coexistence of the two contaminants (MPs and heavy metals) in the stomach contents of the species captured in an area known for its industrial activity. Due to the negative impact on the ecosystem that this coexistence between MPs and heavy metals can cause, further in-depth research must be carried out concerning the phenomena of adsorption and desorption between these two contaminants to better assess the bioaccumulation of heavy metals. and the dual health and environmental risk.

Keywords: Microplastics, heavy metals, fish, Moroccan Atlantic coast, risk indexes.

SUSTAINABILITY-ORIENTED MANAGEMENT IN POLISH TANNERIES

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ABSTRACT

This study is part of a broader research project examining the current condition of the Polish tanning industry, which has undergone significant deindustrialization, with only about 30% of previously identified companies still active in leather manufacturing. In contrast, the global leather tanning market continues to grow steadily. It was valued at USD 28.36 billion in 2025 and is projected to reach USD 37.54 billion by 2035, with a compound annual growth rate (CAGR) of 2.31%, driven mainly by demand from the footwear, apparel, and automotive sectors, according to Business Research Insights.

An attempt was made to characterize the Polish tanning sector in terms of its adoption of sustainable development principles and the United Nations Sustainable Development Goals (SDGs), particularly in facility management and sustainable project management. A multiple case study methodology was employed, based on data collected from 20 Polish tanneries that participated in a structured survey. Most of these firms are micro- or small-sized enterprises with annual revenues of up to PLN 5 million, operating primarily at the national or European level. They mainly process calfskin and cowhides sourced domestically and internationally, largely for the footwear industry, and demonstrate awareness of global trends such as environmentally responsible practices or technological modernization.

The findings show that 85% of the surveyed tanneries incorporate sustainable development principles into their facility management and operational practices. At the strategic level, 45% report alignment of their objectives with between one and sixteen SDGs. Additionally, 25% of the facilities implement project-based initiatives, primarily related to production and technological improvements. These projects generally follow sustainability criteria, with most project-active firms integrating SDGs into their planning processes. During implementation, the tanneries apply the three-pillar model of sustainability to ensure sustainable outcomes. As a result, completed projects generate sustainable benefits and lasting improvements.

The study offers empirical insights and serves as a reference for manufacturing firms with profiles similar to tanneries, illustrating practical approaches to integrating sustainable development into organizational governance and project management.

Keywords: sustainable development, SDGs, Polish tanneries, plant management, project management, leather manufacturing.

RISK-AVERSION ADJUSTED PORTFOLIO OPTIMIZATION WITH MACHINE LEARNING AND EXPLAINABLE AI

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ABSTRACT

With the increasing complexity of financial markets, integrating machine learning (ML) and explainable artificial intelligence (XAI) into portfolio optimization has become essential for developing adaptive and transparent investment strategies. This study aims to enhance traditional portfolio construction by incorporating data-driven trend forecasting and risk-adjusted decision-making. Specifically, we investigate the impact of S&P 500 trend movements on portfolio construction involving 24 stocks from eight industry sectors and a risk-free asset within a single-period framework adjusted for risk aversion. Portfolios are constructed using three risk measures: Variance, Conditional Value at Risk (CVaR), and Mean Absolute Deviation (MAD). The optimization process combines Python for computational modeling with AMPL for implementing complex mathematical formulations. To model risk aversion behavior, six supervised classification algorithms—Logistic Regression (LR), K-Nearest Neighbors (KNN), Support Vector Machines (SVM), Decision Trees (DT), Random Forest (RF), and eXtreme Gradient Boosting (XGBoost)—are trained using 29 technical indicators derived from technical analysis. In parallel, asset return forecasting is conducted using four regression approaches: Linear Regression, Long Short-Term Memory (LSTM), XGBoost, and Light Gradient Boosting Machine (LightGBM). Model interpretability is ensured through XAI techniques, namely Local Interpretable Model-agnostic Explanations (LIME) and SHapley Additive exPlanations (SHAP), to identify the most influential features driving model decisions. The empirical results demonstrate that model performance varies across optimization frameworks. Decision Trees achieve the highest Sharpe ratio in Mean-Variance portfolios (≈1.75), Logistic Regression performs best in Mean-CVaR portfolios (≈1.09), and KNN yields superior results in Mean-MAD portfolios (≈0.95). In return forecasting, Linear Regression outperforms alternative models according to the selected evaluation metric. Furthermore, XAI analysis highlights the significance of the Average Directional Index (ADX) with a ten-period setting, particularly in KNN and LR models, underscoring the value of explainability in financial decision-making.

Keywords: Portfolio Optimization, Technical Analysis, Machine Learning, Explainable Artificial Intelligence

COMPARATIVE EVALUATION OF TRITICALE BREADS WITH BLONDE AND DARK FERMENTED BREWERS' SPENT GRAIN

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ABSTRACT

Bakery products play a central role in satisfying the nutritional needs of consumers. This study examined the sensory and physical characteristics of bread produced from seven triticale (*Triticum aestivum* × *Secale cereale*) cultivars - Ingen 33, Ingen 35, Ingen 40, Ingen 54, Ingen 90, Fanica and Costel - grown in the Republic of Moldova, incorporating 10% fermented brewers' spent grain (FBSG). Bread samples with FBSG derived from the production of blond beer (BFBSG) and dark beer (DFBSG) were compared with control samples (CS) lacking FBSG. The sensory attributes of the bread (appearance, color, aroma, taste, odor, texture) were evaluated using a nine-point hedonic scale, along with the physical characteristics of specific volume, porosity and elasticity. Bread samples containing DFBSG generally obtained higher overall acceptability scores than CS, except for the Costel and Fanica varieties. For BFBSG, Ingen 33 (8.43) and Ingen 54 (8.13) obtained the highest scores. However, high levels of FBSG negatively affected the flavor and texture, probably due to the high fiber content and acidity of FBSG. The variety of triticale also influenced the overall perception, with all breads obtaining scores above 7 (good) and many above 8 (very good). In terms of physical characteristics, breads with FBSG showed reduced specific volume, porosity and elasticity compared to CS ($p \leq 0.05$). The increased acidity in the FBSG samples probably modified the structure of gluten proteins, decreasing gas retention capacity and elastic properties. As a result, the doughs became less extensible, leading to lower volume and a weakened crumb

structure. Overall, the results indicate that although FBSG can improve certain sensory attributes, its incorporation at 10% compromises key physical properties of triticale-based breads.

Keywords: sensory and physical characteristics, fermented brewers' spent grain, dough.

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PROTECTION AND CONSERVATION OF THE MEDITERRANEAN SLIPPER LOBSTER: A CONTEMPORARY PRACTICAL APPROACH TO SAFEGUARDING A THREATENED SPECIES

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ABSTRACT

Marine species of commercial value, including lobsters, have been overfished in recent decades and are increasingly threatened also by other human activities. Lobsters have long provided food, income, and trade opportunities worldwide, but modern fishing pressure has depleted some local lobster populations beyond recovery (e.g., in Italy). A contemporary example of conservation efforts is the Mediterranean slipper lobster, *Scyllarides latus*, distributed throughout the Mediterranean Sea and the central–eastern Atlantic. This nocturnal species shelters in caves and rocky crevices during the day to avoid diurnal predators. Its main threats are overfishing, habitat loss, and climate change. Owing to its large size and high market value, it is heavily exploited, mainly by divers and with trammel or gill nets. The selective removal of large, highly reproductive individuals has led to declining populations and smaller average sizes. The species is legally protected in several countries (e.g., France, Israel, Italy, Spain), yet illegal fishing persists. Because of the extensive marine areas and the limited number of inspectors or rangers, the most effective strategy for protecting this species is the establishment of Marine Protected Areas (MPAs). They have proven the most effective management tool: studies in northern Israel show that abundance, density, and size are significantly higher within MPAs compared to a similar unprotected control area. Such reserves can be effective if sufficiently large, and include habitats preferred by lobsters. Well-managed reserves can also enhance nearby unprotected zones through the spillover of adults and juveniles. Habitat loss can be mitigated by creating stable artificial reefs suited to lobster behavioral ecology. In regions where lobster fishing is permitted, minimum legal-size limits and protection of egg-bearing females should be strictly enforced. Rising seawater temperatures further threaten the species by disrupting molting, altering distribution, and promoting invasive predators such as lionfish, alongside the collapse of mollusk populations, the main food of this lobster, in the eastern Mediterranean.

Keywords: Overfishing, *Scyllarides latus,* habitat loss, climate change, marine reserves, artificial reefs

THE USE OF AI-SUPPORTED HYBRID APPROACHES IN THE PRODUCTION PROCESS OF MEDICAL ILLUSTRATION

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ABSTRACT

This study examines the use of artificial intelligence–based image generation tools as reference resources within the medical illustration production process and proposes a hybrid working method that integrates AI-generated visuals with classical illustration practices. In the study, anatomical sketch images were initially produced using artificial intelligence tools. These images were not treated as final outputs; instead, they served as preliminary references for form, proportion, and composition.

Subsequently, the AI-generated sketches were reinterpreted, corrected, and further developed by the researcher using digital illustration software such as Adobe Photoshop and Procreate. During this stage, the illustrations were redrawn in accordance with established medical illustration principles, with particular emphasis on anatomical accuracy, visual clarity, and aesthetic coherence. The illustrator's anatomical knowledge and manual intervention played a decisive role in refining and validating the final visuals.

The findings indicate that artificial intelligence can effectively function as a supportive tool in the early stages of medical illustration, particularly in generating initial visual references and accelerating the sketching process. However, the study also demonstrates that AI-generated imagery alone is insufficient to meet the scientific and communicative requirements of medical illustration without expert human interpretation and correction.

Rather than positioning artificial intelligence as a replacement for the medical illustrator, this research argues for its use as a complementary technology within a hybrid production workflow. In this context, AI is evaluated as a reference-generating and process-supporting tool that enhances efficiency while preserving the illustrator's creative and scientific responsibility. The study highlights the potential of AI-supported hybrid methods for both medical illustration practice and education.

Keywords: artificial intelligence, medical illustration, hybrid method, digital illustration, anatomical reference

EXPLORING THE IMPACT OF TECHNOLOGY INTEGRATION ON JOB SATISFACTION: PERSPECTIVES OF SPECIAL EDUCATION TEACHERS FOR CHILDREN WITH AUTISM SPECTRUM DISORDER

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ABSTRACT

The rapid integration of technology in education has transformed teaching practices particularly in special education settings where teachers work with children diagnosed with Autism Spectrum Disorder (ASD). This study aims to explore the influence of technology integration on job satisfaction among teachers of children with ASD in Jordan. Teaching these children require not only professional expertise but also the ability to use digital tools that enhance communication, instruction, and behavioral support. Guided by the Technology Acceptance Model (TAM), the study proposes technological adaptability is a key factor influencing teachers' satisfaction and retention. A quantitative, descriptive–correlational research design will be employed using a structured online questionnaire distributed to in-service special education teachers across schools and specialized centers in Amman. The instrument will assess two domains: technology integration, and job satisfaction. Data will be analyzed using descriptive statistics, Pearson's correlation, and multiple regression to determine the relationships and predictive power among the variables. It is anticipated that teachers with greater confidence in integrating technology into teaching practices, will report significantly higher job satisfaction. The expected results will provide empirical evidence on how technological factors contribute to professional fulfillment among special education teachers. The study's findings are expected to inform policymakers and educational leaders in designing targeted professional development programs that enhance teachers' technological competencies, promote well-being, and reduce burnout in special education environments.

Keywords: technology integration, job satisfaction, special education, autism spectrum disorder.

THE ACTION-ORIENTED APPROACH AS A FOUNDATION FOR SOFT SKILLS DEVELOPMENT IN HIGHER EDUCATION

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ABSTRACT

In recent years, the development of soft skills has become a central priority in higher education, reflecting the growing complexity of academic, professional, and societal demands. Beyond disciplinary knowledge, universities are increasingly expected to equip students with transversal competencies such as communication, collaboration, critical thinking, autonomy, and adaptability. Traditional teaching methods, largely centered on content transmission, often fall short in fostering these skills effectively. This study explores the action-oriented approach as a pedagogical framework for developing soft skills in university contexts.

Grounded in competence-based and learner-centered pedagogy, the action-oriented approach positions learners as active social actors who engage in meaningful tasks within authentic or simulated real-life contexts. By emphasizing action, interaction, and collaboration, this approach creates dynamic learning environments that encourage students to apply knowledge and skills practically. This study investigates how action-oriented practices support the structured and sustainable development of soft skills in higher education.

A qualitative and analytical research design is employed, involving the analysis of action-oriented learning scenarios, classroom observations, and students' reflective feedback. Findings reveal that task-based and collaborative activities significantly enhance communication, teamwork, autonomy, and decision-making skills. Additionally, the approach promotes learner engagement and accountability, reinforcing students' active participation in the learning process.

The study demonstrates that the action-oriented approach provides a coherent and effective framework for embedding soft skills into higher education curricula. It underscores the importance of rethinking instructional design by moving from traditional knowledge delivery toward active, task-driven, and competence-focused learning. By integrating real-world tasks and collaborative projects, universities can cultivate students' practical and interpersonal abilities while fostering critical thinking and adaptive capacities.

Overall, this research contributes to ongoing discussions on innovative pedagogical practices and offers both theoretical and practical insights for educators. It highlights the potential of action-based learning to bridge the gap between disciplinary knowledge and essential soft skills, preparing students to navigate complex academic and professional environments successfully. The findings support a shift toward more interactive, participatory, and skill-oriented teaching methods that align with the evolving demands of higher education.

Keywords: action-oriented approach, soft skills, higher education, competence-based learning, pedagogy.

AI-AUGMENTED LEADERSHIP, EMPLOYEE ADAPTATION, AND WORK ENGAGEMENT IN WHITE-COLLAR WORK SETTINGS

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ABSTRACT

The increasing use of artificial intelligence and digital technologies in organizations has led to important changes in leadership practices. In many contemporary workplaces, leaders are expected not only to manage people but also effectively integrate digital tools and data-driven systems into daily operations This emerging form of leadership, often refered to as AI-augmented or digital leadership, has become particularly relevant in white-collar work environments. However, empirical evidence on jow such leadership influences employee attitudes and behaviors remains limited. The aim of this study is to examine the relationship between AI-augmented leadership and employee work engagement, with a specific focus on the mediating role of individual adaptation. Drawing on the literature on AI-augmented leadership and organizational behavior, it is proposed that leaders who effectively use and promote digital Technologies may facilitate employees' ability to adapt to technological and organizational changes. In turn, this adaptive capacity is expected to enhance employees' level of engagement at work. The study is planned to be conducted among white-collar employees working in technology-oriented and knowledge-intensive organizations. Data will ve collected using a structured questionnaire. AI-augmented leadership will be measured using Digital Leadership Scale, employee adaptation will be assessed with the I-Adapt Scale, and work engagement will be measured using the Utrecht Work Engagement Scale (UWES-9). The proposed research will be tested through structural equation modelling. It is expected that AI-augmented leadership will be positively related to employee adaptation and work engagement, and that individual adaptation will play a mediating role in this relationship. The findings of this study are anticipated to contribute to the growing literature on AI-supported leadership and employee behavior. In addition, practical implications for managers regarding the effective use of digital Technologies and the support of employee adaptation processes are expected.

Keywords: AI-Augmented Leadership, Digital Leadership, Employee Adaptation, Work Engagement.

THE FOURTH MISSION: A SYSTEMATIC LITERATURE REVIEW ON HOW EMBEDDED HIGHER EDUCATION INSTITUTIONS SHAPE SOCIETY

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ABSTRACT

Universities serve as both catalysts for innovation and pillars of regional development in a knowledge-based global economy. They are increasingly pursuing a number of societal missions in addition to teaching and research, such as the third mission of technology transfer and community engagement and the newly emerging fourth mission that places an emphasis on social shaping, sustainability, and local partnerships. Using qualitative thematic analysis, this study examines the conceptualization of the fourth mission through a systematic literature review (SLR) of 21 chosen studies. The findings show a great deal of terminological inconsistency, with activities from the third and fourth missions overlapping, putting the fourth mission under the category of fuzzy concepts. Four conceptual categories were found: studies that only addressed the fourth mission, studies that addressed the third and fourth missions, studies that focused on the third mission but had conceptual and functional overlap, and studies that used alternative framings like civic university or social mission. Sustainability and regional embeddedness stand out as major themes in every category, emphasizing the hybrid roles that universities play in bridging the gap between local societal demands and global knowledge functions. The results imply that the fourth mission is less of a consistently labeled phenomenon and more of an implicit conceptual framework. The limited number of English-language studies in the sample and the interpretive character of qualitative classification are among the limitations. This study offers an analytical framework that can assist future empirical research and guide university strategy-making and regional policy development by clarifying the conceptual boundaries and essential elements of the fourth mission.

Keywords: embeddedness, mission, society, sustainability, university

HADITH LITERATURE IN THE REPUBLICAN PERIOD IN TURKEY

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ABSTRACT

Hadith literature, which we refer to as Hadith books, has shown great diversity since the first centuries of Hadith history. Especially in the 3rd century and thereafter, known as the Classification Period in Hadith History and also referred to as the Golden Age of Hadith, Hadith sciences were greatly diversified, and hundreds and thousands of works began to be produced in each branch of science. This diversity of Hadith literature, that is, the Hadith books, in Hadith history has presented a magnificent beauty and richness for Islamic Culture and Civilization. However, after the Ottoman Empire, with the beginning of the Republican Period in Turkey and the abolition of Arabic script and its replacement with Latin script, a great void was created in the field of Hadith literature. In order to fill this void and to meet the needs of the public for Hadith in the new era with the new script, it was decided by the Turkish Republic to have Sahih al-Bukhari translated in the early years of the Republic. This task, initially assigned to Ahmet Naim Bey, was completed by Kamil Miras Bey upon his death, and this beautiful work was published by the Presidency of Religious Affairs in 8 volumes under the title "Sahih al-Bukhari Muhtasari Tajrid Sarih Translation and Commentary".

This new era of Hadith Literature, which began in this way, continued with works written as textbooks following the establishment of Theology Faculties, Master's or Doctoral theses, and other academic works. This was followed by a major translation boom that began commercially. Almost all classical hadith sources, especially the Kutub al-Sittah, were translated.

In this study, we will attempt to classify the hadith studies conducted in Turkey during the more than one century of the Republic period, according to their content and academic nature. Classifying this excellent body of Hadith Literature according to literary genres will make a significant contribution to the field of Hadith Studies.

Keywords: Hadith Literature, Türkiye, Republic Period, Classification.

NONLINEAR VIBRATIONS OF AN ATOMIC FORCE MICROSCOPE UNDER DMT INTERACTION WITH MOVING CANTILEVER AND SAMPLE

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ABSTRACT

Atomic Force Microscopy (AFM) is a key experimental technique for nanoscale surface characterization, where the dynamic interaction between the cantilever tip and the sample strongly influences measurement accuracy and signal interpretation. In most conventional AFM models, the sample is assumed to be rigid and immobile, while only the cantilever dynamics are taken into account. However, in many realistic experimental situations, such as soft materials, externally excited substrates, or high-frequency environments, the sample itself may undergo vibrations, leading to coupled and highly nonlinear dynamics.

In this study, we investigate the nonlinear vibration behavior of an AFM system by considering the simultaneous motion of both the cantilever and the sample. The tip–sample interaction is modeled using the Derjaguin–Muller–Toporov (DMT) contact force, which accounts for adhesive effects in the contact regime and introduces strong nonlinearities into the system. A coupled nonlinear dynamical model is derived, where the relative tip–sample distance becomes explicitly time-dependent due to the motion of the sample. The governing equations are expressed in a non-dimensional form in order to identify the dominant physical parameters controlling the system response.

A slow–fast decomposition combined with numerical time integration is employed to analyze the system dynamics. The existence and stability of equilibria, bifurcation scenarios, and transitions between non-contact, contact, and tapping modes are examined in detail. Special attention is devoted to the influence of the amplitude and phase of the sample motion on the cantilever response. The results show that sample vibration can significantly alter the structure of the slow manifold, shift bifurcation thresholds, and generate new dynamic regimes that do not appear in classical AFM models with a fixed sample.

This work provides new insights into AFM nonlinear dynamics under more realistic operating conditions and contributes to a better interpretation of experimental observations in dynamic AFM modes.

Keywords: Nonlinear vibrations; Atomic Force Microscopy; DMT contact model; Tapping mode; Slow–fast dynamics.

EVALUATING THE EFFECTIVENESS OF DANCE MOVEMENT THERAPY IN IMPROVING BALANCE AND POSTURAL STABILITY IN ADULTS AGED 30–50 YEARS

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ABSTRACT

Postural stability is a complex adaptive process that involves multisensory integration, neuromotor coordination, and the continuous regulation of body alignment. While dance-based therapeutic modalities have been extensively examined in geriatric and clinical populations, their preventive application in middle adulthood remains insufficiently explored. This study investigated the effects of an eight-week structured Dance Movement Therapy (DMT) program on static balance, dynamic balance, postural stability, functional mobility, and self-perceived balance competence in adults aged 30–50 years.

A single-group pretest–posttest experimental design was implemented with 30 participants who completed biweekly 60-minute DMT sessions. The intervention protocol integrated rhythmic sequencing, multidirectional weight-shift patterns, proximal stabilization tasks, guided improvisational movement, and spatial orientation exercises. Outcome measures included the Berg Balance Scale, Timed Up and Go test, computerized stabilometric assessment of center-of-pressure displacement, and a validated balance self-perception questionnaire. Statistical analyses were conducted using paired-sample t-tests with significance set at $p < .05$, complemented by effect size estimation (Cohen's d).

It was anticipated that participation in the DMT program would yield statistically significant improvements in objective balance performance, reductions in postural sway parameters, enhanced functional mobility, and elevated subjective balance confidence. These findings would support the conceptualization of DMT as an integrative, multidimensional intervention capable of promoting neuromotor adaptability and embodied regulation in middle adulthood.

Keywords: Dance Movement Therapy, postural balance, postural stability, sensorimotor integration, middle-aged adults

INTRODUCTION

Postural stability is a dynamic, adaptive function that arises from the interplay between sensory perception, central processing, and motor execution. Rather than being a fixed mechanical ability, balance reflects the body's ongoing capacity to maintain alignment and respond to internal changes and varying environmental conditions. Effective control of upright posture and movement transitions relies on continuous adjustments in muscle activity, precise sensory feedback, and anticipatory actions that help stabilize the body during everyday tasks.

From a neurofunctional perspective, balance depends on the brain's ability to calibrate multiple sensory inputs. Visual cues, vestibular signals, and somatosensory information are weighted differently depending on the situation, allowing the central nervous system to generate appropriate

postural strategies. When this coordination is less efficient, it can lead to subtle increases in body sway, delayed muscle activation, and decreased movement precision, which may affect functional independence (Horak, 2006).

Modern motor control theory increasingly views balance as a skill that can be developed and refined through experience and task-specific training. Interventions that integrate coordination, rhythm, spatial awareness, and controlled weight transfer have been shown to be particularly effective in promoting integrative neuromotor responses. Within this context, Dance Movement Therapy (DMT) offers a multidimensional approach that combines structured motor activity with embodied cognitive and emotional processing.

According to the American Dance Therapy Association, DMT is a psychophysical intervention that uses intentional movement experiences to support both functional integration and psychosocial wellbeing. In this approach, movement is not seen simply as physical exercise but as a medium through which perception, emotion, cognition, and motor control interact. Instead of focusing on technical dance performance, DMT emphasizes exploratory movement, rhythmic attunement, spatial awareness, and relational engagement. Through this embodied process, individuals can refine their coordination, enhance trunk stability, and strengthen their awareness of body position in space. Dance-based therapeutic practices involve controlled weight shifts, exploration of movement in multiple directions, and rhythmically structured sequences. These activities stimulate proximal muscle activation and improve the timing of muscle coordination needed for effective postural control.

Repeated practice of adaptive movement tasks can enhance anticipatory postural adjustments and improve the efficiency of motor planning (Koch et al., 2019). Unlike traditional strength-training programs that focus on isolated muscle activation, DMT encourages variability within safe movement boundaries, promoting flexible postural strategies rather than rigid stabilization.

Research suggests that dance-based interventions may also support better integration of proprioceptive and vestibular signals during dynamic activities (Ribeiro & Oliveira, 2021). By continuously varying direction, tempo, and spatial orientation, DMT challenges the body's regulatory systems responsible for maintaining balance under changing conditions.

Beyond its neuromotor effects, DMT offers a psychological component that can indirectly enhance postural performance in adults. Improved emotional regulation, reduced stress-related muscle tension, and heightened body awareness have all been linked to better coordination and increased confidence in movement execution (Bräuninger, 2014).

While the therapeutic effects of dance-based programs have been well-studied in older adults and clinical populations, less attention has been given to individuals aged 30–50 years. This age group often experiences reduced regular physical activity, prolonged sitting at work, and cumulative stress, all of which can gradually impair postural control (Tinetti, 1986).

This study aimed to investigate the effects of an eight-week structured Dance Movement Therapy (DMT) program on static balance, dynamic balance, postural stability, motor coordination, and self-perceived balance in adults aged 30–50 years. By comparing participants' functional performance before and after the intervention, the study seeks to determine whether DMT can serve as an effective, multidimensional approach for enhancing physical regulation and embodied competence during middle adulthood.

Dance Movement Therapy can be understood as an integrative, movement-based intervention in which intentional bodily engagement serves as a medium for both functional and psychosocial improvement. Rather than treating movement solely as a form of physical exercise, DMT positions embodied action as a regulatory system where motor coordination, perceptual processing, and emotional organization interact. From a neuromotor perspective, dance-oriented interventions

appear to enhance postural control through coordinated multiplanar movements, controlled weight shifts, and rhythmic modulation. These experiences can refine the timing of muscle activation and improve anticipatory postural adjustments. By repeatedly practicing patterned yet variable movement tasks, participants are encouraged to expand their repertoire of stabilization strategies, reducing reliance on rigid compensatory patterns.

Existing research suggests that therapeutic dance can have a positive impact on balance by promoting activation of key muscles and improving sensorimotor responsiveness (Koch et al., 2019; Ribeiro & Oliveira, 2021). Beyond objective measures of balance, this study also examined participants' self-perceived balance as a reflection of embodied self-regulation. By systematically comparing functional performance before and after the intervention, the study aimed to determine whether DMT could serve as a preventive and functional strategy for enhancing neuromotor coordination and postural adaptability in adults aged 30–50.

MATERIALS AND METHODS

Research Design

This study used a single-group, pre- and post-intervention experimental design to examine changes in functional performance following an eight-week Dance Movement Therapy (DMT) program. By comparing each participant's baseline and post-program results, the design allowed observed differences to be interpreted as potential effects of the intervention. This approach is particularly well-suited for evaluating embodied, movement-based therapies, as it captures how individuals adapt and respond over time (Koch et al., 2019).

Instead of relying on cross-sectional comparisons between different participants, the study focused on within-person progress, providing a clearer picture of how balance-related abilities and postural control evolved throughout the program.

Participants

Thirty adults between the ages of 30 and 50 volunteered to take part in the study. To minimize potential confounding factors affecting postural performance, participants were required to meet the following criteria:

1. No diagnosed neurological or musculoskeletal conditions that could impact balance,
2. Medical clearance for moderate physical activity,
3. No engagement in concurrent balance-focused rehabilitation programs, and
4. Commitment to attend all sessions of the intervention.

Before beginning the study, participants received clear explanations of the procedures and objectives, and all provided written informed consent. Ethical conduct adhered to professional standards, in line with the principles of the American Dance Therapy Association. In addition, demographic information including age, sex, and self-reported physical activity levels was collected to provide context for interpreting the outcomes.

Intervention Procedure

Participants completed an eight-week structured Dance Movement Therapy (DMT) program, with two 60-minute sessions each week. Sessions were held in a dedicated movement space and led by a practitioner trained in DMT techniques.

To balance consistency with individualized therapeutic flexibility, each session followed a three-phase structure:

- **Warm-Up Phase (10–15 minutes):**

The sessions began with gentle mobilization exercises, rhythmic activities, and low-intensity coordination tasks. This phase aimed to increase joint mobility, heighten proprioceptive awareness, and prepare participants for the more complex movements to follow.

- **Core Therapeutic Phase (35–40 minutes):**

The main portion of the session included structured rhythmic sequences, multidirectional weight shifts, guided improvisational exploration, and trunk-focused stabilization exercises. Movements were designed to challenge spatial orientation, coordination, and adaptive postural control. Intentional variation in tempo and direction encouraged flexible motor planning and dynamic sensorimotor responses.

- **Integration and Recovery Phase (5–10 minutes):**

Sessions concluded with controlled breathing, gentle movement, and reflective body awareness exercises. This phase promoted neuromuscular relaxation and helped consolidate the motor learning gained during the session.

Intervention Content

The DMT program was designed with a focus on therapeutic and functional motor goals, rather than technical dance performance. Following contemporary dance-based rehabilitation approaches (Ribeiro & Oliveira, 2021), the intervention incorporated several key elements:

- **Rhythmic Sequencing:** Structured temporal patterns to improve movement timing and coordination.
- **Sensorimotor Coordination Tasks:** Multi-directional movements aimed at refining proprioceptive sensitivity and vestibular responsiveness.
- **Guided Improvisation:** Exploratory movement prompts that encourage adaptability and heightened body awareness.
- **Proximal Stabilization Exercises:** Trunk-focused activation strategies to support optimal postural alignment.
- **Spatial Awareness Training:** Activities emphasizing orientation, controlled directional changes, and smooth transitions between different support bases.

Movement complexity was gradually increased throughout the eight-week program to promote progressive neuromotor adaptation and enhance postural control.

Instruments and Outcome Measures

To assess the effects of the Dance Movement Therapy program, a combination of objective and subjective tools was used:

- **Berg Balance Scale (BBS):** Evaluated participants' performance on tasks requiring both static and dynamic balance control.
- **Timed Up and Go (TUG) Test:** Measured functional mobility and the efficiency of transitional movements.
- **Stabilometric Analysis:** Recorded center-of-pressure displacement and variability under standardized conditions to quantify postural sway.

- **Balance Self-Perception Questionnaire:** Captured participants' subjective sense of balance ability and confidence during movement.

All assessments were conducted at the start of the study (week 0) and immediately following the eight-week intervention (week 8), allowing for a clear comparison of functional changes over time.

Statistical Analysis

Data were processed and analyzed using SPSS software (version 26). The dataset was first checked for missing values and extreme scores. Normality of distribution was assessed with the Shapiro–Wilk test, and homogeneity of variance was verified using Levene's test where appropriate.

To evaluate the impact of the intervention, pre- and post-program scores for each outcome measure were compared using paired-sample t-tests. Statistical significance was set at $p < 0.05$. In addition to significance testing, effect sizes (Cohen's *d*) were calculated to quantify the magnitude of observed changes.

Graphical plots were also produced to illustrate individual differences and group-level trends, providing a clear visual representation of functional improvements following the Dance Movement Therapy program.

RESULTS

Based on theoretical and empirical evidence, it is anticipated that the eight-week Dance Movement Therapy (DMT) program will lead to measurable improvements in neuromotor coordination and postural regulation. Participants are expected to show positive changes in both objective measures of balance and their subjective perceptions of movement stability.

These anticipated effects align with previous research indicating that dance-based therapeutic interventions can enhance sensorimotor integration, functional mobility, and postural control (Biekmann et al., 2020; Koch et al., 2019; Ribeiro & Oliveira, 2021). Improvements are likely to be observable in clinical performance tests, stabilometric parameters, and participants' self-reported confidence and competence in balance-related tasks.

Static and Dynamic Balance

It is anticipated that participants will show a significant improvement in Berg Balance Scale (BBS) scores following the intervention, reflecting enhanced ability to manage transitional postures, perform controlled weight shifts, and maintain stability during functional tasks.

Stabilometric measures are expected to indicate a reduction in both the amplitude and variability of center-of-pressure (CoP) displacement during quiet standing. Such changes would suggest more efficient postural control and better integration of sensory information.

To illustrate individual progress, a line graph will depict each participant's BBS trajectory, with the x-axis representing participants (1–30) and the y-axis showing BBS scores. Most participants are expected to demonstrate an upward trend, highlighting consistent functional improvements across the group.

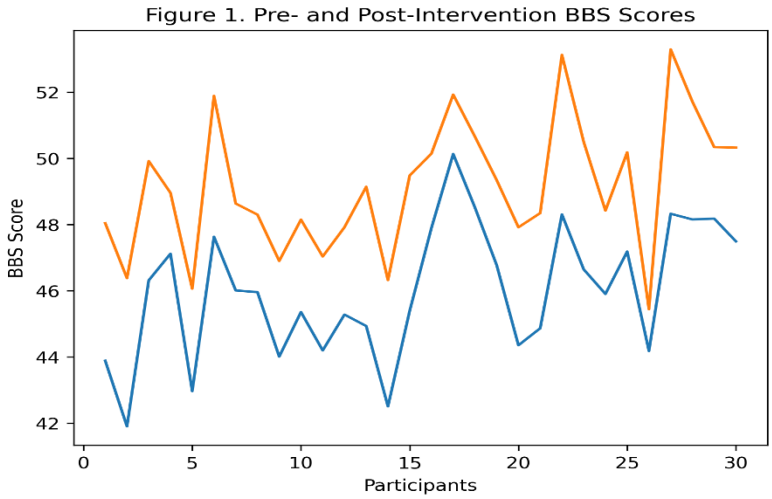


Figure 1. Conceptual illustration of pre- and post-intervention BBS scores.

Functional Mobility

Following the intervention, participants are expected to complete the Timed Up and Go (TUG) test more quickly, reflecting improved transitional control, coordination, and dynamic stability during sit-to-stand and walking tasks. Shorter completion times would indicate greater movement efficiency and enhanced anticipatory postural adjustments during functional mobility.

To visualize these changes, a bar graph will display the mean TUG times before and after the intervention, with the x-axis representing assessment phases (Pre, Post) and the y-axis showing time in seconds. A downward shift in the post-intervention values is anticipated, illustrating faster and more controlled performance.

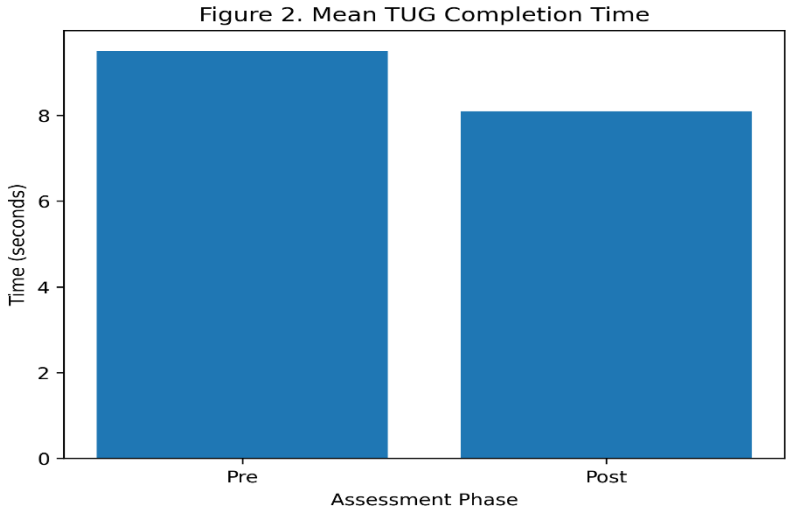


Figure 2. Conceptual comparison of the mean TUG completion times.

Postural Stability Parameters

Following the Dance Movement Therapy (DMT) program, we anticipate measurable improvements in objective stabilometric indices, such as reduced center-of-pressure (CoP) variance and slower CoP movement velocity. These changes would suggest enhanced proximal stabilization and more precise control of subtle postural sway.

The structured yet exploratory movements in DMT featuring multidirectional weight shifts, rhythmic modulation, and trunk-focused coordination are expected to improve the timing and synergy of core musculature, supporting more efficient balance regulation during quiet standing.

To illustrate these effects, a line or bar chart will compare CoP amplitude and variability before and after the intervention, highlighting reductions that reflect improved postural control and sensorimotor integration.

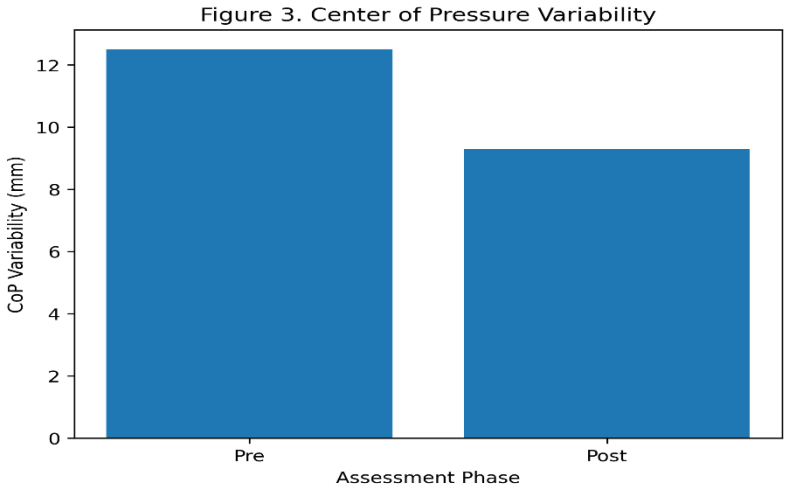


Figure 3. Conceptual depiction of changes in stabilometric parameters.

Self-Perceived Balance Competence

Alongside objective measures, participants were expected to feel more confident in their balance, as reflected in the self-perception questionnaire. From the perspective of Dance Movement Therapy (DMT), intentionally engaging the body through structured and exploratory movement can heighten body awareness and boost a person's sense of control over their movements.

Improvements in these subjective ratings suggest more than just better physical stability they reflect enhanced embodied self-regulation and increased assurance in daily movement tasks.

To visualize this change, a bar chart compares average questionnaire scores before and after the program, showing an expected rise in post-intervention values, indicating greater self-perceived balance and confidence.

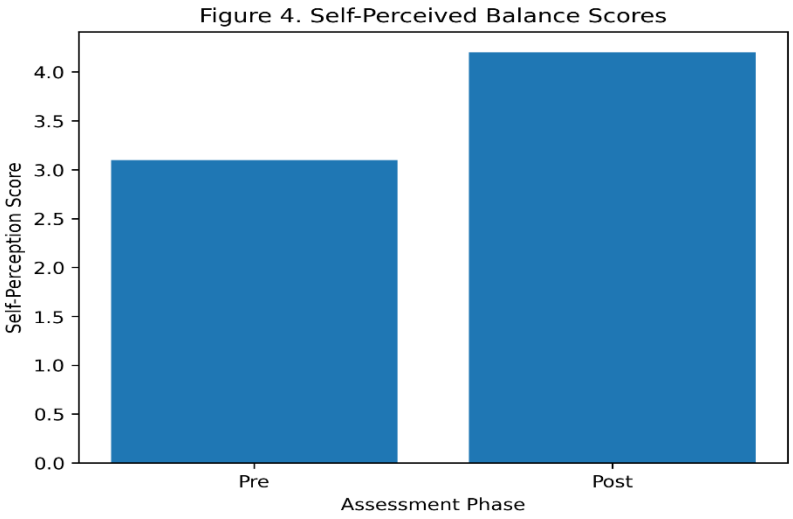


Figure 4. Conceptual comparison of self-perception scores.

Integrated Interpretation of Anticipated Outcomes

Taken together, the anticipated results suggest that Dance Movement Therapy (DMT) can serve as a multidimensional approach, supporting both neuromotor control and embodied self-awareness. Participants are expected to show measurable improvements across several areas:

- **Static and dynamic balance performance** – better control during both standing and moving tasks.
- **Functional mobility efficiency** – smoother, faster, and more coordinated transitions, such as sit-to-stand or walking.
- **Stabilometric indicators of postural control** – reduced sway and more precise center-of-pressure adjustments.
- **Subjective balance confidence** – greater awareness of body position and improved confidence in movement.

The combination of objective and self-reported improvements underscores that DMT is more than conventional exercise. By integrating rhythmic patterns, spatial exploration, and mindful movement, the program encourages flexible, adaptive postural strategies rather than rigid stabilization.

For adults aged 30–50, particularly those with sedentary work routines or high daily stress, these changes may have preventive value enhancing movement efficiency, improving coordination, and potentially lowering the risk of balance-related functional decline over time.

DISCUSSION

The findings of this study suggest that participating in a structured Dance Movement Therapy (DMT) program can lead to noticeable improvements in static balance, dynamic balance, and overall postural stability in adults aged 30–50 years. These changes are likely driven by enhanced neuromuscular activation, better integration of sensory information, and improved proprioception all of which are actively engaged through therapeutic movement activities (Koch et al., 2019; Lu et al., 2024).

Unlike traditional exercise programs that often focus on repetitive movements, DMT emphasizes intentional, expressive, and relational movement. As described by the American Dance Therapy

Association (2023), dance movement therapy uses movement as a psychotherapeutic tool to support emotional, cognitive, physical, and social integration. In practical terms, this means that movement is not just physical exercise; it serves as a regulatory system connecting bodily actions with perception and emotion. This integrated approach may enhance motor planning, intersegmental coordination, and postural adaptability.

Reductions in postural sway and improvements in stabilometric measures can be interpreted as the result of stronger trunk muscle engagement and more efficient anticipatory postural adjustments. Multidirectional and rhythmic tasks likely encourage co-activation of the deep stabilizing muscles, refining segmental control and dynamic balance (Ribeiro & Oliveira, 2021). Additionally, elements such as guided improvisation and spatial exploration may engage cortical–subcortical motor networks that govern timing, coordination, and adaptive motor responses (Dimonte et al., 2023; Koch et al., 2019). These mechanisms may explain the observed improvements in objective measures (e.g., BBS, TUG, stabilometry) as well as participants' subjective sense of balance.

From a lifespan perspective, adults in their 30s and 40s often face subtle declines in postural efficiency due to sedentary work, chronic stress, and limited movement variability. In this context, DMT may act as a preventive strategy, restoring sensorimotor flexibility and reinforcing adaptive movement patterns. By incorporating rhythm, interpersonal mirroring, and expressive interaction, DMT also integrates cognitive and emotional modulation into movement, strengthening embodied self-regulation (Lu et al., 2024).

Although dance-based interventions have been extensively studied in older adults, research in middle-aged populations remains limited (Wu et al., 2022). This study contributes to filling that gap by examining both functional performance and perceived balance in a population that is not clinically impaired but may be at risk for gradual postural decline.

CONCLUSION

Taken together, these anticipated findings reinforce the view of Dance Movement Therapy (DMT) as a multidimensional approach that goes beyond simple physical exercise. DMT appears to support postural control not just through strengthening muscles, but by promoting coordinated neuromuscular activity, dynamic weight shifts, and adaptive motor responses that develop through structured yet expressive movement experiences. In this way, DMT may enhance both the physical and perceptual processes that underlie effective movement and balance.

Beyond its biomechanical benefits, DMT's experiential nature encourages greater body awareness, proprioceptive sensitivity, and kinesthetic perception. Developing these skills can help individuals make more precise motor adjustments and improve sensory feedback during movement. At the same time, engaging in expressive movement may strengthen psychological factors such as self-confidence, emotional regulation, and perceived competence in bodily movement. These psychosocial dimensions are closely linked to motor performance, as emotional and cognitive states can directly influence attention, coordination, and stability.

For adults aged 30 to 50, DMT may be especially valuable. This age group often faces increasing work-related demands, prolonged sedentary behavior, and gradual musculoskeletal changes that can compromise postural efficiency and movement quality. In this context, DMT offers a sustainable, functionally meaningful strategy for improving balance, supporting safe and coordinated movement, and promoting overall well-being. By simultaneously targeting neuromuscular function, body awareness, and psychological engagement, DMT provides a holistic framework for enhancing movement competence and quality of life (American Dance Therapy Association [ADTA], 2023; Lu et al., 2024).

REFERENCES

- American Dance Therapy Association. (2023). What is dance/movement therapy? https://adta.org
- Bandura, A. (1997). Self-efficacy: The exercise of control. W. H. Freeman.
- Biekmann, F., Fuchs, R., & Schack, T. (2020). Effects of dance-based interventions on balance and postural control in adults: A systematic review and meta-analysis. Journal of Aging and Physical Activity, 28(4), 573–586. https://doi.org/10.1123/japa.2019-0205
- Blair, S. N. (2009). Physical inactivity: The biggest public health problem of the 21st century. British Journal of Sports Medicine, 43(1), 1–2. https://doi.org/10.1136/bjsm.2008.054825
- Booth, F. W., Roberts, C. K., & Laye, M. J. (2012). Lack of exercise is a major cause of chronic diseases. Comprehensive Physiology, 2(2), 1143–1211. https://doi.org/10.1002/cphy.c110025
- Bräuninger, I. (2014). Effects of dance movement therapy on stress regulation and quality of life. The Arts in Psychotherapy, 41(5), 445–451. https://doi.org/10.1016/j.aip.2014.08.002
- Dimonte, V., Gonella, S., Albanesi, B., Malinverni, E., Campagna, S., & Conti, A. (2023). The contribution of dance movement therapy in promoting interpersonal skills during the COVID-19 pandemic: A descriptive phenomenological study. International Journal of Environmental Research and Public Health, 20(2), 1376. https://doi.org/10.3390/ijerph20021376
- Granacher, U., Lacroix, A., Roettger, K., Gollhofer, A., & Muehlbauer, T. (2013). Effects of core instability strength training on trunk muscle strength, spinal mobility, and balance in older adults. Journal of Strength and Conditioning Research, 27(9), 2359–2367. https://doi.org/10.1519/JSC.0b013e31827da1b0
- Hodges, P. W., & Richardson, C. A. (1997). Contraction of the abdominal muscles associated with movement of the lower limb. Journal of Neurophysiology, 77(3), 132–144. https://doi.org/10.1152/jn.1997.77.1.132
- Horak, F. B. (2006). Postural orientation and equilibrium: Neural mechanisms of balance control. Journal of Neurophysiology, 96(3), 1–17. https://doi.org/10.1152/jn.00468.2006
- Karpati, F. J., Giacosa, C., Foster, N. E. V., Penhune, V. B., & Hyde, K. L. (2015). Dance and the brain: A review. Annals of the New York Academy of Sciences, 1337(1), 140–146. https://doi.org/10.1111/nyas.12632
- Kibler, W. B., Press, J., & Sciascia, A. (2006). The role of core stability in athletic function. Sports Medicine, 36(3), 189–198. https://doi.org/10.2165/00007256-200636030-00001
- Koch, S. C., Kunz, T., Lykou, S., & Cruz, R. (2019). Effects of dance movement therapy and dance on health-related psychological outcomes: A meta-analysis. The Arts in Psychotherapy, 63, 85–94. https://doi.org/10.1016/j.aip.2019.03.002
- Lu, X., Zhang, Y., Li, J., & Wang, W. (2024). Effects of dance interventions on physical function, postural control, and quality of life in middle-aged and older adults: A systematic review. Journal of Aging and Physical Activity.
- Massion, J. (1992). Movement, posture and equilibrium: Interaction and coordination. Progress in Neurobiology, 38(1), 35–56. https://doi.org/10.1016/0301-0082(92)90034-C
- Peterka, R. J. (2002). Sensorimotor integration in human postural control. Journal of Neurophysiology, 88(3), 1097–1118. https://doi.org/10.1152/jn.2002.88.3.1097
- Powell, L. E., & Myers, A. M. (1995). The Activities-specific Balance Confidence (ABC) Scale. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 50A(1), M28–M34. https://doi.org/10.1093/gerona/50A.1.M28
- Ribeiro, A. S., & Oliveira, L. P. (2021). Dance-based movement interventions and postural balance: A systematic review. Journal of Bodywork and Movement Therapies, 25, 206–214. https://doi.org/10.1016/j.jbmt.2020.11.012

- Shumway-Cook, A., & Woollacott, M. H. (2017). Motor control: Translating research into clinical practice (5th ed.). Wolters Kluwer.
- Teixeira-Machado, L., DeSantana, J. M., & Dantas, E. H. M. (2019). Dance improves cognitive, motor, and brain plasticity in healthy older adults: A systematic review. Neuroscience & Biobehavioral Reviews, 103, 162–172. https://doi.org/10.1016/j.neubiorev.2019.06.011
- Tinetti, M. E. (1986). Performance-based assessment of mobility and balance. Journal of the American Geriatrics Society, 34(2), 119–126. https://doi.org/10.1111/j.1532-5415.1986.tb05480.x
- Wu, X., Xiong, L., Zheng, H., & Wang, L. (2022). Dance movement therapy for neurodegenerative diseases: A systematic review. Neurorehabilitation and Neural Repair. httsps://doi.org/10.1177/15459683221110539.

ANALYSIS OF POTENTIAL ENERGY CONVERSION AND POWER GENERATION EFFICIENCY AT HOOVER DAM HYDROELECTRIC PLANT

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ABSTRACT

This study investigates the mechanisms and efficiency of potential energy conversion into electrical energy at the Hoover Dam Hydroelectric Plant. Although hydropower is theoretically capable of achieving near-perfect efficiency, real-world systems experience significant losses due to hydraulic friction, turbulence, mechanical dissipation in turbines, and electrical losses in generators. Using high-resolution Supervisory Control and Data Acquisition (SCADA) data, the research analyzes key operational parameters including water discharge (Q), hydraulic head (H), turbine settings, and generator output (Pe). Data were preprocessed through synchronization, resampling, and calibration, yielding a clean and uniform dataset suitable for quantitative modeling.

The methodology integrates fundamental physical laws, such as energy conservation and fluid dynamics, with efficiency models that decompose overall performance into hydraulic (ηh), volumetric (ηv), and generator (ηg) efficiencies. Simulation results highlight that Hoover Dam's historical efficiency, once estimated at approximately 82%, has improved to nearly 87% through modernization efforts, including advanced turbines and optimized wicket gate systems. Nevertheless, analysis indicates that around 20–25% of theoretical potential energy is still lost during the conversion chain. Computational Fluid Dynamics (CFD) simulations further suggest that mitigating turbulence and optimizing penstock flow distribution could improve efficiency by an additional 1.5–2%.

The findings demonstrate that even marginal improvements in hydraulic and mechanical performance can yield substantial energy gains—equivalent to powering tens of thousands of households annually. Beyond Hoover Dam, this study provides a transferable framework for assessing efficiency in other large-scale hydroelectric facilities and offers practical insights for modernization, design optimization, and sustainable energy policy.

Keywords: Hoover Dam, hydropower efficiency, SCADA data, potential energy conversion, CFD simulation, turbine optimization

THE EFFECTS OF A YOGA PROGRAM ON SYMPTOMS IN YOUNG WOMEN WITH PRIMARY DYSMENORRHEA: PARTICIPANT EXPERIENCES

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ABSTRACT

Objective: This study aimed to investigate the effects of a yoga program on self-reported menstrual pain management, bodily changes, emotional well-being, and self-awareness among young women with primary dysmenorrhea.

Methods: Thirty young women diagnosed with primary dysmenorrhea participated in the study. Participants attended an 8-week yoga program, consisting of two 45-minute sessions per week. The program included physical postures (asana), breath-control techniques (pranayama), and exercises focused on body awareness. Following the program, focus group interviews were conducted to collect qualitative data regarding participants' experiences. Data were analyzed using thematic analysis, resulting in four main themes: menstrual pain management, bodily relaxation, emotional well-being, and self-awareness.

Results: Participants reported that yoga practices were effective in managing menstrual pain and provided relief in the lower abdomen and lower back regions. In terms of bodily perception, relaxation, lightness, increased flexibility, and overall comfort were emphasized. Emotionally, yoga was associated with feelings of calmness, happiness, increased energy, and psychological well-being. Additionally, participants reported improvements in body awareness, self-appreciation, breath control, and motivation for exercise.

Conclusion: The yoga program demonstrated positive effects on menstrual pain management, bodily relaxation, emotional well-being, and self-awareness in young women with primary dysmenorrhea. These findings suggest that yoga and similar body awareness exercises can be effective interventions to support women's health.

Keywords: Primary dysmenorrhea, Yoga, Women, Body awareness, Emotional well-being, Self-awareness

EVALUATION OF DYSMENORRHEA-RELATED AWARENESS LEVELS AND PAIN INTENSITY IN YOUNG WOMEN WITH PRIMARY DYSMENORRHEA

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ABSTRACT

Primary dysmenorrhea, defined as menstrual pain in the absence of identifiable pelvic pathology, is a common gynecological condition among young women. It is frequently associated with cramp-like pelvic pain, as well as lower back, hip, and headache symptoms, and can significantly affect daily comfort and well-being. Despite its high prevalence, knowledge and awareness regarding symptom management among affected women remain underexplored.

This study aimed to evaluate dysmenorrhea-related awareness and pain intensity in young women with primary dysmenorrhea. A total of 46 female participants (mean age 19.32±1.41 years) diagnosed with primary dysmenorrhea were included. Demographic data were recorded, and participants completed a 10-item structured questionnaire assessing their awareness of dysmenorrhea and pain management strategies. Pain intensity and regional pain distribution were measured using the Visual Analog Scale (VAS).

Results indicated a mean overall pain intensity of 6.66±2.19. Regional assessments revealed mean scores of 7.15±1.89 for hip pain, 6.65±2.12 for lower back pain, and 4.39±2.74 for headache. The mean score on the dysmenorrhea awareness questionnaire was 7.15±2.05, corresponding to a moderate level of awareness.

These findings demonstrate that although young women with primary dysmenorrhea experience significant pain, their awareness regarding the condition and strategies for symptom management remains limited. The results highlight the need for targeted educational interventions to improve understanding of dysmenorrhea and support effective self-management among this population.

Keywords: Primary dysmenorrhea, Pain intensity, Dysmenorrhea awareness, Women, Menstrual pain.

COMBUSTION EFFICIENCY ENHANCEMENT AND CARBON DEPOSIT CONTROL IN MARINE DIESEL ENGINES USING AN AUTOMATED FUEL TREATMENT SYSTEM

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ABSTRACT

This study represents an innovative approach aimed at fundamentally transforming the maintenance and operational efficiency of marine diesel engines by rethinking the monitoring and management of engine fouling. It addresses one of the most critical challenges in the maritime sector: the formation of carbon deposits resulting from incomplete combustion. The study proposes an automated solution for removing these deposits, based on the integration of sensors and precise detection thresholds.

At the heart of this system, a programmable logic controller (PLC) manages the operation of all components in real time, enabling continuous engine condition monitoring, significant performance improvements, and a reduction of pollutant emissions such as carbon monoxide (CO) and unburned hydrocarbons (HC). The system stands out for its ability to tackle engine fouling, extend engine lifespan, reduce maintenance costs, and ensure consistent performance.

This investigation introduces a novel approach to energy management in marine engines, combining optimal performance, sustainability, and compliance with environmental standards. It lays out a clear roadmap toward cleaner, more efficient, and environmentally responsible operation, providing stakeholders in the sector with a tangible solution to the current challenges of reliability, efficiency, and ecological responsibility.

Keywords: Marine diesel engines; Carbon deposit removal; Automated monitoring system; Emission reduction

INTRODUCTION

In the maritime fishing sector, diesel engines are the lifeblood of vessels. Their reliability, performance, and fuel efficiency directly determine the success of offshore operations. Despite their robustness, these engines face a common technical challenge: fouling by carbon deposits. This soot and carbon residue gradually accumulates in combustion chambers, injectors, valves, and other critical components, disrupting normal engine operation [2,5].

This phenomenon, well known to chief engineers, also affects fuel consumption, reduces equipment lifespan, and can result in significant costs associated with repairs or full engine overhauls [5,3]. Therefore, it is essential to explore practical solutions that can not only prevent the formation of these deposits but also remove them effectively.

One promising approach involves the development of automated systems for carbon deposit removal. These systems typically inject controlled amounts of specific fuel additives directly into the diesel fuel, designed to dissolve existing deposits and enhance combustion efficiency. Unlike heavy mechanical interventions, such as comprehensive engine maintenance, this non-invasive method allows continuous operation, minimizing downtime while extending engine service life [2,3].

From an economic standpoint, improving fuel efficiency and reducing maintenance interventions can decrease operating costs by 10–15% annually for medium-sized vessels. Additionally, such systems require minimal modifications to existing engine configurations, making them accessible even for vessels with limited technical infrastructure [2].

Beyond technical and economic benefits, this approach contributes to more sustainable maritime operations. By improving combustion, it reduces emissions of fine particles (PM2.5), carbon monoxide (CO), and unburned hydrocarbons (HC) by up to 20%, while also decreasing fuel consumption by 2–4%, supporting better resource management and cleaner vessel operation [1,5].

CARBON DEPOSIT FORMATION IN INTERNAL COMBUSTION DIESEL ENGINES

Carbon deposits often referred to as “soot” or “coking,” are dark residues that develop mainly because of incomplete combustion in diesel engines. These deposits consist primarily of unburned hydrocarbons from the fuel and, in some cases, traces of engine oil. When exposed to the high temperatures within the engine, these compounds crystallize and adhere to the surfaces of critical components, including the intake and exhaust valves, cylinder walls, fuel injectors, and exhaust passages [1, 2].

The formation of carbon deposits is directly linked to imperfect combustion of the air-fuel mixture, which is essential for diesel engine operation. During the combustion process, a portion of the fuel does not burn completely, producing hydrocarbon residues that mix with exhaust gases and, occasionally, with lubricating oil present in the combustion chamber. Over time, these residues accumulate, gradually forming significant carbon deposits [3, 4].

Carbon deposits are black, carbon-rich residues that form inside diesel engines, particularly on fuel injectors, valves, cylinder walls, and within the exhaust passages (see figure 1). They result primarily from incomplete combustion of the fuel, typically diesel, and over time can lead to



mechanical malfunctions, reduced engine performance, and increased fuel consumption.

Figure 1: Piston, valves and **:** Injectors contaminated with carbon deposits resulting from incomplete combustion (Real case from a fishing vessel)

Several factors contribute to the formation of these deposits, including:

- Combustion: Diesel engines rely entirely on internal combustion to generate power. Specifically, the air-diesel mixture in the combustion chamber produces the explosion that drives the engine. However, incomplete combustion can occur due to low temperatures, poor air-fuel mixing, or irregular engine operation, leaving partially burned fuel that forms soot;
- Fuel quality**:** The quality of diesel fuel is critical for engine performance. Low-grade fuel containing impurities, high sulfur levels, or imbalanced chemical properties increases the likelihood of incomplete combustion. This results in more soot and carbon residues that accumulate on injectors, valves, cylinder walls, and exhaust passages;
- Lubricating oil contamination: Oil entering the combustion chamber from worn piston rings, faulty valve guides, or insufficient lubrication can partially burn under high temperatures. This process generates soot that combines with other residues, forming carbon deposits over time on pistons, valves, and cylinder walls;
- Other causes: Several additional factors contribute to carbon deposit formation. A fuel-rich mixture, where more fuel is injected than can be fully burned with the available air, produces unburned residues that adhere to internal engine surfaces.

The presence of these deposits can substantially reduce engine performance by lowering thermal efficiency, increasing fuel consumption, and, in severe cases, causing mechanical failures. A thorough understanding of the mechanisms behind carbon formation is therefore essential for implementing effective control measures, such as the use of fuel additives, optimization of injection timing, and routine maintenance practices [1, 5]. The table 1 below summarizes the main effects of these carbon deposits on diesel engine performance.

Table 1: Impact of Carbon Deposits on the Performance of Diesel Engines

Consequences	***Description***
Loss of power	Carbon deposits accumulating on internal components such as valves, injectors, or piston heads disrupt optimal engine operation. Partial obstruction of these elements affects the proper air-fuel mixture, preventing complete combustion. As a result, the engine cannot develop its full power, leading to a significant drop in performance.
Increased fuel consumption	To compensate for the loss of power caused by carbon deposits, the engine injects additional fuel in an attempt to maintain the same performance level, resulting in higher fuel consumption.
Difficult starts and rregular operation	Accumulated deposits in the combustion chambers interfere with the ignition of the air-fuel mixture. This obstruction reduces the efficiency of the initial explosion, leading to hard starts, vibrations during ignition, and unstable or irregular idling.
Premature engine wear	Over time, carbon deposits form an abrasive layer inside the engine. This layer increases friction between components, particularly valves, piston rings, and injectors, acting as a wear agent and significantly reducing the engine's lifespan.
Increased vibrations and engine noise	When the engine is fouled by carbon deposits, accumulated residues disrupt the combustion cycle and the fine mechanics of the engine. This causes rougher operation and a noticeable increase in engine noise.

The buildup of carbon deposits can cause premature wear of engine components, raise maintenance costs, and have significant environmental consequences. The table 2 presents the main economic impacts associated with the formation of carbon deposits.

Table 2: Economic Impacts of Carbon Deposits

Economic Impacts	***Description***
Cost of internal engine components	Carbon deposits accumulate on critical components such as valves and their seats, injectors, pistons, and cylinder liners. Over time, these deposits cause wear, malfunctions, or failures. Repairing or replacing these parts can be expensive, depending on the extent of the damage.
Cost related to turbocharger issues	Carbon deposits do not stop at the combustion chamber; they also affect the exhaust system, directly impacting the turbocharger, particularly the turbine blades. This can cause imbalance, reduced turbo efficiency, or even complete failure.
Cost due to increased fuel consumption	Engines fouled by carbon deposits lose efficiency. To compensate for the power loss, the fuel injection system increases fuel flow, resulting in overconsumption estimated between 5% and 15%. This can represent hundreds of extra liters of diesel per month, significantly increasing operational costs.
Additional maintenance costs	To prevent these issues, shipowners schedule regular manual decarbonization procedures. While preventive, these operations add recurring costs on top of standard engine maintenance.

Also, Carbon deposits in diesel engines, along with certain chemical compounds in diesel fuel, lead to incomplete combustion. This inefficient combustion produces exhaust smoke. The table 3 below summarizes the main environmental impacts associated with the accumulation of carbon deposits in the engine.

Table 3: Environmental Impacts of Carbon Deposits

Environmental Impacts	***Description***
Increased pollutant emissions	Carbon deposits lead to incomplete combustion of diesel fuel, producing higher levels of carbon monoxide (CO), unburned hydrocarbons (HC), and fine particulate matter.
Higher NOx emissions	Fouling alters the combustion temperature, promoting the formation of nitrogen oxides (NOx), which are highly harmful to both the environment and human health.
Black smoke from the exhaust	Engines affected by carbon deposits emit more visible black smoke, a clear sign of poor combustion that contributes to air pollution.

Decarbonization is essential for preventing diesel engines from becoming clogged. Chemical methods, mechanical techniques, or hydrogen injection each have their strengths, but they also come with limitations in terms of effectiveness, cost, complexity, and suitability for different types of engines. This underscores the need for a complete solution that is both preventive and corrective, and ideally automated. Such a system could intelligently treat the fuel, reduce the buildup of carbon deposits, and ensure the engine runs efficiently and reliably over the long term.

INNOVATIVE DESIGN OF AN AUTOMATED DIESEL FUEL MANAGEMENT SYSTEM FOR IMPROVED ENGINE EFFICIENCY

In this section, we present a study and the design of an innovative automatic system for treating the quality of diesel fuel used in marine engines. This system has been developed to combat the formation of carbon deposits inside the combustion chambers, which cause engine fouling, reduced performance, and increased pollutant emissions. Additionally, we distributed a questionnaire to gather the opinions of chief engineers on deep-sea fishing vessels regarding this system. Their feedback was positive, which encouraged us to continue and further pursue this investigation.

Technical Description of the System: The system's architecture is a fundamental element, as it defines how the device is integrated into the fuel supply circuit on board the vessels. The architecture of the system is illustrated in figure 4. This treatment device will perform periodic fuel conditioning based on the fouling condition of the marine diesel engine. It will be installed in parallel with the main fuel supply circuit. It is mainly composed of :

– Treatment Line: This line is responsible for injecting the fuel treatment product. Its activation depends on the fouling condition of the engine, automatically initiating the operation when needed.

– Recycling Line: This line ensures the recycling of fuel from the start of the treatment process, maintaining the supply of treated fuel to the diesel engine and ensuring continuous cleaning.

In this diesel fuel quality treatment system, a chemical process is employed using additives designed to remove carbon deposits formed in the internal components of marine diesel engines. This treatment is carried out by injecting a specific additive formulated to effectively clean these deposits. The additive used is BG 245 Premium Diesel Fuel System Cleaner, which is recognized for its ability to dissolve residues and restore engine performance. This high-performance cleaning additive is specially formulated for diesel engines, helping to restore and maintain fuel system efficiency, improve combustion, and eliminate internal deposits caused by fuel fouling. It acts directly on: the cleaning of fuel injectors; the removal of carbon deposits in the combustion chambers and other fouled engine components; the reduction of pollutant emissions (CO, HC, particulate matter); the improvement of diesel combustion, even in the presence of heavy molecules. It stands out for its performance in several areas: the effectiveness of cleaning components fouled by carbon deposits, improvement of internal component lubrication, optimization of combustion quality, and the prolonged action of the product. Moreover, it is fully compatible with automatic treatment systems, making it particularly well suited for use in my system.

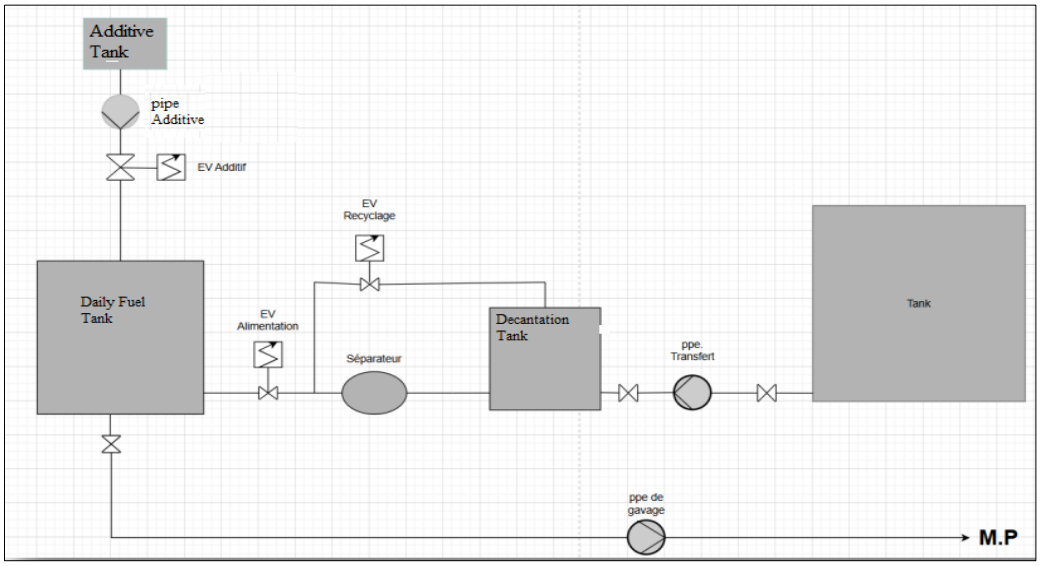


Figure 4: System Integration Diagram

Description of the Components of the Studied System:

1. **Additive Tank:** A small reservoir dedicated to storing the treatment additive, it is central to the automatic system. Made of 316 austenitic stainless steel, it offers excellent corrosion resistance, chemical compatibility with fuels and additives like BG 245, and strong mechanical and thermal properties. Its design ensures durability and safe storage in harsh maritime environments. The tank dimensions depend on the amount of diesel to be treated, which determines the required additive volume. For effective cleaning of marine diesel engine components, two tons of diesel is sufficient. Considering diesel's density (≈0.832 kg/L at 15 °C), the required tank volume can be calculated accordingly.

We have the following data: 1 tonne = 1,000 kg and Density ≈ 0.832 kg/L. Therefore, the volume of 1 tonne of diesel can be calculated as:

$$\text{Volume (L)} = \frac{2000\ \text{kg}}{0,832\ \text{kg/L}} \approx 2\,403,85\ \text{litres}$$

For 2 tonnes of diesel, the volume would be approximately ≈ 2 404 liters.

Next, the required amount of additive for this volume of diesel is calculated. The quantity of **BG 245** to be added depends on the manufacturer's recommended dosage, which is: 1 dose = 325 mL for 75 L of diesel fuel.

$$\frac{2\,404\ \text{L}}{75\ \text{L}} \approx 32,05\ \text{doses}$$

$$32,05 \times 325\ \text{ml} \approx 10\,416\ \text{ml} = 10,42\ \text{litres}$$

Therefore, to treat 2 tonnes of diesel (≈2,404 L), approximately 10.4 liters of the BG 245 additive are required. This volume helps determine the required size of the additive tank for effective treatment.

We aim to store in this tank a quantity of additive equal to 10.4 L × 3 = 31.2 L of BG 245. This amount is sufficient for the duration of the voyage, and if it is depleted, additional additive can be added to the tank. We have: 31.2 liters = 31,200 cm³. Thus, the dimensions of this tank in centimeters (cm) are shown in the table below:

Table 4: Study of the Additive Tank Dimensions

Length (L)	Width (W)	Height (H)	Total Volume
40 cm	30 cm	26 cm	31,200 cm³ (31.2 L)
50 cm	25 cm	25 cm	31,250 cm³ (31.25 L)
60 cm	30 cm	18 cm	32,400 cm³ (32.4 L)

2. **Additive Pump :** This pump transfers the additive from the additive tank to the daily tank, where it mixes with diesel. It is a constant-flow pump, ensuring a stable and precise additive dosage.

3. **Additive Solenoid Valve:** This electromechanical component controls the opening and closing of the additive flow from the additive pump to the daily tank, based on commands from the automation system.

4. **Supply Solenoid Valve:** This solenoid valve primarily ensures the supply of fuel to the daily tank, operating according to commands from the automation system.

5. **Recycling Solenoid Valve**: This solenoid valve enables the recycling of diesel from the separator back to the decantation tank, while stopping the supply to the daily tank.

6. **Cylinder Temperature Sensor:** A type K thermocouple that monitors cylinder temperature, with a transmitter converting its signal for PLC compatibility.

7. **Combustion Pressure Sensor:** The Kistler 6054CU20 piezoelectric sensor continuously monitors cylinder pressure and sends an amplified signal to the PLC for real-time analysis.

8. **CO and HC Emissions Sensor:** An NDIR sensor that monitors CO and HC levels, using a heated sampling system and condensate trap to provide reliable signals to the PLC.

9. **Level Sensor:** A float-type sensor that continuously monitors diesel levels in the daily tank and sends a standard analog signal to the PLC to control fuel supply.

10. **Audible Alarm:** A sound alarm that notifies the watch officer in the engine room when the treatment system has started.

11. **Indicator Lamps:** Visual indicators that show the operating status of certain system components.

12. **Switch:** A component used to control the start or stop of fuel supply to the daily tank.

13. **Programmable Logic Controller (PLC)**: The PLC is an electronic device used to automate industrial processes. It consists of a **CPU** for program execution, **I/O modules** for sensors and actuators, **memory** for storing programs and process data, and **communication modules** for connecting with other devices. In this project, the PLC continuously monitors the system and executes programmed tasks based on input values.

System Power Diagram: Shows the electrical connections that provide stable and safe power to all system components.

PLC Control Diagram: The PLC wiring diagram shows how the system's components are connected to the programmable logic controller, including inputs (sensors, switches) and outputs (actuators, solenoid valves, alarms). This wiring allows the PLC to receive the information needed to control the process and operate the equipment according to the programmed instructions. The PLC control diagram for the automatic treatment system is shown in Figure 5.

Operating Principle of the System: This system is designed to provide automatic fuel treatment to eliminate carbon deposits in the combustion chambers, which otherwise cause fouling, reduced

engine performance, and economic and environmental impacts. The entire system is controlled by a PLC, which executes the Ladder program based on sensor inputs. The operation can be summarized as follows: the PLC continuously monitors sensor signals and compares them to predefined thresholds. When abnormal conditions are detected, it triggers the additive pump and corresponding solenoid valves to inject the treatment into the daily tank. Indicator lamps and an audible alarm notify the watch officer of system status, while level sensors and control logic manage fuel supply and recycling. Safety measures, including emission temperature monitoring and controlled heating cables, ensure reliable, secure, and fully automated operation.

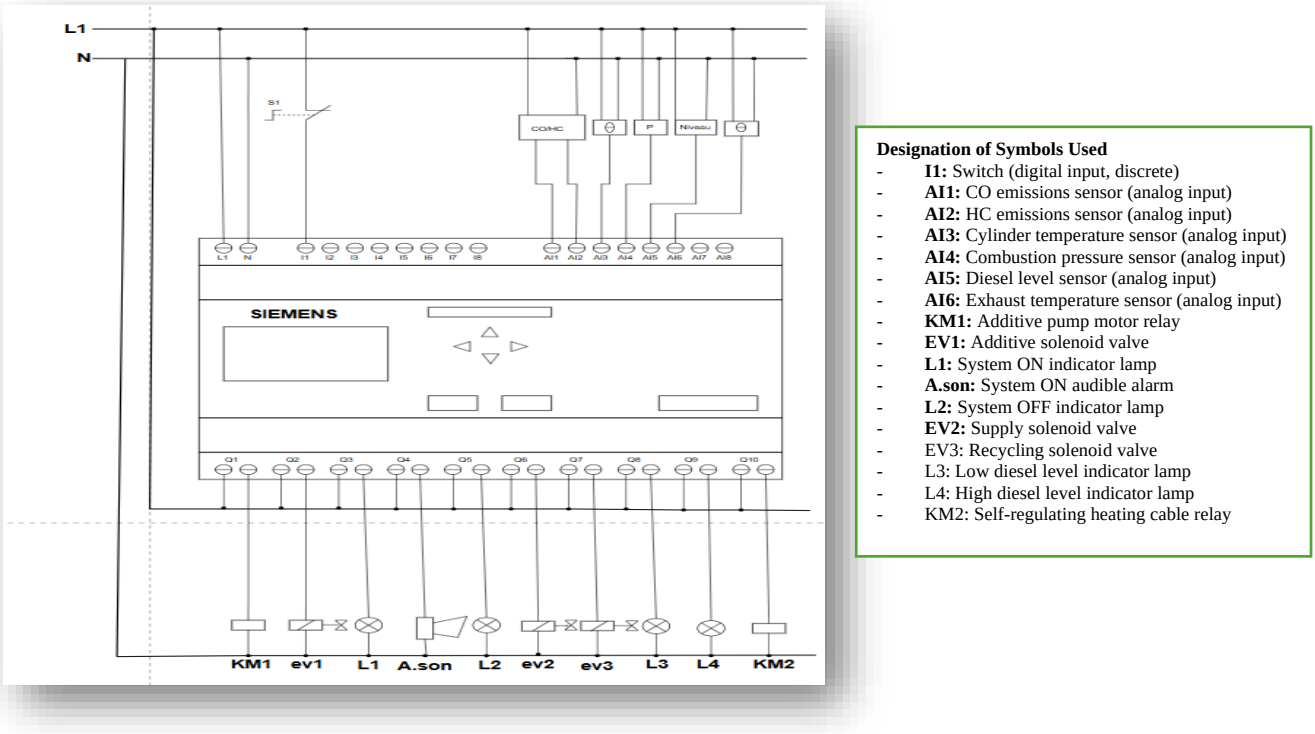


Figure 4: System Integration Diagram

GRAFCET Diagram: is a fundamental tool for representing, in a structured and logical way, the different operating steps of a system. It allows visualization of the sequences of actions to be executed based on the system's states. This representation helps to understand the overall behavior of the system and ensures consistent management of transitions and operations. The following GRAFCET diagram in figure 5 illustrates the operating logic of this system.

RESULTS AND DISCUSSION

The proposed automatic fuel treatment system was evaluated to determine its effect on the performance of marine diesel engines, deposit reduction, and combustion efficiency. The results show a significant improvement in engine operation after implementing the system. Improved fuel quality leads to more homogeneous combustion, increasing thermal efficiency by **10–15%** and engine power by **8–12%**.

The system also reduces carbon deposit formation in critical components such as injectors and combustion chambers by approximately **30–40%**, which enhances engine reliability and extends maintenance intervals by **20–25%**. In addition, the optimization of combustion decreases fuel consumption by **5–12%**. Environmental performance is also improved, with reductions of **20–**

30% in CO and HC emissions and up to **35%** in particulate matter. Overall, the system enhances engine efficiency, reliability, and environmental performance while reducing operational costs.

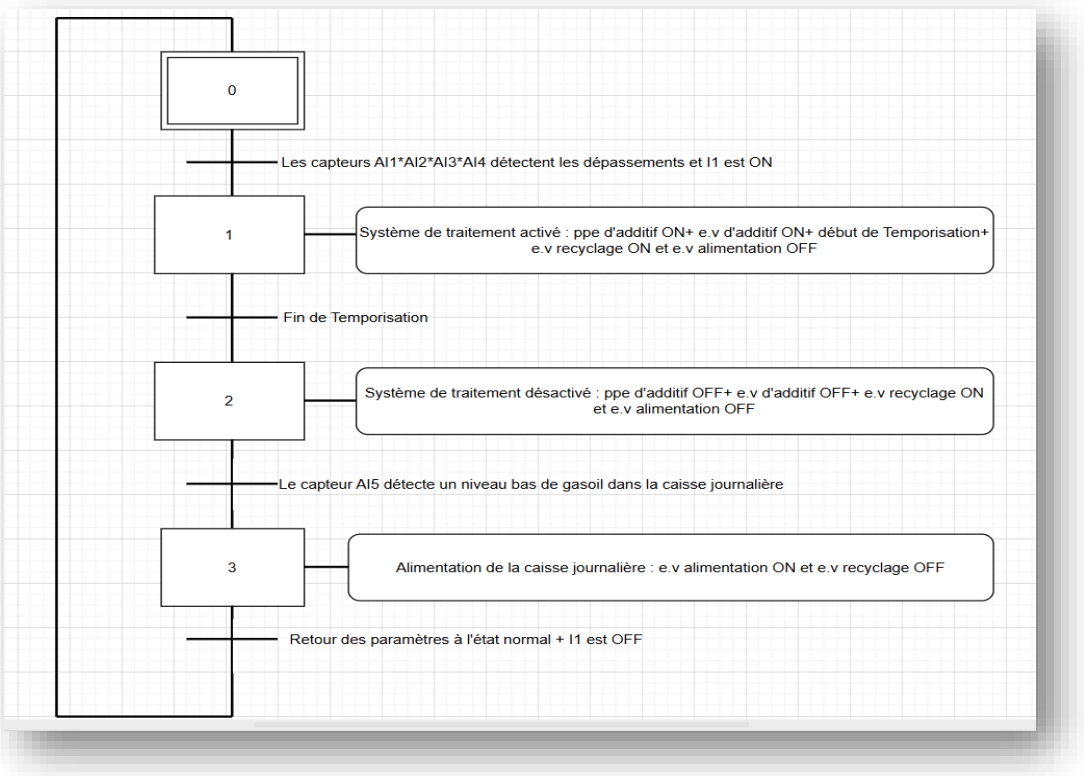


Figure 5: GRAFCET Diagram of the System

CONCLUSION

This study addresses the problem of fouling in marine diesel engines caused by carbon deposit formation resulting from incomplete fuel combustion. This issue leads to reduced engine performance, increased fuel consumption, and higher pollutant emissions. The study led to the design of an automatic diesel fuel treatment system based on sensors, actuators, and a programmable logic controller. This system monitors and improves fuel quality in order to limit deposit formation. Consequently, it helps improve engine efficiency, reduce maintenance costs, and minimize environmental impact.

REFERENCE

Corbin J.C., Mensah A.A., Pieber S.M., et al. 2018. Trace Metals in Soot and PM2.5 from Heavy Fuel Oil Combustion in a Marine Engine. *Environmental Science & Technology*, 52(11):6714–6722.

Jeong S., Bendl J., Saraji Bozorgzad M., et al. 2023. Aerosol emissions from a marine diesel engine running on different fuels and effects of exhaust gas cleaning measures. *Environmental Pollution*, 316(Pt 1):120526.

Reynolds T. 1995. The Effect Of Using An Additive On The Combustion Behaviour And Soot Emission Of Marine Fuels. *WIT Transactions on The Built Environment*, 12:10306.

Wang X., Ni P. 2022. Soot Distribution and Thermal Regeneration of Marine Diesel Particulate Filter. *Energy Engineering*, 119(4):1697–1710.

Zheng C., Wang Y., Zhou C., Liu C., Gao X., Shao L., Zhou Z., Wu Z. 2024. Advancing Marine Post Combustion Soot Control: Diesel Engine Particles and Soot Capture through Electrostatic Enhanced Filtration. *Process Safety and Environmental Protection*, 190:622–630.

A MEASUREMENT SYSTEM PLANNED TO BE DEVELOPED FOR THE REAL-TIME MONITORING OF SHIP-GENERATED AIR POLLUTION IN NARROW WATER CHANNELS WITH HIGH MARITIME TRAFFIC

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ABSTRACT

In many countries, densely populated areas are generally located around narrow, natural or man-made waterways, and hundreds of thousands of people live in these areas. In these waterways, where ship traffic is particularly heavy, the amount of emissions from marine vessels sometimes leads to very serious air pollution. In very narrow and long waterways like the Bosphorus, the increase in emissions from ships sometimes reaches serious levels. To measure this pollution and transmit this data instantly to control centers on land, it is necessary to first place sensors on the sea. Furthermore, the data obtained from these sensors must be transmitted instantly to centers on land. By evaluating the emission data collected at this center using an Artificial Intelligence application, it will be possible to intervene against ships causing air pollution as soon as possible. Two different systems can be used to transmit air pollution data to land. The first is marine radio communication systems, and the second is mobile systems such as 4G/5G. In evaluating these two systems;

- Data latency can be brought close to 1 ms, especially in 5G systems,
- Communication can be made up to a maximum distance of 3-4 km from the shore with 4G/5G systems, and 60-70 km with VHF,
- Since air pollution data in narrow water areas is not very large in volume and does not require high speed, the most suitable system for this purpose is the VHF radio system,
- There is no need to establish a separate VHF system on the Turkish coasts for this purpose, as there is a VHF network operated by the General Directorate of Coastal Safety in Turkey covering our entire coastline,
- Therefore, for the targeted system, the existing VHF infrastructure should be used first, and if the sea area to be controlled is 3-4 km, a model can be developed where mobile communication systems can also be used for this coverage,
- A computer system that stores the data collected from the emission measurement sensors and an Artificial Intelligence system that will evaluate the collected data should be established,
- According to the evaluated data, it will be possible to minimize marine pollution values by instantly intervening in the ships determined to cause pollution.

Keywords: Air Pollution, Mobile Communication Systems, VHF Radio System, Pollution Sensors, Artificial Intelligence Applications

GREEN VALORIZATION OF FOOD WASTES: ANTIOXIDANT POTENTIAL OF DEEP EUTECTIC SOLVENT EXTRACTS

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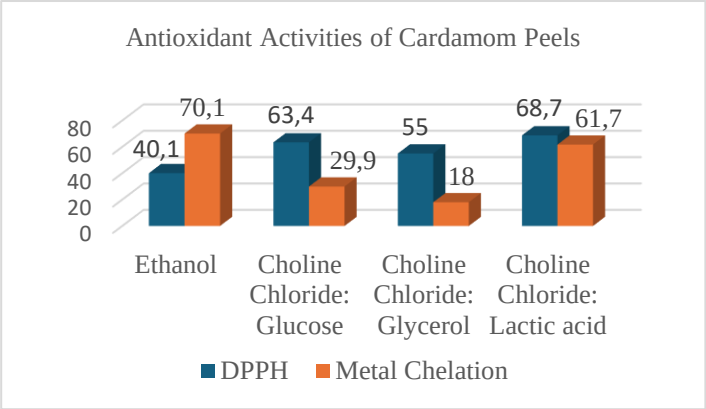
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ABSTRACT

All plant-based foods contain phenolic compounds in varying amounts and compositions. Previous studies have demonstrated that the consumption of bioactive compounds, particularly phenolic compounds with antioxidant properties, may play a potential role in reducing the incidence of certain degenerative diseases. Bioactive compounds present in food wastes—such as seeds, leaves, pomace, peels, and stems—can be recovered using different technologies and subsequently utilized in the production of functional foods. Considering the increasing global population and food consumption, the valorization of food waste is of great importance; likewise, the use of sustainable and environmentally friendly methods in experimental studies is equally essential.

In this study, the antioxidant effects of waste cardamom materials derived from cardamom, commonly used in food preparation, were investigated in terms of DPPH radical scavenging activity and metal chelating capacity. For the extraction of bioactive compounds from these wastes, Deep Eutectic Solvents (DES), which stand out due to their biodegradable and sustainable properties, were employed in combination with Ultrasound-Assisted Extraction (UAE). The obtained results were compared with those achieved using ethanol as a conventional solvent. For the extraction procedures, choline chloride–lactic acid (ChCl:La) (1:2), choline chloride–glycerol (ChCl:Gly) (1:2), and choline chloride–glucose (ChCl:Glu) (1:1) solvent mixtures were selected as DES.

The results demonstrated that the highest DPPH radical scavenging activity was achieved using the ChCl:La solvent (68.7%), followed by ChCl:Glu (63.4%). Regarding metal chelating capacity, the highest value was observed with ethanol (70.1%), while the ChCl:La solvent exhibited a comparable activity (61.7%). Overall, these findings indicate that sustainable deep eutectic solvents represent a promising alternative to conventional solvents for the valorization of food waste and contribute significantly to the advancement of green chemistry.



Keywords: Deep eutectic solvents, food waste**,** ultrasound assisted extraction, sustainable solvent

* The data presented in this study were generated within the scope of a TÜBİTAK 2209-A Student Research Project.

FROM POLICY AMBITION TO BUSINESS PRACTICE: EMPIRICAL EVIDENCE ON CIRCULAR ECONOMY IMPLEMENTATION IN THE EUROPEAN UNION

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ABSTRACT

The transition to a circular economy has become one of the defining elements of the European Union's sustainability policy in recent years. While traditional environmental regulation primarily focused on managing environmental burdens at the end of production and consumption processes, the logic of the circular economy prioritises structural transformation of economic operations. This approach considers the entire lifecycle of products and materials as relevant from a regulatory perspective, from design and production through consumption to the post-use phase.

This study examines how the legal framework for the circular economy has developed in the European Union and what role classical instruments of state regulation, economic incentives, and self-regulatory and co-regulatory solutions play in this framework. The research combines legal-doctrinal and policy analysis with quantitative analysis based on Eurostat's harmonised indicators. The study covers sustainable product policy, ecodesign regulation, waste management frameworks, and the regulatory conditions of secondary raw materials markets.

The quantitative analysis examines the relationship between circular material use rates (2015–2023) and regulatory stringency across EU-27 Member States. The results reveal substantial cross-country heterogeneity: while the Netherlands achieved a 30.6% circular material use rate, Romania reached only 1.3% in 2023. Regulatory stringency alone does not guarantee better performance; higher circularity rates are consistently associated with stronger institutional capacity, more effective enforcement, and complementary market-based incentives.

Based on the analysed data and legal frameworks, it can be established that the European Union has gradually developed a complex, lifecycle-based regulatory model in recent years. The changes have not remained purely at the normative level: increases in recycling rates, improvements in resource productivity, and expansion of economic activities related to the circular economy indicate that regulatory frameworks are indeed shaping economic operations. The study concludes that the effectiveness of the European Union's circular economy model depends not only on the quality of legislation but also on the extent to which EU framework regulations, Member State implementation, and economic actors' cooperation can sustainably build upon each other.

Keywords: circular economy; European Union law; policy instruments; regulatory effectiveness; empirical analysis; Member State implementation

INTRODUCTION

Over the last decade, the concept of the circular economy has emerged as a cornerstone principle that not only shapes economic policy but also informs legislative frameworks in the increasingly critical discourse surrounding sustainable development. Thereby fostering a paradigm shift that emphasizes resource efficiency and waste reduction across various sectors.

The notion arose from a critical examination of the linear economic paradigm. These relies on the extraction of natural resources, their subsequent processing, and the subsequent classification of products as waste post-consumption. The "take–make–dispose" logic long appeared as the self-evident operational order of industrial societies, but its sustainability constraints have become increasingly evident. The finiteness of resources, the growth of waste generation, and the intensification of environmental burdens all indicated that the linear structure is unsustainable in the long term, either economically or ecologically. Conversely, the circular economy seeks to prolong the utility of products, materials, and resources within the economic system for the maximum duration feasible (Geissdoerfer et al., 2017; Stahel, 2016). At the centre of this approach is the idea that material flows should lose as little of their economic utility as possible, meaning that reuse, repair, remanufacturing, and recycling should appear not as exceptional solutions but as integral parts of economic operations (Kirchherr et al., 2017).

However, the transition to a circular economy cannot be understood merely as technological or business innovation (Lacy and Rutqvist, 2015). The transformation of economic structures necessarily entails a reorganisation of regulatory frameworks. Law does not simply react to these changes but is itself a formative factor: it delineates the room for manoeuvre of market actors, determines the system of obligations and incentives, and institutionalises those normative expectations that are connected to the sustainable transition. In recent times, the idea of the circular economy has seen considerable evolution. Whereas previous frameworks predominantly emphasized waste minimization and recycling initiatives, modern interpretations (Ghisellini et al., 2016; Korhonen et al., 2018; Murray et al., 2017) employ a more comprehensive, systems-oriented approach Agreeing with Prieto-Sandoval et al.'s (2018) opinion the consensus definition of the circular economy comprises three key elements: keeping resources in economic circulation, value retention, and minimising environmental burdens. McDowall et al. (2017) also point out that European and Asian – particularly Chinese – regulatory models differ significantly, which can be explained by cultural and institutional differences, and which also indicates that the normative content of the circular economy is not independent of the given regulatory context.

The European Union has taken on a defining role in promoting this process in recent years. The European Green Deal (European Commission, 2019) and the circular economy action plans (European Commission, 2015; 2020) have created a comprehensive policy and regulatory framework that treats the development of a resource-efficient economic model not as a narrowly defined environmental task but as an economic structural challenge. One of the most important features of this approach is the foregrounding of lifecycle thinking: regulation considers the entire lifecycle of products, from design and production through consumption to the post-use phase. This practice resonates with the sustainability matters intertwined with the exploitation of global reserves. (United Nations Environment Programme, 2019) and the priorities identified by the European Environment Agency (European Environment Agency, 2022).

Another characteristic of the EU regulatory model is that it operates within a multilevel governance structure. Environmental protection and resource management fall under shared competence in EU law, meaning both the European Union and Member States have regulatory responsibilities. The EU level primarily sets strategic directions and establishes harmonising norms, while Member States are responsible for transposing these rules, institutional application, and enforcement.

This study examines the legal frameworks of the circular economy from this perspective, complemented by quantitative empirical analysis. It seeks to answer how the emerging regulatory model in the European Union reorganises the relationship between state regulation, market incentives, and self-regulatory mechanisms. On the other hand, what extent this is suitable for the gradual transformation of the linear economic structure. To this end, the paper does not treat the circular economy merely as an environmental policy issue but as a complex legal and governance

problem in which the EU and Member State levels, as well as the behaviour of economic actors, are all determining factors.

MATERIAL AND METHODS

The research utilizes a hybrid methodology that integrates doctrinal legal examination with empirical quantitative analysis. This approach enables the exploration of how the circular economy appears in the European Union's normative structure and what measurable impact these regulatory instruments have on Member States' circular economy performance. The legal-doctrinal analysis focuses on the one hand on the EU's legal material related to the circular economy. On the other hand, it is looking for an answer to with particular attention to legislative and policy initiatives aimed at improving resource efficiency, reducing waste generation, and keeping materials in economic circulation. The analysis of the regulatory environment extends to the European Green Deal, the circular economy action plan, and all norms that are determining the circular economy. Especially from the perspectives of product design, sustainable product policy, waste management, and secondary raw materials markets. The research starts from the premise that circular economy regulation cannot be understood from a single legal domain, as product design and ecodesign provisions, waste management framework rules, and norms related to consumption and market aspects only together delineate the regulatory structure that makes the lifecycle-based approach legally operational.

The quantitative analysis is based on Eurostat's harmonised indicators, which track the circular material use rate, recycling rates, waste generation, and resource productivity in EU-27 Member States between 2015 and 2023. The central research question of the analysis is: what relationship can be demonstrated between regulatory stringency and circular economy performance?

Regulatory stringency is approximated using the author's own comparative composite index, which takes four dimensions into account: the coverage of extended producer responsibility schemes, the scope of ecodesign regulations, the level of green public procurement targets, and the ambitiousness of recycling targets. The index does not serve quantitative ranking purposes but rather facilitates qualitative comparison of Member States' regulatory approaches.

The evaluation of data is rooted in descriptive statistics and reviews the circular performance of Member States identified by distinct levels of regulatory enforcement, specifically high, medium, and low. Part of the methodological framework is also the consideration that EU law operates in a multilevel system, so the practical effectiveness of circular economy regulation is determined not only at the EU legislative level but equally by how directives, programmes, and targets are embedded in Member State legal systems, administrative practices, and development policy priorities.

RESULTS: THE DEVELOPMENT AND EFFECTIVENESS OF THE REGULATORY MODEL

The Emergence of Lifecycle-Based Regulatory Logic

One of the most important characteristics of the EU regulation of the circular economy is the foregrounding of lifecycle-based thinking. This reasoning indicates that regulatory measures encompass not merely waste management but also the realms of product design, manufacturing processes, and consumption practices. The normative emergence of lifecycle thinking has been gradual: while earlier environmental regulation primarily concentrated on so-called "end-of-pipe" solutions, the new model seeks to permeate all economic processes.

The first defining area of lifecycle-based regulation is product design and ecodesign. Through the Ecodesign Directive (European Parliament and Council, 2009), the European Union created the possibility as early as 2009 to influence products' environmental performance at the design stage. While the directive originally applied to energy-using products, within the Sustainable Product Policy Initiative, the regulatory logic later extended much more broadly (European Commission, 2020). Central to ecodesign are fundamental aspects including longevity, repairability, the presence of recyclable elements, and the convenience of disassembling goods. The aim of this regulation is that products should enter the market in such a way that they are longer-lasting and fit more easily into the circular economy model.

The second key area is waste management. The Waste Framework Directive (European Parliament and Council, 2008) and its 2018 amendment (European Parliament and Council, 2018) determine the basic principles of EU waste policy. The regulation distinctly relies on the waste hierarchy, which delineates a specific prioritization sequence wherein prevention, reuse, recycling, and energy recovery are to be implemented in that order. The recycling targets prescribed by the amended regulation have become more ambitious: by 2025, 55% of municipal waste must be recycled, rising to 60% by 2030 and 65% by 2035. The emphasis is thus no longer merely on waste management but also on reinterpreting it as a resource.

The third area is the regulation of the secondary raw materials market. The success of a circular economy relies heavily on how well recycled materials can stand their ground against new raw materials. In recent years, the European Commission has taken several measures to stabilise this market, including developing quality standards for secondary raw materials and prescribing minimum proportions of recycled content for certain product groups. This regulation stems from the recognition that the circular economy cannot close at the recycling level; materials must actually return to the economic cycle.

Quantitative Results: The Relationship Between Regulation and Performance

Based on Eurostat (2023) data, the EU-27 average circular material use rate was 11.2% in 2015, which increased to 11.7% by 2021 and 11.8% by 2023. This indicates that slightly more than one-tenth of the materials used in the EU economy came from secondary, recycled sources. While this represents an improvement over the previous decade, progress remains modest, and the EU average can be considered low relative to the ambitions of circular transition. According to EEA assessments, the EU's circular material use rate increased from 10.7% to 11.8% between 2010 and 2023, meaning the growth is real but not particularly rapid.

In contrast, differences between Member States are extremely significant. According to 2023 data, the Netherlands led with a 30.6% circular material use rate, while Romania was among the laggards with 1.3%. France achieved 17.6%, Austria 14.3%, Germany 13.9%, and Poland 7.5% in the same year. These differences show that the common EU regulatory framework alone does not produce uniform performance; actual circularity continues to depend heavily on institutional capacity, economic structure, waste management infrastructure, and enforcement quality.

Table 1: Circular Material Use in Selected Member States and EU-27 (2023)

Country	Circular Material Use (%)	Regulatory Stringency	EPR Coverage	Ecodesign Scope
Netherlands	30,6	High	Comprehensive	Full
France	17,6	High	Comprehensive	Full
Austria	14,3	High	Comprehensive	Full
Germany	13,9	Medium	Comprehensive	Full
EU-27 average	**11,8**	—	—	—
Poland	7,5	Medium	Medium	Partial
Hungary	6,5	Low	Limited	Minimal
Bulgaria	2,3	Low	Limited	Minimal
Romania	1,3	Low	Limited	Minimal

Source: Eurostat env_ac_cur; author's compilation based on EEA country profiles and indicator pages.

Based on the data, it can first be established that there is a positive relationship between regulatory stringency and circular performance, but this relationship is not mechanical. The Netherlands' example shows that an ambitious regulatory environment can coincide with a high circular material use rate. However, a comparison of Germany and France suggests that favourable outcomes require more than the existence of a formal regulatory framework: enforcement quality, institutional coordination, and economic structure are at least equally important.

Secondly, the difference between the EU average and Member State extreme values indicates that the impact of harmonisation is limited if not accompanied by adequate national implementation capacities. Austria's 14.3% and Poland's 7.5% values, as well as Romania's 1.3% performance, clearly indicate that even under an identical legal framework, very different implementation paths exist. This confirms the assumption that actual circular economy performance depends not only on the existence of norms but also on their institutional embeddedness.

Thirdly, longer-term trends are not uniform either. In the Netherlands, the circular material use rate increased from 25.5% to 30.6% between 2010 and 2023, in France it essentially stagnated from 17.5% to 17.6%, in Austria it rose from 6.8% to 14.3%, and in Germany it increased from 11.2% to 13.9%. These divergent trajectories suggest that for Member States that have achieved higher circularity levels, further growth becomes increasingly difficult to attain, while in other countries growth can be faster if institutional and market conditions become favourable.

Overall, the quantitative results do not confirm that regulatory stringency alone determines circular performance. Rather, they show that regulation is effective when combined with strong implementation capacity, adequate waste management infrastructure, secondary raw materials markets, and consistent policy coordination. This is a particularly important conclusion for interpreting Member State differences.

Based on longer-term EEA data, the EU's circular material use rate increased from 10.7% to 11.8% between 2010 and 2023. During the same period, the Netherlands progressed from 25.5% to 30.6%, Austria from 6.8% to 14.3%, Germany from 11.2% to 13.9%, and France from 17.5% to 17.6%, meaning Member State trajectories differ significantly from each other.

Effectiveness of Regulatory Instruments: Case Studies

To better understand the quantitative results, a more detailed analysis is undertaken of two Member States – the Netherlands and Romania – which represent opposite ends of the regulatory spectrum. The Netherlands is the European leader in the circular economy with a 30.6% circular material use rate, while Romania shows the EU's lowest performance with a 1.3% rate. Comparing these two countries enables identification of which factors contribute to the observed differences in regulatory effectiveness.

The Netherlands' success results from several mutually reinforcing factors. First, the existence of a comprehensive national strategy can be mentioned: the country adopted the "From Waste to Resource" strategy in 2016, which aims for a fully circular economy by 2050. The strategy does not remain at a declarative level but sets specific targets for the construction industry, agriculture, manufacturing, and consumer goods markets alike. Second, the Netherlands not only transposes minimum EU requirements but also introduces its own rules that go beyond them. For example, for construction materials it prescribed a minimum proportion of mandatory recycled content from 2020 onwards, which exceeds the requirements of the EU Waste Framework Directive. Third, the Dutch public administration possesses strong professional capacity for implementing the circular economy transition. Rijkswaterstaat plays a prominent role in circular planning of infrastructure developments, while selective collection systems operated by local governments contribute to high recycling rates. In the Netherlands' case, therefore, regulatory stringency, institutional capacity, and social acceptance jointly create the environment in which the circular economy can become actual economic practice.

In Romania's case, the 1.3% circular material use rate cannot be attributed to the complete absence of regulatory frameworks, as the country – as an EU Member State – has formally transposed EU directives into national law. The poor performance is rather rooted in implementation problems. Above all, Romanian environmental authorities do not have sufficient human and professional resources for effective enforcement of the rules. Understaffing and insufficient professional training of environmental inspectorates result in formally existing rules not being consistently monitored in practice. Furthermore, Romania's economic structure does not favour the emergence of a circular economy: the country has a lower share of manufacturing industry, and fewer companies operate that could integrate recycled materials into their production processes. A significant part of the economy continues to be made up of agriculture and raw material extraction, which typically build on linear production chains. The issue is heightened by the shortcomings in waste management systems, restricted recycling efforts, and a deficiency in public awareness. These factors together result in EU regulation remaining formally transposed but actual implementation falling short of normative expectations, and the circular economy failing to substantially embed itself in economic practice.

Market, Self-Regulatory, and Multilevel Implementation Mechanisms

The regulatory structure of the circular economy is increasingly hybrid in nature. Alongside mandatory legal norms, incentive and coordinating solutions that do not only oblige but also orient are gaining more space. This change is particularly observable where technological development is rapid, market relations are complex, and legislation can only respond to innovations with delay. Industry standards, voluntary commitments, and certain self-regulatory mechanisms appear in this system not as alternatives to law but as complementary elements.

Frameworks of extended producer responsibility (EPR) exemplify this mixed rationale quite effectively. EPR schemes are based on mandatory legal frameworks, but economic actors' self-

organisation plays a significant role in their operation. In the Netherlands, for example, packaging manufacturers have concluded voluntary agreements that go beyond statutory minimums.

Nevertheless, the strengthening of self-regulation is not without problems. While involving market actors can certainly increase regulatory flexibility and practical adaptability, it also raises questions of accountability and protection of public interest. The goals of the circular economy are not fully identifiable with corporate rationality. Should the regulatory framework depend excessively on voluntary adherence, there exists a potential for a disparity to emerge between normative objectives and the prevailing market behaviors. The role of the state therefore does not diminish but transforms: less often as an exclusive commander, more as a framework-setter, coordinator, and monitor.

The relationship between the EU and Member State levels also deserves special attention. The circular economy is realised in a multilevel regulatory space, which on one hand is advantageous because it allows consideration of Member State specificities. On the other hand, however, differentiated implementation can result in substantial inequalities. As a result of the assortment of economic arrangements, contrasting administrative skills, and uneven infrastructure enhancements, the pursuit of European Union targets does not proceed uniformly. This is not merely a technical matter but also affects regulatory cohesion. Should the prerequisites for the circular economy exhibit considerable variation across Member States, this would influence the operation of the internal market, the competitive landscape, and the credibility of regulatory frameworks.

DISCUSSION

Based on the study, several conclusions can be drawn that may guide future regulation:

a) Product policy is a first key area from the circular economy perspective. Without a comprehensive implementation of the standards regarding durability, reparability, and recyclability during the product design phase, any future regulatory actions will yield only marginal advancements. Strengthening product policy regulation is therefore not a technical detail but a fundamental condition for circular transition.

b) The second key area from the circular economy perspective is the secondary raw materials market. Promoting recycling alone is insufficient if market utilisation of recovered materials remains uncertain. Regulation must therefore focus not only on waste management but also on those economic and legal conditions that can make secondary raw materials genuinely competitive alternatives to primary resources. Particularly important in this regard may be prescribing mandatory recycled content for certain product groups – such as plastics or construction materials –, tightening green public procurement targets, and developing tax incentives that support companies using recycled materials. These three instruments together can create the market environment in which using secondary raw materials becomes an economically rational decision.

c) The issue of Member State implementation is also of crucial significance. The divergent achievement of EU goals across Member States indicates that harmonisation alone does not create identical conditions for transition. One focus of future regulatory developments should therefore be strengthening implementation capacities. This supports the integration of institutions and diminishes the variations among Member States.

d) The regulation of the circular economy is ultimately not a task that can be captured in a single legislative act but a longer-term institutional and economic structural transformation. While the European Union’s steps thus far have undoubtedly created the foundations of this process, one of

the main questions for the coming period will be the extent to which regulatory instruments can facilitate deeper transformation of the economic system that is not merely partial or declarative.

CONCLUSIONS

Examination of EU circular economy regulation reveals that the European Union has gradually built a normative model in recent years that significantly exceeds the frameworks of traditional environmental regulation. The emphasis is no longer exclusively on ex-post management of environmental damage but on aligning the structure of economic processes with sustainability considerations already at the early stages of products' lifecycles.

The regulatory logic of the circular economy is structural in this sense: it attempts to treat in a unified context the entire process from design through production and consumption to becoming waste. This approach has not only created new legal policy priorities but has also transformed the subject of regulation. Product durability, repairability, material recyclability, and the market role of secondary raw materials are no longer peripheral issues but central elements of the sustainability transition.

The quantitative analysis supported three main conclusions:

a) regulatory stringency is a necessary but not sufficient condition for achieving a high circular material use rate. To effectively navigate challenges, we must also have strong regulatory structures, enhanced institutional skills, prompt implementation, and encouraging market rewards. The Dutch example clearly shows that regulatory ambition can only produce actual economic change if institutional and infrastructural conditions are also available.

b) inequalities between Member States are significant and persistent. The difference between the Netherlands' 30.6% and Romania's 1.3% performance indicates that even under an identical EU legal framework, highly country-specific factors determine actual results. This difference is not merely an empirical curiosity but illuminates one of the fundamental dilemmas of the EU regulatory model: the tension between harmonisation and Member State autonomy.

c) recycling alone does not guarantee realisation of the circular economy. Many Member States display considerable recycling rates; however, the resources that are processed are typically exported rather than being restored to the national economic framework. This suggests that from the perspective of the circular economy's actual domestic impact, regulating the waste management phase alone is insufficient; strengthening the secondary raw materials market and developing demand-side incentives are also necessary.

Overall, it can be established that the European Union's circular economy regulatory model represents an important step towards transcending the linear economic structure. However, the model's long-term effectiveness cannot be considered given, as it depends on whether EU framework regulation, Member State implementation, and economic actors' adaptation can sustainably build upon each other and actually produce structural change in economic operations. For the future, fostering convergence between Member States, stabilising the secondary raw materials market, and further strengthening product policy instruments will be crucial, with particular regard to broader application of ecodesign regulations and introduction of minimum mandatory recycled content proportions.

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REFERENCES

Geissdoerfer M, Savaget P, Bocken NMP, Hultink EJ 2017. The circular economy – A new sustainability paradigm? Journal of Cleaner Production, 143: 757–768.
Ghisellini P, Cialani C, Ulgiati S 2016. A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. Journal of Cleaner Production, 114: 11–32.
Kirchherr J, Reike D, Hekkert M 2017. Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling, 127: 221–232.
Korhonen J, Honkasalo A, Seppälä J 2018. Circular economy: The concept and its limitations. Ecological Economics, 143: 37–46.
Lacy P, Rutqvist J 2015. Waste to wealth: The circular economy advantage. London: Palgrave Macmillan, 264 pp
McDowall W, Geng Y, Huang B, Bartekova E, Bleischwitz R, Turkeli S, Kemp R, Doménech T 2017. Circular economy policies in China and Europe. Journal of Industrial Ecology, 21(3): 651–661.
Murray A, Skene K, Haynes K 2017. The circular economy: An interdisciplinary exploration of the concept and application in a global context. Journal of Business Ethics, 140: 369–380.
Prieto-Sandoval V, Jaca C, Ormazabal M 2018. Towards a consensus on the circular economy. Journal of Cleaner Production, 179: 605–615.
Stahel WR 2016. The circular economy. Nature, 531: 435–438.
European Commission, 2015. Closing the loop – An EU action plan for the circular economy, COM(2015) 614 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614 [12.03.24]
European Commission, 2019. The European Green Deal, COM(2019) 640 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2019:640:FIN [12.03.24]
European Commission, 2020. A new circular economy action plan for a cleaner and more competitive Europe, COM(2020) 98 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:98:FIN [12.03.24]
European Environment Agency, 2022. Circular economy in Europe – Developing the knowledge base, EEA Report No 2/2022. Available at: https://www.eea.europa.eu/publications/circular-economy-in-europe [12.03.24] Eurostat, 2023. Circular economy indicators. Available at: https://ec.europa.eu/eurostat/web/circular-economy [12.03.24]
United Nations Environment Programme, 2019. Global resources outlook 2019: Natural resources for the future we want, A Report of the International Resource Panel. Available at: https://www.resourcepanel.org/reports/global-resources-outlook [12.03.24]
European Parliament and Council, 2008. Directive 2008/98/EC on waste and repealing certain Directives (Waste Framework Directive), Official Journal of the European Union L 312, 22.11.2008. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098 [12.03.24]
European Parliament and Council, 2009. Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products, Official Journal of the European Union L 285, 31.10.2009. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0125 [12.03.24]
European Parliament and Council, 2018. Directive (EU) 2018/851 amending Directive 2008/98/EC on waste, Official Journal of the European Union L 150, 14.6.2018. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018L0851 [12.03.24]

NATURAL CLAY-BASED REGENERATION PROCESS FOR USED MARINE OILS

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ABSTRACT

Marine engine lubricants, particularly engine oils, are essential for keeping ship machinery running smoothly. These oils reduce friction, prevent corrosion, and extend the lifespan of equipment, ensuring engines perform efficiently. Made from base oils, either petroleum or synthetic, and various additives, lubricants are designed to offer superior performance. However, with continuous use, these oils begin to break down due to exposure to heat, contaminants, and mechanical wear. Disposing of used oils at emptying stations leads to significant environmental pollution, underscoring the urgent need for sustainable methods to regenerate these oils.

The applications of this research extend beyond just the maritime industry. It holds promise for offshore platforms and heavy machinery sectors as well. By applying such purification technologies, the maritime industry could drastically reduce its environmental impact, comply with stringent regulations, and enjoy substantial cost savings. In this study, we investigate the potential of using natural Moroccan clay to purify used marine oils, providing a cost-effective and eco-friendly solution to oil disposal. The regeneration process not only helps protect the environment but also reduces operational costs for the maritime industry by lessening the need for fresh oil. The regenerated oils can be reused in non-critical engine components, minimizing waste and lowering the cost of new oil purchases.

We conducted a thorough physico-chemical analysis of both fresh and used oil samples. The regeneration process involved treating the used oils with sulfuric acid to remove contaminants and restore vital properties. We evaluated key parameters, including viscosity, flash point, and pour point, to determine the success of the regeneration process. The results reveal that natural Moroccan clay can effectively act as a regenerating agent, offering a promising solution for sustainable oil management.

Keywords: Environment; Marine oil; Used oils; Regeneration; Moroccan clay; Waste valorization

URBAN RESILIENCE IN ROMANIA'S SMART CITIES

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ABSTRACT

This presentation analyzes urban resilience in Romania's smart cities of today. The topic is part of a larger project entitled 'City Focus, which researches mutliple aspects related to urban resilience, governance capacity, digital infrastructure, social cohesion and even more. This presentation aims to look into how our project researches cities integrating data platforms, how mobility systems and energy management functions so as to address climate risks, demographic change, and service continuity. Emphasis is also placed on institutional coordination, citizen participation, and ethical data use.

Using a local case analysis, the project identifies patterns of adaptation, current limits of technocratic solutions, and discusses the role of local knowledge in crisis response. Findings contribute to urban studies by linking smart city tools with resilience outcomes relevant to Central and Eastern European contexts. Policy implications are also discussed, from both the points of view of planners and decision-makers.

Keywords : resilience; digital infrastructure

BRIDGING COMMUNITY HEALTH AND CLINICAL INNOVATION: THE EVOLVING ROLE OF FAMILY MEDICINE IN MODERN HEALTHCARE SYSTEMS

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ABSTRACT

Background: Family Medicine (FM) and General Practice (GP) represent the cornerstone of sustainable healthcare, ensuring continuity, comprehensiveness, and equity in patient care. In an era shaped by demographic transitions, chronic disease burden, and rapid digitalisation, the scope and responsibilities of family physicians have expanded significantly.

Objective: This study explores the evolving functions of Family Medicine within modern healthcare ecosystems, highlighting innovative strategies that integrate preventive care, multidisciplinary collaboration, and digital health technologies.

Methods: A mixed-method approach was applied, combining a literature review of international primary care models (2018–2024) with qualitative data from semi-structured interviews among 150 family physicians practising in both urban and rural settings. Key themes analysed included clinical adaptability, patient engagement, interprofessional coordination, and educational reform.

Results: Findings revealed that family physicians increasingly act as care coordinators and public health advocates, facilitating early diagnosis, chronic disease management, and telemonitoring. Over 70% of respondents emphasised the necessity for enhanced digital literacy and evidence-based decision-making tools in primary care. Furthermore, collaborative care networks were associated with improved patient satisfaction and cost efficiency.

Conclusion: The transformation of Family Medicine towards integrated, patient-centred, and technology-assisted care models is essential to meet the challenges of the 21st century. Strengthening academic training, promoting innovation, and reinforcing primary care leadership remain pivotal to global health resilience.

Keywords: Family Medicine, General Practice, Primary Care, Health Systems Innovation, Digital Health, Interdisciplinary Collaboration

A DOORWAY TO CHILDHOOD: VIRTUAL CHILDHOOD MUSEUM

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ABSTRACT

Childhood provides a vital perspective for understanding the cultural, social, and economic structures of societies. Historical transformations in the concept of childhood, when examined through childhood culture, contribute to the development of positive perceptions in this academic field. While games, toys, and clothing reflect societal values and educational approaches, these elements are often underrepresented or limited in traditional museum settings. This research aims to reinterpret childhood culture within a digital museum environment, allowing participants to interactively experience the heritage of the past. The study is structured within the framework of action research, a methodology designed to improve educational practices through systematic problem-solving. Developed using Unity software, the museum offers a 3D interactive environment where users can explore traditional games from various continents as well as local Turkish culture. The implementation process follows six systematic steps: needs analysis, planning, design, prototype development, application with feedback, and final reporting. Data collection involves qualitative techniques, including semi-structured interviews with children, parents, and teachers. Grounded in constructivist learning theory, the research encourages active participation to enrich the learning process. This virtual museum serves as a bridge between generations, fostering cultural memory while providing an innovative model for digital museology. It establishes a digital archive that preserves cultural heritage and addresses the shortage of educational materials. The prototype applications of the virtual museum developed within the scope of the study were carried out with the participants. In this context, interviews were conducted with participating children, teachers, and parents. The qualitative data analysis process of the interviews is currently ongoing.

Keywords: childhood, virtual museum, childhood culture, digital heritage, interactive learning

CIRCASSIAN PROVERBS AND THEIR EQUIVALENTS IN TURKISH IV

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ABSTRACT

Compilations of words, idioms or proverbs made from colloquial speech are the most original and reliable data obtained first-hand, especially in the fields of philology, language and literature. Because the most reliable and basic source of a language is the mouth of the people who speak that language as their mother tongue. Circassian (Adığabze) is still spoken not only by the people in the Northwestern Caucasus region, but also by the Circassians in different countries who were forced to live outside this region with the Great Caucasian Exile in 1864. Today, there is a very large Circassian Diaspora in Turkey, Syria, Jordan, Israel, America and many other European countries, and their numbers are much higher than the Circassians still living in the Caucasus. However, Circassians outside (except those in Israel) do not have a written language. Circassians, whose homeland is the Caucasus, are now on the verge of extinction due to Russian pressure and the encompassing influence of great cultures in the diaspora. As a matter of fact, it is considered among the endangered languages by UNESCO. As a theological academician who is a native speaker of Circassian and has a degree in Philology, we felt a historical responsibility in the face of this dire situation of this language. With the idea of making a contribution to this language and culture that is about to disappear, we started to write the Circassian proverbs that we heard and compiled from the mouth of our mother, Semiha Gezer. We are bringing the data of this compilation study, which has been going on for about 10 years, to the literature, along with its Turkish equivalents. In this way, we are trying to postpone the extinction process of the Circassian language a little further. We also think that this is a valuable contribution to human culture in the fields of philology, language and literature.

Key Words: Circassian. Turkish. Proverb. Caucasus. Culture.

Introduction

When we speak of Circassians or Circassian peoples, we are referring to a group of peoples living in the Northwest Caucasus, consisting of many tribes such as Abzah, Shapsug, Kabardey, Bjeduğ, Chemguy, Besleney, etc. The word Circassian, however, is a name given to these peoples by outside societies. In other words, the word Circassian is not originally Circassian. It is a phonetically derived version of the Latin word Circass, generally used for Caucasian peoples, pronounced in Ottoman Turkish. Russians also pronounce this word as Cherkesk, according to their own language phonetics. For this reason, Circassians do not like the word Circassian and do not particularly like it being used for them. Because this word is a foreign word. They call themselves Adyghe. They also do not like the word Circassian. Instead, they use the word Adygabze, which means Adyghe language.

Introduction In Circassian history, a major turning point occurred in 1864 with the defeat of Sheikh Shamil against the Russians, breaking the resistance of the Caucasian peoples against Russian forces that had continued intermittently for a century. The Russians wanted to displace the Muslim population in the region and replace them with Russians. Therefore, these people were told to emigrate, otherwise they would be tried as war criminals. This led to the Great Caucasian Exile, which would last for about 10 years. With the permission of the Ottoman Caliph, they were initially migrated to the lands of present-day Anatolia. Later, they were systematically settled in other Ottoman territories outside of present-day Anatolia, such as Syria, Jordan, Iraq, Israel, and the Balkans.

In this study, we will focus on the Circassian dialect spoken by our mother, Semiha Gezer, a descendant of the Braç clan of the Abzah tribe of Circassians, who settled in Kozlu Village, Erbaa, Tokat. Here, we will present the fourth part of some Circassian proverbs and idioms that we collected from our mother, Semiha Gezer. We previously presented the first part as a paper at a symposium on language and literature research. (See Gezer, Arif, Some Proverbs in Circassian (Adyghe Language) and Their Turkish Equivalents, National Language and Literature Research Symposium UDEAS, October 20-22, 2021, Van, Turkey, pp. 223-236) We presented the second part as a paper at another symposium in Antalya, known by the acronym DEKAK, also related to language and literature research. (See Gezer, Arif, Circassian Idioms and Proverbs and Their Turkish Equivalents II, 17th International Congress of Language, Literature and Culture Studies (DEKAK), Full Texts Book Volume IV, 02-06 November 2023, Antalya, Turkey, pp. 803-813). We presented the third part as a paper at another International Scientific Congress. (See Gezer, Arif, Circassian Proverbs and Their Turkish Equivalents III, 1st International Scientific Research Congress, Congress Book, 10-11 February 2024, Astana Publications, pp. 110-122). This work is a continuation of those. As long as our mother is alive, we intend to continue, publish, and contribute these Circassian proverb compilations to the literature.

About Semiha Gezer, Our Source Person

Our mother, Mrs. Semiha Gezer, was born in 1938 in Kozlu Village, Erbaa District, Tokat Province. Her father was Necmi Özkan. She belonged to a family known as Braç. Her mother, Mrs. Kâmile, came from a neighboring village. Semiha Gezer was the fourth of six siblings. She was married at the age of 15. She and her husband lived in the same village. Her husband, İsa Gezer, was 5 years older than her and belonged to the Bjeduğ clan of the Circassians. He also studied at a madrasa in his youth. He knew Ottoman Turkish. According to the conditions of the time, his religious knowledge and culture were at a good level. This couple had 10 children. They lost three of them at a young age. They raised 7 of them in poverty and hardship. The third one is Arif Gezer, who caused this conflict. The person who influenced Semiha Gezer the most was primarily her mother, Mrs. Kâmile. Her mother, a very devout and pious woman, was arrested. However, due to the circumstances of the time, she had no opportunity for education. She ensured her daughter received religious instruction. From a young age until her marriage, she studied the Quran and other religious sciences for years with Mahmudko (Mahmudoğlu) İbrahim Hoca, a close neighbor. Semiha Hanım, raised in this way at her father's house, later recounted her own life. She also learned Ottoman Turkish. In the village conditions of that era, she was known almost as an honorary female religious teacher. She would recite Mevlids (religious poems), give religious talks, and attend funerals of women. Despite being very poor, she underwent a difficult and challenging pilgrimage to Mecca, staying there for three months.

Our mother, Semiha Hoca Hanım, was a devout, Sufi, pious, and sincere person. Besides her religious talks, she was also known for her cultural stories and anecdotes. She inherited her devout personality from her mother. She placed great importance on education. In a time when reading and even teaching the Quran was forbidden, and therefore religious education was very difficult, both she and her husband, İsa Gezer, received religious education. Later, they ensured their children also received religious education. They strongly advised that all children, boys and girls, should be educated, especially religious studies.

Semiha Gezer was from the Abzeh tribe of Circassians. Her father's family name was Braç. However, the family was known as "Hanefkoj bıne" (the family of the light-eyed ones). This word is still used as their nickname. Her native language was Circassian (Adygabze-Abzeh). She learned Turkish later in primary school. In the house where she was born and raised, she had two grandmothers, one of whom was very old. One was Vahide Hanım, her father's mother, and the other was her mother-in-law, that is, Semiha Hanım's father's grandmother. The main source of Semiha Hoca Hanım's extensive "Circassian proverbs, idioms, and stories culture" was these two grandmothers.

According to Mrs. Semiha Gezer, Bıslımeniğe, Šıfığe, and Xabze (Islam, Humanity, Circassian Culture) complement each other. These three concepts form a very harmonious whole and support each other like three legs. Therefore, Circassians should uphold all three together. Mrs. Semiha attached great importance to this matter and gave advice and guidance to her children and those around her in this direction. Again, according to her, a good and cultured Circassian is someone who possesses all three qualities simultaneously.

Mrs. Semiha passed away on September 20, 2024. She lived a long and fruitful life. She saw 7 children, 17 grandchildren, and 7 great-grandchildren. With her passing, our process of collecting and writing down Circassian proverbs from her unfortunately came to an end in September 2024.

Circassian (Adygabze) Proverbs and Their Turkish Equivalents

(Hanefkoj Semiha Nenejım Kiojığe Guşıejxer: Proverbs Shared by Grandmother Semiha Hanefkoj-with the Blue Eyes)

1. Tham tıwıjıı usı yış'ın.

May Allah feed him to the wolves.

Although it is used as a curse, it is sometimes used for situations such as weariness, complaining, regret, etc. It is usually said about animals that damage crops or cause other negative things.

2. Wöf'ure l'ı f'ure sıfı yazeşırep.

One never tires of good weather and a good man.

In this expression, the 'l' can be changed to 'man', and the 'sıf' specifies 'person', and both refer to both men and women. However, the 'sıf' in this expression can be used humorously to refer to women. Then the meaning becomes, "No woman ever tires of a good man."

3. Kukuwım kıpeojire txım yıoağ: Sıwoğapseme wiseğapse.

The echoing sound of the owl said: "If you deceive me, I will deceive you."

This beautiful saying, starting from the echoing of the mountains, aims to express the reality of the deception between people, as it reverts to its original state, with a beautiful joke.

4. Wı'âle fe widel, widelefe wotkhe.

You are crazy as long as you are a child, you are happy as long as you are crazy.

5. Parer bow nalet.

Money is very cursed.

This expresses the Circassian cultural perception that money is actually a blessing, but it also has an ominous or cursed aspect that can bring people together and bring them down.

6. Yıhaye maf'e xenağ.

His excrement even caught fire from his anger.

According to Circassian culture, extreme anger or rage doesn't just ignite the person's head; it turns into a flame that engulfs their entire body, even the excrement in their stomach. There is a very powerful depiction here.

7. Lır mıssew saserıy mılışew, tızexeçıjığo khuğo.

Before the meat burns and the skewer turns black, It's time to go.

This proverb also contains the meaning of the Turkish idiom "Neither the skewer nor the kebab should burn." However, it also expresses another meaning and connects this saying to the fact that the time to leave has come.

8. Şımısıştı haem, yıkojığe kessığ.

The time has come for the guest who will not stay to leave.

9. Wıje paste rişx.

May you eat cake with your mouth. It is the equivalent of the beautiful Turkish expression "May you eat honey with your mouth." However, the "pasta" in this sentence is not the Turkish "pasta." It is a salty and oily paste made from cornmeal. This paste is a very valuable treat in Circassian culture. Therefore, the expression "May you eat paste (cornmeal paste) with your mouth" was created as a prayer for the person receiving it.

10. Wışha yemıpesırer, nemiim yışha yemıpes.

Do not consider what you do not deem worthy for yourself, worthy for others.

11. Udanıçe yeğashi.

So thin that he is, he is spinning wool.

He's become nothing but skin and bones.

He's become the tool for spinning yarn. (Tree, stick, pole.)

12. We pşxirer tı koni yıl.

What you eat is from our storehouse.

Said to people we love or those whose hospitality we enjoy. In other words, what you eat doesn't diminish us in any way; On the contrary, we consider it our profit.

Topic: A wooden storage shed with legs, placed in the house or basement, or erected next to it like an office silo.

13. Nekulır yış'ıyzı, yıpeçe yısejığ.

He made the sausage and then defecated inside it. In other words; He ruined his work. He did something like a cow giving a bucket full of milk and then kicking it over, but in the end he destroyed its good side. It's a proverb equivalent to the Turkish saying "He defecated in the bowl he ate from."

14. Mıy pş'e yiejep, thaper kızepırğaz.

There's nothing good left in this, turn the page.

That is; There's nothing left to say about this, change the subject.

15. Halughır, halve sikhuçe pşxınfay.

You should eat bread when it turns into halva.

That is, you shouldn't eat before you're really hungry. When you're really hungry, everything you eat turns into halva. That's when you enjoy what you eat.

16. Ane değure l'ı değure sıfı yazeşıştep.

No one ever tires of a good table and a good man.

This saying is more often used for women. That is, no woman would say no to marrying a rich and good man.

17. Thamatit'ur zıwınem yıfeştep.

Two heads of families cannot fit in one house.

Two heads cannot fit in one house.

Two sultans cannot fit in one world.

The whole world is too small for two sultans.

According to legend, Piri Reis prepared the first world map and presented it to Yavuz Sultan Selim. He said, "Sir, here you go. I have drawn a map of the whole world." Yavuz Sultan Selim looked at this world map drawn by Piri Reis for a long time (which is indeed very close to the world map known today). Then he said: "If this is all that they call the world, then this world might be a little too much for one sultan, but too little for two sultans!"

18. Wızşağatecıştım wımıtıs.

Do not sit where you will be removed.

Do not sit in someone else's place.

Do not sit in the place of the leader.

19. Zıssemıy yılıyağeçe yıharep, kıdireğazezı yeha.

No one takes a gift because it is more than they need. They save it up in times of hardship. They put it aside or find and gather it to take it. That's how they take it. This saying is mostly used for gifts taken to engagements and weddings.

20. Nıbem psaperiy günaharıy xepxışt.

You will both earn merit and commit sin because of the matter of satisfying your hunger.

That is, if you feed yourself through lawful means and serve to feed others, you will earn merit. However, if you feed yourself through unlawful means, or if you are stingy towards people and show no respect or kindness to anyone, you will commit sin. You will certainly encounter one of these two possibilities. Because one way or another, you have to eat. You have to eat. Your stomach will either lead you to merit or to sin. There is no escape from this...

21. Mafe lıtağer, ş'exe bleçışt.

The days are numbered, pass quickly.

This is generally said to console those about to go to military service.

I remember my mother, Semiha Gezer, using this Circassian proverb in the following way:

It was in the 1980s. My mother Semiha Gezer's nephew, Ismail Ozkan, was getting older and preparing to go to military service for two years. But he was very sad. He was making farewell visits. He came to his aunt Semiha Gezer's house. He told her he was very sorry and expressed his sadness. Semiha Gezer was trying to console her nephew Ismail. She said:

- “My son, my child! Look, every man goes to the army and should go. Going to the army is an honor. It's a debt to the homeland. You will go like everyone else, and God willing, you will return safe and sound. Don't worry at all. The days are numbered and they pass quickly. Before you know it, your military service will be over and you'll be back. Why are you so sad? Why are you thinking so gloomily?”

Then, a conversation took place between her and her nephew, Ismail Ozkan:

- “Aunt! I'm not sad about going to the army.”

- “Then what are you sad about?”

- “I'm sad that I'm going to the army before I get married.”

- “What will happen, my child? You'll get married when you come back!”

- “But these girls won't be here by the time I return. They'll all be married.” - “Look at what you’re upset about!.. Don’t worry, son! The girls will never end. Newer, more beautiful ones will come along. They’ll start dancing and playing games. Oh dear, oh dear!...”

- “They will come along, but they’ll call us ‘brother, brother.’ In other words, in their eyes, we’ll be old...”

22. Şiger yeförep, şemım zirğaforep. Zefel’e şısıx.

The calf isn’t suckling, the cow isn’t suckling. They’re just waiting.

This is a saying for people who, despite needing each other, refuse to cooperate, don’t come together, and don’t help each other out of sheer stubbornness. Yet, if each of them helped the other, their own needs would be met just as much. In other words, both need each other. But because of unnecessary stubbornness, they both wait, needing each other.

23. Çetıwır şısew pş’ıse yaoaterep.

You don't tell stories in front of a cat.

That is, when you are about to say something, if you don't want that statement to reach the intended audience, you shouldn't say it in front of people who might relay it to them.

24. Eleşıgur şısew kabar yaoaterep.

You don't tell news in front of a child. They can get your news from that child.

25. Nıko nuk, yane zıkurmenıxer.

My children, even if you all give half each, that will be enough for your mother. May your mother be sacrificed for you.

That is, it would be enough if you all gave half to your mother.

Conclusion and Evaluation

In this study, we have tried to present some Circassian idioms and proverbs, along with their Turkish equivalents, which we compiled from the conversations and stories of our mother, Semiha Gezer, who is fluent in her native Circassian language. While the number of these proverbs, which we heard directly from our mother, is close to 300, we have limited ourselves to presenting only 50 here to avoid exceeding the average length of an article.

First, we transliterated the Circassian proverbs into Latin characters. Then, we translated them. Afterwards, we added any events or stories our mother told that illustrated the reason for the saying. We also indicated any equivalent proverbs used in Turkish Language and Literature. We created a basis for comparing the usage of the same topic or joke in both cultures. Since our field is Theology and Hadith, we sometimes included examples from hadiths related to the topic. When we consider all these proverbs as a whole, it is possible to make the following assessments:

There are some Turkish words in the Circassian (Adygabze) language used by Circassians in Anatolia. This is quite normal. Because Circassians in Anatolia have lived together with Turks in this geography for 150 years. They marry Turks. Apart from some cultural jokes, they do not show serious resistance in terms of both giving and receiving daughters in marriage. In addition, their written language and the education they receive in schools are only in Turkish. Naturally, the entry and use of Turkish words into Circassian has occurred. Just as it is normal for Russian words to enter the language spoken by Circassians living in the Caucasus, it is quite normal for Turkish words to enter Circassian in Türkiye and for Arabic words to enter Circassian used in Arab countries.

It is a fact that most of these proverbs reflect ancient Circassian culture. However, it is also possible that some developed after the great migration, that is, while living in Anatolia. Proverbs containing Turkish words, in particular, are highly likely to have originated in these lands after the migration.

Some of these proverbs are single sentences. But most are in the form of couplets, consisting of two sentences or clauses. Moreover, almost all of them strive to use homonyms. In this way, a more emphatic and poetic style of expression is created. These proverbs and idioms are also a beautiful reflection of Circassian culture. Because they reflect the Circassians' way of thinking and perception, their sense of humor, their prayers and curses, their aspects of cleanliness or hospitality...

This study also reveals the cultural interactions between Circassians and Turks. The fact that a large number of these Circassian proverbs have equivalents in Turkish shows, in our opinion, how close the two cultures are to each other and how much they interact.

Source Person: Gezer, Semiha (1938-2024), Tokat/Erbaa/Kozlu Village, Primary School Graduate.

Date of Compilation: 2015 - 2024.

Compiled by: Arif Gezer.

COMPLETE UTERINE RUPTURE DURING CESAREAN SECTION: CASE REPORT

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ABSTRACT

Among the complications that may occur during pregnancy especially during delivery uterine rupture is one of the most feared. The fetus is generally lost, and maternal life is at risk. Although uterine ruptures may rarely occur spontaneously, they are most often associated with a prior cesarean section (30–40%) or previous uterine surgery. If the broad ligament remains intact, the rupture is defined as incomplete; otherwise, it is considered complete. An incomplete rupture can progress to a complete rupture at any time. Additionally, there may be a “separation” of the cesarean scar. In such cases, the clinical course may be milder, as the fetal membranes remain intact and the fetus does not enter the abdominal cavity. Diagnosis is not always straightforward. If uterine rupture is suspected, emergency surgical intervention is required. Although uterine preservation is preferred, the decision depends on the location and extent of the rupture. Cesarean hysterectomy is indicated especially in cases of severe bleeding.

CASE:The patient, aged 28, had undergone two previous cesarean sections, the most recent due to a uterine rupture. At 37W6D, the patient was taken in for cesarean section, during which a complete uterine rupture was observed. The amniotic sac was seen bulging into the abdominal cavity. A baby with Apgar scores of 8 and 9 was delivered. The placenta was found to be invading the site of the previous rupture on the right lateral side of the uterus. The uterine tissue in this region appeared thinned. There was active bleeding at the placental bed, which was controlled with sutures. The uterus was preserved.

All studies indicate that the most common cause of rupture is a uterine scar from a previous cesarean. The risk of rupture is also related to the type of incision made. A classical vertical incision scar is ten times more likely to rupture than a lower segment transverse incision scar. One-third of classical scar ruptures occur before the onset of labor. The rupture rate after classical cesarean section is reported to be 6.4%, while it is 1.4% after a lower segment incision. Separations of lower segment incisions are also more frequent.

Keywords:complet uterine rüptüre, cesarean, amniotic sac



COMPLIANCE VS. INTEGRATION: EVALUATING THE DIVERGENT IMPACT OF DIFFERENT RISK MANAGEMENT PRACTICES ON ORGANIZATIONAL PERFORMANCE IN MOROCCAN SOES.

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ABSTRACT

State-owned enterprises (SOEs) in developing countries face persistent challenges in reconciling financial and social objectives, particularly when navigating between two contrasting approaches to risk management: compliance driven formalization and integrated risk management frameworks. This study examines how these two extremes of risk management practices relate to organizational performance in Moroccan public commercial offices, with a critical focus on their contextual relevance. Data were collected from 140 managerial employees across five Moroccan SOEs and analyzed using Partial Least Squares (PLS) path modeling with bootstrapping techniques. The results show that compliance-oriented and formalized risk management practices exert a significant and positive effect on both financial and social performance, whereas integrated risk management practices display mixed and sometimes statistically insignificant effects. These findings indicate that, contrary to normative prescriptions favoring integration, Moroccan SOEs have not yet reached the organizational maturity required to effectively benefit from integrated risk management systems. At this stage, prioritizing formalization, standardization, and procedural compliance appears to be more appropriate and impactful than pursuing full integration. By explicitly contrasting these two approaches, the study questions the transferability of integrated risk management models to developing public sector contexts and offers practical insights for policymakers and managers seeking to enhance governance and performance in SOEs.

Keywords: State-Owned-Enterprises; Organizational Performance; Risk Management Efficiency.

Introduction

Risk is an inherent part of organizational life, and its management has become a decisive lever for steering performance, especially within state-owned enterprises (SOEs). Operating at the intersection of public accountability and market pressure, SOEs face expectations that go far beyond those of typical private firms. In this context, risk management evolves from a defensive practice into a strategic capability that supports value creation, optimizes the allocation of scarce resources, and strengthens resilience in the face of uncertainty (Adebawojo & Akindehinde, 2017; Zabłocka-Kluczka & Sałamacha, 2023). When embedded within broader strategic decision-making processes, risk management becomes a key driver of sustainable organizational performance.

This research concentrates on Moroccan public commercial offices (OMPAM), whose contribution to national stability and development remains critical. Over the past decade, the Moroccan government has launched major reforms to modernize governance structures and strengthen performance across SOEs. The creation of the National Agency for Strategic Management of State Holdings and Performance Monitoring of SOEs (ANGSPE) exemplifies this orientation, supported by new regulatory frameworks aligned with Morocco’s New Development Model (NMD).

Introduced in 2021, the NMD recognizes SOEs as engines of competitiveness and territorial development. It calls for deeper managerial autonomy paired with rigorous performance oversight. By encouraging SOEs to generate revenues, invest strategically, and make timely decisions, the NMD aims to reduce excessive dependence on the state while reinforcing accountability. At the same time, the move toward results-based management places emphasis on measurable outcomes, societal value, and performance indicators that capture efficiency, effectiveness, and relevance.

Despite recent improvements, including a 34% rise in net results in 2022 compared with 2021 ,persistent deficits in major institutions such as the National Office of Electricity and Drinking Water (ONEE) and the National Railways Office (ONCF) reveal structural tensions. These realities highlight the need to assess performance not only in financial terms but also through broader organizational and social lenses.

This paper therefore examines a variable that has often remained secondary in performance models applied to SOEs: risk management efficiency (Moullin, 2017). Evidence from major academic databases confirms the limited attention given to this issue; for instance, a targeted ScienceDirect search combining “risk management” with “SOE” or “public sector” yields only 56 relevant publications across all periods.

The empirical analysis focuses on Moroccan public commercial offices ,ONCF, ONDA, ONP, ONEE, and ONHYM ,identified through document analysis of public institutions and based on the classification proposed by Marhoui et al. (2022). The study explores how risk management practices interact with internal processes to support agility and improve overall organizational outcomes in an increasingly complex and globalized environment (Kosztyán et al., 2020).

Understanding how risk management efficiency aligns with process maturity and performance provides valuable guidance for both decision-makers and managers. The findings aim to inform the design of integrated frameworks in which risk management and operational systems reinforce one another. In particular, process maturity emerges as a crucial mediating element, amplifying the positive influence of risk management on performance (Peljhan et al., 2018). Beyond theoretical contributions, this research offers actionable insights for strengthening SOE competitiveness in uncertain markets and building organizations capable of adapting, innovating, and responding proactively to disruption (Radaelli, 2021).

Taken together, these perspectives highlight the importance of treating risk management as an integral component of strategic and operational planning rather than as an isolated administrative function. Such an integrated vision is indispensable for SOEs seeking to align performance objectives, enhance efficiency, and remain responsive in complex environments.

Literature Review and hypothesis development

Organizational performance: An overview

In literature, there are two groups of authors. The first group considers organizational performance simply as the performance of organizations. Theses often claim to study organizational performance but actually address performance in the broadest sense (Deschaintre, 2017; Grall, 2022; Lachtar, 2012). According to Crozier and Friedberg (2009), an organization can be understood in three ways: a group of people coordinating their activities to achieve common goals, a response to collective action problems involving coordination, stabilization, and development, and finally, as organized action or the process that generates groups or organizational structures. This perspective aligns with previous sections of this thesis.

The second group of authors considers organizational performance a distinct field. They argue that organizational performance has different meanings depending on individuals and context

(Benkirane & Benazzi, 2025), leading to uncertainties and conceptual difficulties in its measurement (Winand and al., 2011). According to Peljhan and al., (2018) organizational performance is "a judgment made by an individual or group about the organization, specifically its activities, products, results, or effects." This framework is based on a robust theoretical foundation derived from an exhaustive review of social science literature, encompassing economic, political, social, and human resource domains. This theoretical base is then tested in the field through surveys. Validated by the order of accountants, this model features "multidimensionality," referring to the aggregation of multiple dimensions and stakeholders interested in promoting the organization. Organizational performance is defined as "the ability to correctly acquire and process human, financial, and physical resources to achieve organizational goals" (Anwar and Abdullah, 2021). Organizational performance includes all expected contributions from staff and involves examining how the organization is structured to minimize associated costs and achieve its objectives efficiently (Yang and al., 2024). This concept is particularly relevant today due to increased competition and the focus on organizational transformation and change, attracting attention from researchers in human sciences, especially industrial and organizational psychologists (Rudolph and al., 2021). Organizational performance includes financial and nonfinancial dimensions (Alatawi and al., 2023; Khanal and al., 2023; Sindhu and al., 2024; Yang and al., 2024; ZabłockaKluczka and Sałamacha, 2023). Financial metrics are based on balance sheet data, such as profit, growth rate, return on equity, and return on assets. However, these only cover part of organizational performance, with nonfinancial indicators like customer satisfaction (Kola Olayiwola and al., 2024), employee satisfaction (Abdelmegeed Abdelwahed and al., 2022), technology (Huynh and al., 2023), environmental indicators (Khanal and al., 2023; Tu and Wu, 2021) and innovation (Castelnovo, 2022) also playing crucial roles. Thus, organizational performance measures how well an organization achieves set goals through organized activities, efficient time management, and social and societal performance (Mori, 2021).

Several models have been developed to measure and enhance organizational performance, each with unique frameworks and focal points. In our research, we extracted 10 models which we mention briefly:

o Balanced Scorecard (BSC): Developed by Kaplan and Norton in the 1990s, this model integrates financial and nonfinancial perspectives to better align strategy with operations, enhancing decision-making processes (Kaplan and Norton, 1996).

o Public Sector Scorecard (PSS): An adaptation of the BSC for public sectors, focusing on nonfinancial metrics crucial for public administration (Kaplan and Norton, 2001b) cited by (Sumerli Sarigül and Coşkun, 2021).

o EFQM Excellence Model: Advocated by CalvoMora and al., (2015) this model emphasizes continuous improvement and organizational excellence across Europe.

o Lean, Six Sigma, and Lean Six Sigma : These methodologies combine efficiency and quality improvement processes, highly applicable in manufacturing and service industries (Snee, 2010).

o McKinsey 7S Framework: Introduced by Peters and Waterman, this model analyzes organizational efficiency through seven interrelated elements (Şalvarlı and Kayiskan, 2018).

o Lynch's Performance Pyramid: Discussed by Tremblay and Malsch, (2012), this model links strategic objectives with operational performance metrics.

o Malcolm Baldrige National Quality Award (MBNQA): This framework emphasizes innovation and improvement, extending to various sectors including education and healthcare (Peng and Prybutok, 2015).

o Skandia Navigator: Developed by Edvinsson, focuses on intellectual capital as a crucial dimension of performance (Edvinsson and al., 1999).

o Common Assessment Framework (CAF): As described by Raharjo and al., (2015) this model is tailored for public administrations in Europe to promote quality and efficiency.

o Swedish Institute for Quality (SIQ): This model, promoted by (Bergman and Klefsjo, 2010), supports continuous quality improvements across organizational processes.

Despite the existence of several organizational performance models, there is a relative lack of models specifically tailored to the public sector. Most models, such as the BSC and the EFQM Excellence Model, were initially developed for the private sector and may require adaptations to meet the unique needs of the public sector, such as transparency, citizen participation, and social responsibility (Moullin, 2017). This gap highlights the need for models specifically designed for the public sector, from which only the Public Sector Scorecard (PSS) emerges as an effective model for the public sector. However, it is largely criticized by scholars for being a mere readaptation of the BSC. Furthermore, the need for tailormade models depending on the context has become an imperative in the contemporary business and organizational landscape (Tworek et al., 2023). As industries become increasingly dynamic and environments more complex, rigid, onesizefitsall frameworks are no longer sufficient. Organizations today must adapt their models to fit the unique challenges and opportunities they face in specific settings. This approach not only enhances the relevance and applicability of strategies but also ensures that organizations can better respond to localized needs and environmental changes. The idea that there is no universal model for success has gained significant traction, particularly in industries characterized by rapid technological advancements and globalization.

Building on this, other scholars argue that the integration of additional variables such as digital use (Benkirane & al., 2021) “Riks evaluation” (Moullin, 2017; Ramos et al., 2023). In fact, Identifying and addressing key risks is essential for achieving effective organizational performance. Risk management is often overlooked in the public sector due to several factors, including perceived complacency and reliance on the regulatory role of the state (Areiqat et al., 2018; Han et al., 2022). These elements are increasingly recognized as critical for organizational success, as they contribute to the agility and sustainability of decision-making processes. Strategic Leadership, for instance, involves a long-term vision that not only guides the organization but also helps cultivate a culture of adaptability and resilience (Benkirane & Benazzi, 2023). Organizational Learning, on the other hand, is vital for fostering innovation and continuous improvement, ensuring that organizations remain competitive in evolving markets. Meanwhile, Organizational Culture shapes the underlying values and behaviors that influence how strategies are implemented and how challenges are overcome.

Together, these variables provide a more nuanced understanding of the organizational landscape, enabling leaders to craft more effective and context sensitive strategies. The persistent focus on these factors reflects a shift towards more holistic, people centric approaches to management, where success is no longer viewed solely through financial or operational lenses but also through the lenses of leadership effectiveness, learning capabilities, and the cultural fit within the organization.

Even when the PSS adapts the principles of the Balanced Scorecard to the needs and requirements of the public sector bit not enough (Moullin, 2017), by emphasizing stakeholder participation, results focus, and continuous process improvement, the PSS offers a robust framework for evaluating and improving organizational performance in the public sector. What Kaplan and Norton do not emphasize enough is the complexity of implementing the PSS, the level of technical expertise, and the availability required to manage this process (Dagou and Hachimou, 2019; Moullin, 2017). This complexity is even more pronounced when introducing the PSS in a

Moroccan company due to cultural reasons related to the lack of involvement from high-level hierarchy and political entities in such exercises, and constraints related to transparency and display; technical reasons due to the lack of available knowledge and skills in management control and strategic thinking; and organizational and functional issues linked to structural rigidity, silo functioning, and lack of coordination and cross functionality. This has been confirmed by several studies which highlight the model's value but focus on the practical difficulties of implementation in educational and training academies in Morocco and elsewhere (Hasnaoui and FEKKAK, 2021; Lawrence and Sharma, 2002), major public enterprises in New Zealand (Northcott and Ma'amora Taulapapa, 2012), and hospitals (Moullin and al., 2007).

Moulin (2017) has conducted a study through which he has listed 6 elements that should be taken into consideration in order to effectively evaluate organizational performance of SOEs. Among these, the integration of risk management into performance models was mentioned as being critical for achieving comprehensive assessments. Livingston and al., (2020) highlight that risk management processes help in identifying, assessing, and mitigating potential disruptions in achieving organizational goals. Ignoring these aspects can render assessments incomplete and expose organizations to vulnerabilities. This has been further validated by (Areiqat and al., 2018) and (Barrett, 2022) who confirm that identifying and addressing key risks is crucial for effective organizational performance. Risk management is often neglected in the public sector due to various factors, including perceived complacency and a reliance on the regulatory state.

In Morocco, the adoption of advanced performance and risk management models encounters specific hurdles. El Ajaje and El Meziane, (2019), along with Hasnaoui and Fekkak, (2021), point out challenges such as bureaucratic inertia, a deficiency of professionals skilled in modern management techniques, and cultural resistance to systematic changes. Additionally, the Moroccan public sector's predominant focus on compliance rather than performance optimization limits the practical application of integrated models that encompass risk management.

Risk management efficiency

The evolution of the concept of risk, from its origins in the Italian term "risicare" meaning 'to dare', has significantly shaped modern risk management practices (Aven, 2016). Risk management has evolved from its early association with gambling to a fundamental business function, marked by the development of probability theory by Blaise Pascal and Pierre de Fermat and later the formal adoption of risk terms in the insurance industry during the 19th century (Dionne, 2013).

Nowadays, risk is primarily viewed by scholars through three lenses: as variance, as downside loss, and as opportunity (Aven, 2016). Each perspective plays a crucial role in the strategic implementation of risk management:

• Variance: In finance, risk is often quantified as the volatility of expected outcomes.

• Downside Loss: This view focuses on potential losses, emphasizing the protective aspect of risk management.

• Opportunity: Highlights the potential gains from undertaking risk, particularly appealing to entrepreneurs and strategic leaders.

In recent years, there has been a paradigm shift in risk management practices, pivoting from basic implementation to a focus on efficiency. This efficiency is crucial not only for managing risks effectively but also for optimizing the use of organizational resources to bolster capacity in facing various uncertainties. The evolution toward efficient risk management is highlighted by the ISO 31000 : 2009 framework, which emphasizes a systematic, structured, and culturally integrated

approach to risk management that aligns with organizational strategies to maximize performance (International Organization for Standardization, 2009).

Efficiency in risk management involves more than the mere handling of potential threats; it requires an optimized strategy that enhances organizational outcomes while minimizing resource expenditure. This concept has been explored by (Ganiyu and al., 2020), who distinguish between risk and uncertainty, suggesting that true risk management efficiency comes from transforming uncertain outcomes into quantifiable risks that can be managed and mitigated.

Efficient risk management practices ensure that resources are allocated judiciously, focusing on critical risks and aligning risk management strategies with organizational goals helps in minimizing wasteful expenditures. It also ensures that response mechanisms are streamlined, developing protocols that facilitate swift decision-making enhances an organization's ability to manage and respond to risks promptly. Finally, efficient risk management ensures that decision-making is improved by integrating risk management into strategic planning, organizations can make more informed, effective decisions.

Aligning risk management with an organization's strategic objectives is crucial for ensuring that the management of risks directly contributes to achieving business goals. This alignment has been emphasized in studies by (Areiqat and al., 2018) and KPMG on 2014 cited by (Joshi and Acharya, 2022), who found a positive correlation between effective risk management practices and organizational performance. They advocate for a risk management process that is not only preventive but also enables organizations to seize opportunities that align with their strategic objectives.

A risk-aware culture is vital for the successful implementation of risk management practices. This cultural aspect is highlighted by Taran and al., (2013) and further explored by Benkirane and Benazzi, (2023) , who discuss the impact of continuous training on enhancing risk perception and management within organizations. Such a culture promotes an open dialogue about risks and supports the sharing of risk information across all levels of the organization, ensuring that risk management is perceived as a value adding activity integral to the organization’s success.

Risk management in SOEs involves not only safeguarding assets but also ensuring these entities meet their public mandates. The strategic integration of risk management with business objectives is facilitated by frameworks such as Kaplan and Norton's Balanced Scorecard, which integrates risk considerations into performance metrics.

Numerous studies have confirmed the positive correlation between organizational performance and risk management efficiency. Many authors have shown that efficient risk management practices do support strategic decision-making and enhance operational resilience, aligning with findings by Peljhan and al., (2018) and Zamuda and al., (2019), who stress the importance of aligning risk strategies with organizational goals for enhanced value creation.

However, achieving optimal efficiency in risk management requires navigating challenges such as maintaining flexibility and fostering innovation while adequately managing risks. Over stringency can stifle adaptability and innovation, while insufficient measures can expose organizations to undue risks (Aven, 2016; Kanes and al., 2017; Reiman and al., 2015). The role of organizational culture in risk management cannot be overstated. A risk aware culture supported by ongoing training and development enhances risk management efficiency (Ho and al., 2024), promoting a proactive and informed approach to managing uncertainties (Semeyutin and al., 2023).

The comprehensive review of literature underscores the multifaceted nature of risk management in SOEs, highlighting its evolution, strategic importance, and operational impact. Effective risk management not only mitigates potential threats but also positions SOEs to capitalize on opportunities, enhancing their ability to achieve both economic and public-oriented objectives.

In conclusion to this literature review, we can base our research on the fact that the variable "effective risk management" could play a major role in the organizational performance model of SOEs. These often operate in complex environments characterized by unique regulatory, political, and economic challenges. Efficient risk management enables these organizations to identify, assess, and mitigate potential threats while capitalizing on opportunities.

By proactively managing risks, SOEs can ensure continuity of operations, enhance decision-making processes, and improve resource allocation, thereby positively impacting their overall performance. This hypothesis is grounded in the understanding that effective risk management minimizes disruptions, reduces costs, and supports strategic objectives, leading to enhanced performance outcomes. We consider the affirmation below as our primary hypothesis:

H1: Integrated risk management positively influences the level of organizational performance in Moroccan public market-oriented enterprises (OMPAM).

H2: The formalization of risk management practices positively influences the level of organizational performance in Moroccan public market-oriented enterprises (OMPAM).

These hypotheses will be tested through empirical research to validate the proposed relationships and understand the dynamics between risk management, and organizational performance in the context of SOEs.

Method

Participants and Procedure

The decision to use a sample size of 140 was based on several factors, including the scope of the research, the focus on managerial perspectives, and the practicalities of data collection. While a larger sample might improve statistical power and generalizability, a sample of 140 is deemed sufficient for the exploratory nature of this study, which aims to understand managerial perspectives across different public sector organizations.

The sampling method, convenience sampling, was chosen due to logistical and accessibility reasons. Convenience sampling is often used in organizational studies where the research focuses on specific groups, such as managerial personnel in public organizations. While it does not guarantee a fully random sample, it ensures that the participants are directly relevant to the research questions. The sample of 140 respondents provided a good representation of middle, top, and senior management across five public sector entities (ONDA, ONCF, ONEE, ONP, and ONHYM), which allowed for a meaningful analysis of the data from different organizational levels.

The inclusion of 51.4% middle management, 18.6% top management, and 7.9% senior management ensures a diverse perspective on organizational dynamics, which is crucial for understanding the hierarchical differences in public sector decision-making processes. Although some responses were excluded due to incomplete data or non-managerial status, the final sample size of 140 remains robust enough to draw meaningful insights, considering the study's objectives and the methodological constraints.

Moreover, the pre-test conducted with a smaller group, reviewed by both the thesis supervisor and external employees, helped refine the questionnaire to ensure clarity and relevance for the managerial roles targeted in the study.

Overall, the sample size of 140 respondents is considered adequate for the study's design and objectives, providing a good balance between data richness and practical feasibility.

Data Analysis

Descriptive statistics and correlations among key variables were calculated using SPSS 2.0.0. Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were conducted to test the reliability and validity of the measurement scales. SPSS was also used for the generation of the latent variables. The structural equation modeling (SEM) using Partial Least Squares (PLS) was performed to test the pro-posed primary hypotheses using SPSS and bootstrapping to test the secondary hypothesis, using SmartPLS software. Model fit was evaluated using R^2 and adjusted R^2. Here are the steps followed in order to generate empirically valid results:

- Step 1 - Data Factorability: To confirm data suitability for factor analysis, we conducted two tests. First, Bartlett's Test of Sphericity. This criterion Evaluates if the correlation matrix significantly differs from an identity matrix. A high value with a p-value close to zero indicates significant correlations, justifying PCA. Second, the Kaiser-Meyer-Olkin (KMO) Test was administered. This criterion measures sampling adequacy. Values above 0.7 are acceptable for PCA (Malhotra, 2004).

- Step 2 - Principal Component Analysis (PCA): We performed PCA with Varimax rotation to enhance item loadings with factors. Varimax is chosen for better axis interpretation, though oblique rotation is also considered due to possible data correlations (Iacobucci and al., 2001).

- Step 3 - Retaining Factors: Using Kaiser's rule, we retained factors with eigenvalues greater than 1, a reliable criterion in statistical literature for determining the number of factors.

- Step 4 - Scale Refinement Methods: To finalize the constructs and prepare for regression, items with factor loadings below |0.3| on multiple factors or none reaching this threshold on any factor were eliminated. Were also removed all items without loadings above |0.5| on any principal components.

The table below synthetizes the followed protocol in order to guarantee validity and reliability of the results:

Table 1 - Synthesis of the Validity and Reliability Protocol

Step of the protocol		Adopted measures
Construct validity	Discriminant	Fornell and Lacker Criterion
	Convergent	AVE > 0,7
Internal validity		PCA and PLS
External validity		PCA and PLS
Reliability		Method of Internal Consistency (Cronbach's Alpha)
The Factorability of Items	Sampling adequacy	KMO > 0,5
	Significance of Inter-Item Correlations	Bartlett's Sphericity <0,05

Source : Synthesis done by the author

Hypothesis Testing

Hypotheses were tested through regression analysis to quantify the direct and indirect effects of the variables. Bootstrap analysis was employed to obtain statistical significance values for t-tests, determining the validity of the hypotheses. The significant level for hypothesis acceptance was set at 95%, with t-values required to be greater than or equal to 1.96.

Scale construction

Scale development for the dependent variable : Organizational Performance

This study adopts quasi-perceptual measures of performance, using Likert scales from 1 to 5. Participants are invited to assess the level of organizational performance of their organization based on their perceptions.

We chose to measure organizational performance by considering two essential aspects: financial performance and social performance. This approach is based on the recognition that the overall success of an organization cannot be evaluated solely in financial terms but must also consider its impact on society and stakeholders.

Scale development for the independent variable : Risk management efficiency

To construct a model for measuring the efficiency of risk management, this study relies on the work of Zamuda and al. (2019), who defined five levels of risk management efficiency, and ISO 31000 recommendations for effective risk management. The proposed fourteen items are adaptations of the fifth level for pioneering risk management and ISO 31000 recommendations. These items are divided into four dimensions to stay true to the format provided by ISO 31000: Regular Training on Risk Management Practices, Integration of Risk Management Practices Across All Processes, Clear Risk Management Policy and continuous improvement.

Results

Description of Responses and Sample Characteristics

A primary step was conducted. This consisted of a descriptive analysis of respondents' profiles:

Professional Categories: Middle Management is the most represented category (51.4%), followed by Top Management (18.6%) and Senior Management (7.9%), indicating a strong presence of middle and senior managers in our sample.

Office Distribution: ONEE is the most frequently mentioned entity (27.9%), reflecting its significant role in Morocco's water and electricity sector. ONP follows with 21.4%, while ONCF and ONDA represent 14.3% and 11.4%, respectively.

Age Distribution: The 26-35 age group is the largest (45.7%), followed by the 36-45 age group (37.1%). Respondents under 25 and over 45 represent 5% and 12.1%, respectively.

Gender Distribution: The sample is relatively balanced in terms of gender, with males at 57.9% and females at 42.1%, ensuring diverse perspectives in the analysis.

Validity of Scales and Variable Operationalization

The objective of this section is to ensure the quality of our variables. The adopted model consists of two independent variables and one dependent variable, measured by item scales (see tables). The operationalization of these variables is critical for the conceptual model's integrity. We use Principal Component Analysis (PCA) via SPSS to refine these measurement scales

Refining Organizational Performance Scale

We measured the organizational performance of Moroccan public enterprises using a nine-item scale across two dimensions (table 2). PCA results showed:

Table 2 - KMO and Bartlett test- PO

Kaiser-Meyer-Olkin for measuring sampling adequacy.		**.795**
Bartlett's test of sphericity	**Khi-square approx.**	**882.740**
	Ddl	**36**
	Signification	**<.001**

Table 3 - Cronbach's Alpha reliability test - PO

Cronbach's Alpha	Number of elements
.873	9

- KMO Index: 0.795, indicating good factorability.
- Bartlett's Test: Significant, confirming adequate correlations.
- Cronbach's Alpha: 0.873 for nine items, indicating strong internal consistency.

Given that the construct has validated all three tests, the data are therefore factorable. PCA with Varimax rotation has extracted a single factor (latent variable/component) to measure organizational performance explaining 69.334% (appendix 1) of the variance. The number of extracted factors is further confirmed firstly by the table of total explained variances, where only one component has an eigenvalue greater than 1 (Appendix 1), and second, through the matrix of components after rotation in the table below. Here are the loadings of all items composing the extracted latent variable :

Table 4 - The matrix of components post rotation - Organizational performance

Items	C 1
POF04 - 7-1-4: I am satisfied with our level of cash flow maintenance.	**.866**
POF02 - 7-1-2: I am satisfied with our level of value creation.	**.846**
POF05 - 7-1-5: I am satisfied with the debt management in the office.	**.832**
POF01 - 7-1-1: I am satisfied with the sales growth rate.	**.823**
POF03 - 7-1-3: I am satisfied with our level of return on investment (ROI).	**.775**
POS02 - 7-2-2: The office adheres to the customer-oriented approach guidelines.	**.886**
POS03 - 7-2-3: Our customers are satisfied with the quality of our main services.	**.877**
POS04 - 7-2-4: Our customers are satisfied with the quality of our ancillary services.	**.837**
POS01 - 7-2-1: The office conducts regular analysis of complaints.	**.781**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

***Source** : Output of the regression test from SPSS*

All loadings have values above 0.5. We could also add that the variance tests among the items reveal a significant result, with an F of 21.514 and a significance of 0.000. Tukey's test of additivity also produces an F of 2.92 with a significance of 0.000. It is essential to note that this test examines the hypothesis of non-additivity, which means that the probability indicates the rejection of the

non-additivity hypothesis if it is true. In this context, it is possible to reject the null hypothesis that the items are non-additive in favor of the additivity hypothesis.

When discussing the variance test among the items (F-test), a significant result with a very low probability (0.000) suggests that the variance among the items is not merely due to chance but is significant. This indicates that there are substantial differences among the items studied. As for Tukey's test of additivity, it aims to determine if the items studied are additive in their relationship. The fact that the probability is very low (0.000) suggests that the hypothesis that the items are non-additive is unlikely. In other words, there is strong statistical evidence to support the idea that the items are indeed additive in their relationship.

In conclusion, these statistical results reinforce the validity of the measures used and the consistency of the items studied, thereby enhancing the credibility of the conclusions drawn from the study.

The PCA with VARIMAX rotation allowed for the extraction of 2 components, accounting for 74.329% of the variance (Appendix 4). The component matrix after rotation (Table 11) establishes that:

The number of extracted factors is further confirmed by the table of total explained variances, where two components have a total value greater than 1 (Appendix 4).

Table 5 – Components matrix post rotation – EMR

Items	C	
	1	2
EMRGIR01 - 2-1-1 - The staff is regularly trained on risk management practices.	**.744**	**-.376**
EMRGIR02 - 2-1-2 - Risk management practices are integrated throughout the entire chain of processes.	**.799**	
EMRGIR03 - 2-1-3 - The adopted risk management practices take into consideration the specificities of the office's internal and external environment.	**.817**	**-.343**
EMRGIR04 - 2-1-4 - The design of the risk management function considers the needs and expectations of external stakeholders.	**.751**	
EMRGIR05 - 2-1-5 - The office conducts regular risk assessments related to its activities.	**.602**	**.667**
EMRGIR06 - 2-1-6 - Incentives are in place to promote proactive risk management.	**.739**	**.343**
EMRFP01 - 2-2-1 - The office has a clear policy regarding risk management.	**.387**	**.821**
EMRFP02 - 2-2-2 - The office has established emergency plans to address major risks.		**.861**
EMRFP03 - 2-2-3 - Resources are primarily allocated to the risk management function.		**.872**
EMRFP04 - 2-2-4 - The office follows the best risk management practices in the sector.	**.699**	**.558**
EMRFP05 - 2-2-5 - Mechanisms for monitoring and evaluating risk management actions are in place.		**.855**
EMRFP06 - 2-2-6 - The strategy of the risk management function is aligned with the office's vision, mission, and values.		**.833**
Extraction Method: Principal Component Analysis.		
Rotation Method: Varimax with Kaiser Normalization.		
a. Convergence of rotation on 3 iterations.		

***Source** : Output of the regression test from SPSS*

We notice that the items "EMRFP04 - 2-3-4 - The office follows the best risk management practices in the sector" and "EMRGIR05 - 2-1-5 - The office regularly assesses the risks related to

its activities" show communalities greater than |0.5| on more than one factor. After removing these items, Cronbach's alpha increased to 0.939 (Table 12).

Table 6 – Cronbach's Alpha of the final construct - EMR

Cronbach's Alpha	Number of elements
.939	10

Source : Output of the regression test from SPSS

Synthesis and discriminant validity

At the end of this analysis of the measurement scales for the variables in our model, we can establish a summary table that outlines the main identified components. We retain a model with 6 factors as represented in the table below:

Table 7 – Synthesis of measurement scales

Variable	Number of items	Cronbach's Alpha	Latent variables
Organizational performance	9	0,873	F1_PO
Risk management efficiency	10	0,930	F1_EMR_GIR F2_EMR_FPGR

The Fornell-Larcker criterion is one of the most popular techniques used to verify the construct validity of measurement models. According to this criterion, the square root of the average variance extracted (AVE) by a construct should be greater than the correlation between this construct and any other construct for discriminant validity, and the AVEs should all be greater than 0.7 for convergent validity. Once these conditions are met, construct validity is established. The correlation table between the means of the items is presented as follows:

Table 8 - Bivariate correlations between the means of the variables.

Pearson's Correlation	Av_EMR	Av_Perf
Av_EMR	0,880	
Av_Perf	.725**	0,767
N	140	140

**. The correlation is significant at the 0.01 level (two-tailed).

After replacing the "AVE" on the diagonal of the correlation matrix with their square roots, we can conclude that the discriminant validity of the construct is validated.

Table 9 - Discriminant analysis and construct validity

Le critère de Fornell-Larcker	AV_EMR	AV_Perf
AV_EMR	0,896	
AV_Perf	.663	0,876

Source : Outputs of multiple correlation tests on SPSS

The preliminary results obtained through PCA will serve as a solid foundation to guide the explanatory phase of our research. Indeed, the factor analysis of certain concepts revealed hidden dimensions, thus contributing to a better understanding of their nature. We therefore retain the following final conceptual model.

After verifying the operationalization of the measured concepts using the item scale, we can now proceed to the hypothesis validation tests.

Test of hypotheses

To estimate the regression model with the dependent variable (F1_PO) and the 5 extracted latent variables (representing the 2 independent variables), the regression equation was estimated. The adjusted R^2 is 0.851 for the training sample, which means that the model explains about 85.1% of the variance in organizational performance.

Table 10 – Test of regression

Hypothèse	Relation	Student's T	Status
H1	F1_EMR_GIR -> F1_PO	-6.040	Rejected
H2	F2_EMR_FPGR -> F1_PO	9.503	Validated

***Source** : Results of regression on SPSS*

Overall, the results of our study reveal important findings regarding the impact of effective risk management on the organizational performance of Moroccan public offices with commercial activities. Firstly, hypothesis H1, which asserts that risk management positively influences organizational performance, is partially confirmed. Specifically, the formalization of risk management practices (H2) is supported, while integrated risk management (H1) shows a negative effect, contradicting our expectations.

Reading of the results

Non-Significant Findings: Integrated Risk Management and Organizational Performance

Through this study, we found that integrated risk management had a negative impact on organizational performance in Moroccan public offices with commercial activities (OMPAM), which was contrary to expectations and existing literature that generally reports a positive relationship. This unexpected result invites deeper reflection on the contextual factors at play in the public sector.

Although theories and earlier studies (Zhang et al., 2014; KPMG, 2017) argue that integrated risk management should improve organizational performance by strengthening resilience and operational efficiency, the Moroccan public enterprise context may constrain these benefits; bureaucratic inefficiencies, political interference, and resistance to change can undermine integrated approaches, making them burdensome when applied rigidly or without local adaptation.

Public organizations frequently prioritize compliance over strategic risk management, producing processes that emphasize regulatory adherence rather than performance optimization; Power (2007) and Dunleavy et al. (2005) note that an excessive focus on regulatory frameworks can slow decision-making and reduce organizational flexibility, which helps explain the negative effect observed here. This points to a limitation of the integrated approach in certain settings: public enterprises may require more flexible, context-sensitive risk management systems aligned with their operational realities, otherwise integrated risk management as implemented may lack the adaptability needed to succeed in a dynamic public-sector environment.

Significant Findings: Formalized Risk Management Practices and Organizational Performance

The formalization of risk management practices was found to positively affect organizational performance, a result consistent with the literature (Bai et al., 2021; Ganiyu et al., 2020). These findings reinforce the view that clear policies, procedures, and mechanisms for managing risk can

enhance effectiveness in the public sector, where formal structures often shape outcomes and drive performance.

The therefore results support the idea that formalized risk management produces more consistent, efficient, and transparent systems for addressing risks-advantages that are particularly important for public organizations subject to heightened scrutiny and regulatory oversight.

Nevertheless, it is important to consider whether the observed benefits of formalization truly drive performance or instead reflect the necessity of bureaucratic structures for functioning within a specific regulatory environment; improvements tied to formalization may sometimes indicate compliance-driven functioning rather than genuine innovation or efficiency.

The negative impact of integrated risk management in public organizations like OMPAM may stem from the difficulty of balancing multiple objectives, where tensions between financial and social goals create trade-offs that integrated frameworks do not adequately resolve. Integrated frameworks often demand flexibility and innovation that public entities-especially in developing economies may lack because of bureaucratic constraints, limited resources, and political dynamics; when integration fails to enhance both financial and social outcomes, it can produce the negative results observed.

Discussion

Interpret the meaning of your results in the context of your research question(s) and the existing literature. Explain whether your findings support or contradict previous studies, and provide possible reasons. Highlight theoretical and practical implications of your findings. Address limitations of your study and suggest directions for future research.

Comparing our findings with existing theory clarifies the relationship between risk management and organizational performance in Moroccan public offices with commercial activities: first, our results challenge the expectation that integrated risk management always improves performance, contradicting studies such as Zhang et al. (2014), KPMG (2017), Peljhan et al. (2018), and Zamuda et al. (2019), which linked integration to greater resilience and operational gains.

In the public sector, integrated risk management can sometimes hinder performance; earlier work by Hood et al. (2001) showed that un-clear processes can generate administrative burdens and bureaucracy, Power (2007) highlighted the costs of excessive compliance focus, Dun-leavy et al. (2005) warned that some risk practices can be counterproductive, and Boin et al. (2005) examined how political and media pressures can compromise integrated approaches.

Second, our findings confirm that formalizing risk management practices positively influences OMPAM performance: clear risk policies, emergency plans, resource-allocation mechanisms, strategic alignment, and monitoring all contribute to better outcomes, aligning with Bai et al. (2021), Ganiyu et al. (2020), Upadhyay (2023), and Zamuda et al. (2019).

These conclusions suggest that formalized risk management enables OMPAM to anticipate, assess, and manage risks more proactively, thereby improving overall organizational performance and supporting the idea that formal structures can generate performance in the public sector (Tomo, 2019; Walker et al., 2010).

State-owned enterprises in developing countries face unique challenges in reconciling financial and social objectives within their risk management practices; this study examined how risk management efficiency affects both financial and social performance dimensions in OMPAM using data from 140 managers across five Moroccan public commercial offices and analyses based on Partial Least Squares and bootstrapping methods.

The results indicate that while formalized risk management practices enhance organizational performance, integrated risk management can have a detrimental effect, underscoring the need to tailor risk management approaches to the public-sector context where bureaucratic rigidity and resource constraints limit the effectiveness of integrated models.

Recent studies (Alamsjah and Yunus, 2022; Sindhu et al., 2024) suggest integrated risk management tends to perform better in private or semi-private organizations, whereas public entities often lack the structural flexibility and innovation-friendly culture required to capitalize on integration; resistance to change, entrenched bureaucracy, and limited resources can impede successful implementation in the public sector (Barrett, 2022; Taran et al., 2023). These contradictions highlight the need for context-specific adaptations of integrated risk management in public enterprises: although integration can theoretically improve resource al-location and stakeholder communication, practical application must ac-count for sectoral constraints and the difficulty of aligning financial and social goals.

In summary, our study both supports and challenges existing theoretical perspectives on risk management and organizational performance; by situating our results alongside prior work (Zhang et al., 2014; Peljhan et al., 2018; Zamuda et al., 2019, and others), we offer new insights into how risk management operates within OMPAM and identify directions for future research.

Conclusion

Summarize the main findings of your study without repeating details. Restate the contribution of your research to theory, practice, or policy. End with a strong concluding remark that emphasizes the significance of your study and outlines potential avenues for further research.

Declaration

Funding:

This research received no external funding

Conflicts of Interest:

The authors declare no conflict of interest.

Data Availability Statement:

The data that support the findings of this study are available from the corresponding author, [BK], upon reasonable request.

Appendix

Appendix 1

Component	Initial Eigen value			Sum of squared loadings			Rotation Sums of Squared Loadings		
	Total	% of variance	% cumulative	Total	% of variance	% cumulative	Total	% of variance	% cumulative
1	4.800	53.336	53.336	4.800	53.336	53.336	4.575	50.836	69.334
Extraction method: Principal component analysis.									

Appendix 2

Component	Initial Eigen value			Sum of squared loadings			Rotation Sums of Squared Loadings		
	Total	% de la variance	% cumulative	Total	% de la variance	% cumulative	Total	% de la variance	% cumulative
1	8.584	66.027	66.027	8.584	66.027	66.027	5.633	43.332	43.332
2	1.079	8.302	74.329	1.079	8.302	74.329	4.030	30.997	74.329
Extraction method: Principal component analysis.									

References

Abdelmegeed Abdelwahed, N. A., Soomro, B. A., & Shah, N. (2022). Determining employee satisfaction, intrapreneurship and firm growth among managers of Pakistan. *Heliyon, 8*(3), e09097.

Adebawojo, A., & Akindehinde, O. (2017). Organizational performance and growth: The mediating role of human asset accounting in Nigeria banking industry. *IOSR Journal of Humanities and Social Science, 22*(1), 24–29.

Alamsjah, F., & Yunus, E. N. (2022). Achieving Supply Chain 4.0 and the importance of agility, ambidexterity, and organizational culture: A case of Indonesia. *Journal of Open Innovation: Technology, Market, and Complexity, 8*(2), 83.

Alatawi, I. A., Ntim, C. G., Zras, A., & Elmagrhi, M. H. (2023). CSR, financial and non-financial performance in the tourism sector: A systematic literature review and future research agenda. *International Review of Financial Analysis, 89*, 102734.

Anwar, G., & Abdullah, N. N. (2021). The impact of human resource management practice on organizational performance. *SSRN*, 3824689.

Areiqat, A. Y., Alali, A., & Arikat, Y. (2018). Risk management to avoid project failure: A comparison study of construction projects in the GCC. *International Journal of Business Continuity and Risk Management*, *8*(2), 87–105.

Aven, T. (2016). Risk assessment and risk management: Review of recent advances on their foundation. *European Journal of Operational Research, 253*(1), 1–13.

Bai, T., Chen, S., & Xu, Y. (2021). Formal and informal influences of the state on OFDI of hybrid state-owned enterprises in China. *International Business Review, 30*(5), 101864.

Barclay, M. A., & Everingham, J.-A. (2020). The governance of mining regions in Australia (2000–2012). *Journal of Rural Studies, 75*, 196–205.

Benkirane, K., Benazzi, K., & Berrah, L. (2021). L'intégration de la dimension digitale dans l'évaluation de la performance globale des entreprises publiques: Étude de cas d'une entreprise publique marocaine. *International Journal of Accounting Finance Auditing Management and Economics*, *2*(6-1), 500-517.

Benkirane, K., & Benazzi, K. (2023). La culture du risque et les pratiques du management des risques dans le secteur public: Étude de cas de l'office national des aéroports.

Kawtar, B., & Khadija, P. B. (2025). Inductors of Organizational Performance in the Public Sector: a Systematic Literature Review Employing PRISMA Guidelines. *Public Organization Review*, 1-24.

Bergman, B., & Klefsjö, B. (2010). *Quality from customer needs to customer satisfaction.*

Boute, A., & Fang, M. M. (2022). China's textbook approach to regulatory reform of the natural gas market. *Utilities Policy, 76*, 101369.

Calvo-Mora, A., Navarro-García, A., & Periañez-Cristobal, R. (2015). Project to improve knowledge management and key business results through the EFQM excellence model. *International Journal of Project Management, 33*(8), 1638–1651.

Castelnovo, P. (2022). Innovation in private and state-owned enterprises: A cross-industry analysis of patenting activity. *Structural Change and Economic Dynamics, 62*, 98–113.

Dagou, O. D. H. W., & Hachimou. (2019). Le Public Sector Scorecard peut-il être soluble dans les collectivités territoriales: Une analyse des variances et invariances entre la Côte d'Ivoire et le Niger. *Revue Contrôle Comptabilité et Audit, 3*(1), Article 1.

Deschaintre, S. (2017). *Le travail dans la performance organisationnelle: Proposition d'une démarche pour étudier la performance du travail* (Thèse de doctorat). Paris 1.

Dionne, G. (2013). Risk management: History, definition, and critique. *Risk Management and Insurance Review, 16*(2), 147–166.

Edvinsson, L., Malone, M. S., & Bonneville, C. (1999). *Le capital immatériel de l'entreprise: Identification, mesure, management.* Maxima.

EL AJAJE, D., & EL MEZIANE, A. (2019). Vers une nouvelle ère du contrôle de gestion public axé sur le Balanced Scorecard. *Revue Contrôle Comptabilité et Audit, 3*(3).

Ganiyu, S. A., Xu, C., Providence, A. M., & Yu, D. (2020). The impact of supply chain risks and supply chain risk management strategies on enterprise performance in Ghana. *Open Journal of Business Management, 8*(4), 1491–1507.

Grall, M. (2022). *De la construction à la consolidation d'un laboratoire d'innovation: Quelles contributions à la transformation d'une grande entreprise? Le cas de la Digital Factory d'Air France* (Thèse de doctorat). Institut Polytechnique de Paris.

Han, M., Ding, A., & Zhang, H. (2022). Foreign ownership and earnings management. International Review of Economics & Finance, 80, 114-133. https://doi.org/10.1016/j.iref.2022.02.074

Hasnaoui, R., & Fekkak, A. (2021). Balanced scorecard, outil de pilotage de la performance des organisations: Cas des académies de l'éducation et de formation au Maroc. *Revue Internationale des Sciences de Gestion, 4*(2).

Ho, P.-H., Huang, C.-W., Lin, C.-Y., & Yen, J.-F. (2024). Risk culture in corporate innovation. *International Review of Financial Analysis, 91*, 102999.

Howie, P., & Atakhanova, Z. (2022). Assessing initial conditions and ETS outcomes in a fossil-fuel dependent economy. *Energy Strategy Reviews, 40*, 100818.

Huynh, T. N., Nguyen, P. V., Nguyen, Q. N., & Dinh, P. U. (2023). Technology innovation, technology complexity, and co-creation effects on organizational performance: The role of government influence and co-creation. *Journal of Open Innovation: Technology, Market, and Complexity, 9*(4), 100150.

International Organization for Standardization. (2009). *International Standard ISO 31000: Risk management ,Principles and guidelines.*

Johansson, T., & Siverbo, S. (2014). The appropriateness of tight budget control in public sector organizations facing budget turbulence. *Management Accounting Research, 25*(4), 271–283.

Joshi, P. L., & Acharya, S. (2022). The changing role of internal auditor as assurer, assessor and advisor.

Kaplan, R. S., & Norton, D. P. (1996). *The balanced scorecard: Translating strategy into action.* Harvard Business School Press.

Kanes, R., Ramirez Marengo, M. C., Abdel-Moati, H., Cranefield, J., & Véchot, L. (2017). Developing a framework for dynamic risk assessment using Bayesian networks and reliability data. *Journal of Loss Prevention in the Process Industries, 50*, 142–153.

Khanal, G., et al. (2023). An investigation of green supply chain management practices on organizational performance using multivariate statistical analysis. *Supply Chain Analytics, 3*, 100034.

Klein, P., Mössinger, C., & Pfingsten, A. (2021). Transparency as a remedy for agency problems in securitization? The case of ECB's loan-level reporting initiative. *Journal of Financial Intermediation, 46*, 100853.

Kola Olayiwola, R., Tuomi, V., Strid, J., & Nahan-Suomela, R. (2024). Impact of total quality management on cleaning companies in Finland: A focus on organizational performance and customer satisfaction. *Cleaning, Logistics & Supply Chain, 10*, 100139.

Kosztyán, Z. T., Csizmadia, T., Kovács, Z., & Mihálcz, I. (2020). Total risk evaluation framework. *International Journal of Quality & Reliability Management, 37*(4), 575–608.

Lachtar, D. (2012). Contribution des systèmes multi-agent à l'analyse de la performance organisationnelle d'une cellule de crise communale. *Thèse de doctorat, ENMP, Paris.*

Lawrence, S., & Sharma, U. (2002). Commodification of education and academic labor—Using the balanced scorecard in a university setting. *Critical Perspectives on Accounting, 13*(5–6), 661–677.

Li, K., Long, C., & Wan, W. (2019). Public interest or regulatory capture: Theory and evidence from China's airfare deregulation. *Journal of Economic Behavior & Organization, 161*, 343–365.

Lian, Y., Lucas, F., & Sörensen, K. (2023). Prepositioning can improve the performance of a dynamic stochastic on-demand public bus system. *European Journal of Operational Research.*

Livingston, G., et al. (2020). Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. *The Lancet, 396*(10248), 413–446.

Mai, T. V., & Casady, C. B. (2023). Delivering transport infrastructure using state-owned enterprises (SOEs): A business history of Vietnam Expressway Corporation between 2004 and 2016. *Structural Change and Economic Dynamics, 65*, 339–350.

Marhoui, S., Ibenrissoul, A., & Rigar, S. M. (2022). Les pratiques d'externalisation dans le secteur public marocain: Une approche intégrée de la décision et de la gestion. *Revue Internationale des Sciences de Gestion, 5*(3), Article 3.

Mori, A. (2021). How do incumbent companies' heterogeneous responses affect sustainability transitions? Insights from China's major incumbent power generators. *Environmental Innovation and Societal Transitions, 39*, 55–72.

Moullin, M. (2017). Improving and evaluating performance with the Public Sector Scorecard. *International Journal of Productivity and Performance Management, 66*(4), 442–458.

Moullin, M., Soady, J., Skinner, J., Price, C., Cullen, J., & Gilligan, C. (2007). Using the Public Sector Scorecard in public health. *International Journal of Health Care Quality Assurance, 20*(4), 281–289.

Northcott, D., & Ma'amora Taulapapa, T. (2012). Using the balanced scorecard to manage performance in public sector organizations: Issues and challenges. *International Journal of Public Sector Management, 25*(3), 166–191.

Pane, E. S., & Sarno, R. (2015). Capability maturity model integration (CMMI) for optimizing object-oriented analysis and design (OOAD). *Procedia Computer Science, 72*, 40–48.

Peljhan, D., Miloš Sprčić, D., & Marc, M. (2018). Strategy and organizational performance: The role of risk management system development. *Studies in Managerial and Financial Accounting, 33*, 65–91.

Peng, X., & Prybutok, V. (2015). Relative effectiveness of the Malcolm Baldrige National Quality Award categories. *International Journal of Production Research, 53*(2), 629–647.

Poppelwell, E., & Overton, J. (2022). Culture, scale and the adaptation of good governance: Insights from SOEs in Samoa and Tonga. *World Development Perspectives, 28*, 100468.

Radaelli, P. (2021). Enterprise risk management in practice: A European perspective. In *Enterprise Risk Management in Europe* (pp. 261–278).

Raharjo, H., Guglielmetti Mugion, R., Eriksson, H., Gremyr, I., Di Pietro, L., & Renzi, M. F. (2015). Excellence models in the public sector: Relationships between enablers and results. *International Journal of Quality & Service Science, 7*(1), 120–135.

Reiman, T., Rollenhagen, C., Pietikäinen, E., & Heikkilä, J. (2015). Principles of adaptive management in complex safety-critical organizations. *Safety Science, 71*, 80–92.

Rudolph, C. W., et al. (2021). Pandemics: Implications for research and practice in industrial and organizational psychology. *Industrial and Organizational Psychology, 14*(1–2), 1–35.

Şalvarlı, M., & Kayiskan, D. (2018). An analysis of McKinsey 7-S model and its application on organizational efficiency.

Semeyutin, A., Kaawach, S., & Kara, A. (2023). CEO risk-culture, bank stability and the case of the Silicon Valley Bank. *Economics Letters, 233*, 111373.

Sindhu, M. I., Windijarto, Wong, W.-K., & Maswadi, L. (2024). Implications of corporate social responsibility on the financial and non-financial performance of the banking sector: A moderated and mediated mechanism. *Heliyon, 10*(9), e30557.

Snee, R. (2010). Lean Six Sigma – Getting better all the time. *International Journal of Lean Six Sigma, 1*, 9–29.

Sumerlİ Sarigül, S., & Coşkun, A. (2021). Balanced scorecard (BSC) as a strategic performance management tool: Application in a multi-national bank. *Research Studies Anatolia Journal, 4*(2), 115–129.

Taran, Y., Boer, H., & Lindgren, P. (2013). Incorporating enterprise risk management in the business model innovation process. *Journal of Business Models, 1*(1), Article 1.

Tomo, A. (2019). Bureaucracy, post-bureaucracy, or anarchy? Evidence from the Italian public administration. *International Journal of Public Administration, 42*(6), 482–496.

Tran, U. T., & Tran, H. T. (2022). Factors of application of activity-based costing method: Evidence from a transitional country. *Asia Pacific Management Review, 27*(4), 303–311.

Tremblay, M.-S., & Malsch, B. (2012). L'explosion de l'audit dans le secteur public: Le risque d'une illusion de contrôle. *Télescope, 18*(3), 1–7.

Tu, Y., & Wu, W. (2021). How does green innovation improve enterprises' competitive advantage? The role of organizational learning. *Sustainable Production and Consumption, 26*, 504–516.

Upadhyay, S. (2023). Impact of the formal and informal institutions on the performance of Indian mining companies: A fuzzy set QCA analysis. *Resources Policy, 82,* 103484.

Walker, R. M., Boyne, G. A., & Brewer, G. A. (2010). *Public management and performance: Research directions.* Cambridge University Press.

Winand, M., Rihoux, B., Qualizza, D., & Zintz, T. (2011). Combinations of key determinants of performance in sport governing bodies. *Sport Business and Management: An International Journal, 1*, 234–251.

Yang, Y., & Jiang, Y. (2023). Buyer-supplier CSR alignment and firm performance: A contingency theory perspective. *Journal of Business Research, 154*, 113340.

Yang, Y., Din, A. U., Mohi Ud Din, Q., & Khan, I. U. (2024). Green leadership in manufacturing industry: Unveiling the green revolution's impact on organizational performance. *Heliyon, 10*(6), e27831.

Yao, Z., Gu, D., & Cao, W. (2019). SOEs as intermediation: Leakage effect under financial repression. *Pacific-Basin Finance Journal, 53*, 349–361.

Zabłocka-Kluczka, A., & Sałamacha, A. K. K. (2023). Organizational resilience as the mediator of relation between brand performance and organizational performance – Reflections from the perspective of crisis times. *Journal of Organizational Change Management, 36*(6), 932–949.

Zamuda, C. D., et al. (2019). Resilience management practices for electric utilities and extreme weather. *The Electricity Journal, 32*(9), 106642.

DETERMINING FACTORS IN K-12 TEACHERS' ACCEPTANCE OF ARTIFICIAL INTELLIGENCE: AN INTEGRATED ANALYSIS OF TAM AND DOI THEORIES

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ABSTRACT

The rapid integration of artificial intelligence (AI) technologies into K-12 education has positioned teachers as critical agents whose acceptance or resistance fundamentally shapes implementation outcomes. While the pedagogical potential of AI-supported education, including personalized learning, intelligent tutoring systems, and automated feedback, has been extensively documented (Crompton et al., 2024; Mustafa et al., 2024; Létourneau et al., 2025), far less attention has been devoted to the determining factors underlying teachers' acceptance of these technologies. This study presents an integrated analysis of K-12 teachers' AI acceptance through the dual lens of the Technology Acceptance Model (TAM) and the Diffusion of Innovation (DOI) theory. Drawing on a systematic literature review conducted across Web of Science, ERIC, and DergiPark databases following the PRISMA guidelines (Page et al., 2021), this paper examines the facilitating and inhibiting factors that shape teachers' behavioral intentions toward AI tools. The findings reveal that perceived usefulness and perceived ease of use, as core TAM constructs, remain robust predictors of teachers' acceptance intentions (Davis, 1989; Scherer et al., 2019; Zhang et al., 2023), while Rogers' (2003) adopter categories provide a meaningful framework for understanding the heterogeneous pace of AI adoption among educators (Üzümcü & Açılmış, 2024). Furthermore, the analysis identifies key barriers to acceptance, including job replacement anxiety (Wang et al., 2023), algorithmic distrust and confirmation bias (Nazaretsky et al., 2022), and ethical concerns regarding data privacy (Filiz et al., 2025). The integrated theoretical framework demonstrates that acceptance-facilitating factors such as professional efficiency and pedagogical benefit interact with inhibiting forces such as perceived threat and insufficient AI literacy, creating a complex landscape that cannot be adequately captured by either theory alone. The study concludes with recommendations for professional development programs that address not only technical competencies but also the ethical awareness and readiness of K-12 teachers and calls for longitudinal research to trace the evolution of AI acceptance over time.

Keywords: Artificial Intelligence in Education, K-12 Teacher Attitudes, Technology Acceptance Model, Diffusion of Innovation, AI Acceptance.

Introduction

Artificial intelligence (AI) refers to computer systems capable of performing cognitive tasks typically attributed to human intellect, such as learning and problem-solving (Baker et al., 2019), and is currently transforming domains ranging from communication to the workplace; however, education constitutes one of the most critical areas of this transformation (Filiz et al., 2025). At the K-12 level, AI technologies are being integrated into instructional processes through personalized learning environments, intelligent tutoring systems (ITS), chatbots, and automated assessment tools, and the positive impact of these tools on student achievement is supported by a growing body of empirical evidence (Crompton et al., 2024; Létourneau et al., 2025). In their systematic review encompassing 169 studies conducted between 2011 and 2021, Crompton et al. (2024) demonstrated that AI provides pedagogical contributions through three main themes: gaming, personalization, and diagnostic tools. Similarly, Létourneau et al. (2025) reported that ITS can achieve effect sizes ranging from 0.75 to 0.80 on K-12 students' learning performance. These findings indicate that AI should be regarded not merely as a technological innovation in education, but as a paradigmatic shift with the potential to structurally transform instructional processes.

Nevertheless, the integration of AI technologies into educational settings has progressed more slowly compared to other sectors (Filiz et al., 2025). One fundamental reason for this disparity is the insufficient consideration of teachers' roles in AI integration (Seufert et al., 2021). Ayanwale et al. (2022) emphasized that the effectiveness of AI in education is largely dependent on teachers' readiness and their attitudes toward the technology. Indeed, Galindo-Domínguez et al. (2023) found that although the majority of primary school teachers in Spain viewed the potential benefits of AI positively, only a small minority had effectively implemented AI tools in their classrooms. This contradiction demonstrates that the gap between positive perception and actual adoption cannot be explained solely by insufficient technical infrastructure; rather, deeper individual and contextual factors determining teacher acceptance require systematic analysis.

One of the most widely employed theoretical frameworks for explaining teachers' technology acceptance is the Technology Acceptance Model (TAM), developed by Davis (1989). According to TAM, two core constructs determine users' behavioral intentions toward technology: perceived usefulness and perceived ease of use (Davis, 1989). TAM has demonstrated a high level of generalizability across different technological contexts (Chocarro et al., 2023; Scherer & Teo, 2019) and has provided strong explanatory power in predicting teacher acceptance behaviors in the field of educational technology. Zhang et al. (2023), in their study based on TAM3, confirmed that perceived usefulness and perceived ease of use were the strongest predictors of pre-service teachers' AI acceptance. However, TAM focuses on the individual level of the adoption process and does not adequately explain the societal diffusion dynamics of an innovation.

At this juncture, the Diffusion of Innovation (DOI) theory, developed by Rogers (2003), offers a complementary perspective. DOI theory classifies individuals within a social system into five categories according to their adoption speed: innovators, early adopters, early majority, late majority, and laggards (Rogers, 2003). Üzümcü and Açılmış (2024) demonstrated that AI adoption patterns among teachers meaningfully correspond to these five adopter categories. Notably, the finding that university faculty members exhibit higher AI awareness compared to other educational levels, owing to advantages in academic freedom and access to research resources, has been evaluated as consistent with Rogers' "early adopters" category (Üzümcü & Açılmış, 2024). Nonetheless, DOI theory lacks the capacity to explain in depth the individual perceptual mechanisms, such as perceived usefulness or anxiety, that influence adoption.

A review of the existing literature reveals that the factors affecting teachers' AI acceptance are not limited to facilitating elements alone. In the context of AI anxiety, Li and Huang (2020) identified eight distinct types of anxiety, including privacy violation anxiety, bias behavior anxiety, job replacement anxiety, ethics violation anxiety, and lack of transparency anxiety. Nazaretsky et al. (2022) demonstrated that algorithm aversion and confirmation bias play a determining role in teachers' distrust toward AI-powered educational technologies. Similarly, Wang et al. (2023) revealed that teachers' perceived level of threat, particularly job replacement anxiety, negatively affects their intentions toward AI-enhanced innovation. On the ethical dimension, concerns such as data privacy, algorithmic bias, and student privacy have been identified as critical barriers constraining teacher acceptance (Filiz et al., 2025; Holmes et al., 2021).

Within this framework, the present study aims to examine the facilitating and inhibiting factors that determine K-12 teachers' AI acceptance from the integrated perspective of TAM and DOI theories. Based on a systematic literature review conducted across the Web of Science, ERIC, and DergiPark databases in accordance with the PRISMA guidelines (Page et al., 2021), this paper analyzes the complex acceptance patterns that cannot be adequately captured by a single theoretical framework, employing a dual-lens approach. The study seeks to answer the following research questions:

1) What are the factors that facilitate K-12 teachers' acceptance of AI?

2) What are the factors that inhibit K-12 teachers' acceptance of AI?

3) How do these facilitating and inhibiting factors exhibit an interaction pattern within the framework of TAM and DOI theories?

Materials and Methods

This study adopts a systematic literature review methodology combined with thematic synthesis to examine the facilitating and inhibiting factors that determine K-12 teachers' acceptance of artificial intelligence technologies. The systematic review approach was selected as the most appropriate method for synthesizing the existing body of empirical and theoretical evidence on teacher acceptance within an integrated TAM and DOI theoretical framework. The review process adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021), ensuring methodological rigor and transparency throughout the identification, screening, and selection stages.

The literature search was conducted across three databases: Web of Science and ERIC (Education Resources Information Center) for the international literature, and DergiPark Academic for the national literature. In addition to these academic databases, policy documents from international organizations such as UNESCO and official documents from the Turkish Ministry of National Education were also included in the search scope. The search covered studies published between 2015 and 2025, capturing the most recent decade of accelerated AI integration in educational contexts. Both Turkish and English search terms were employed in the search strategy. The primary search terms included "AI-supported education," "artificial intelligence in K-12 education," "artificial intelligence in education," "teacher attitudes," and "intelligent tutoring systems." The search strategy was structured to encompass title, ABSTRACT, and keyword fields across all three databases.

Specific inclusion and exclusion criteria were applied to determine the sources to be included in the review. The inclusion criteria encompassed peer-reviewed journal articles, books, and national and international policy documents that examined AI applications at the K-12 level and addressed teacher attitudes toward these technologies. The exclusion criteria eliminated studies that focused

exclusively on the higher education level, were not directly related to the intersection of artificial intelligence and education, or whose full texts were not accessible. The selection process was carried out in two stages: in the first stage, a preliminary evaluation was conducted based on titles and ABSTRACTs; in the second stage, the full texts of studies that passed the preliminary evaluation were subjected to a final assessment according to the established criteria.

From the broader corpus of identified studies, works that addressed the determining factors of teacher acceptance, including perceived usefulness, perceived ease of use, adoption patterns, anxiety, trust, algorithmic distrust, and ethical concerns, were thematically selected for the present analysis. This thematic extraction was guided by the dual theoretical lens of TAM and DOI, ensuring that the selected literature provided evidence relevant to both individual-level acceptance mechanisms and societal-level diffusion dynamics. The final set of sources was critically evaluated and synthesized through a thematic analysis approach. The thematic synthesis organized the findings into two overarching categories: factors facilitating teachers' AI acceptance and factors inhibiting teachers' AI acceptance. Within each category, sub-themes were identified based on the convergence of evidence across multiple studies, and these sub-themes were subsequently interpreted through the integrated TAM-DOI theoretical framework. This analytical strategy enabled not only the identification of discrete facilitating and inhibiting factors but also the examination of the interaction patterns between these factors, which constitutes the third research question of this study.

Findings and Discussion

The thematic synthesis of the reviewed literature revealed a complex set of determining factors that shape K-12 teachers' acceptance of artificial intelligence technologies. These factors were organized into two overarching categories, facilitating factors and inhibiting factors, each comprising multiple sub-themes.

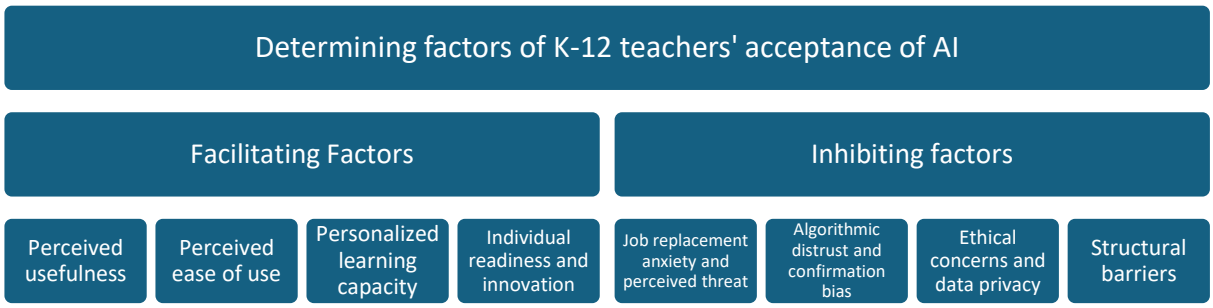


Figure 1. Determining Factors of K-12 Teachers' Acceptence of AI

Facilitating Factors

The analysis identified four primary sub-themes within the category of factors that facilitate K-12 teachers' AI acceptance: perceived usefulness, perceived ease of use, personalized learning capacity, and individual readiness and innovation.

Perceived usefulness emerged as the most consistently reported facilitator of teachers' AI acceptance across the reviewed studies. Zhang et al. (2023), in their study with 471 pre-service teachers, confirmed that perceived usefulness was the strongest predictor of behavioral intention toward AI, exerting a greater influence than perceived ease of use. Chocarro et al. (2023) corroborated this finding in the context of educational chatbots, demonstrating that perceived utility significantly predicted teachers' usage intention with a positive and statistically significant parameter value. These findings are firmly aligned with the core proposition of TAM, which posits

that users' behavioral intentions are primarily determined by the degree to which they believe technology will enhance their job performance (Davis, 1989). Within the K-12 context, this perceived usefulness manifests specifically as professional efficiency gains. Filiz et al. (2025) reported that teachers in Türkiye valued AI tools for their capacity to facilitate lesson planning, material preparation, and student performance evaluation. Similarly, Chounta et al. (2022) found that 69% of Estonian K-12 teachers believed AI would save time in searching for course materials, while 53% anticipated assistance in assignment assessment and 61% expected support in administrative reporting tasks. Chan and Tsi (2024) further confirmed that teachers appreciated generative AI tools for accelerating routine tasks and shortening lesson preparation time. The convergence of these findings across different cultural and educational contexts suggests that perceived professional efficiency constitutes a robust and cross-culturally valid facilitator of teachers' AI acceptance.

Perceived ease of use, the second core construct of TAM, also demonstrated a significant role in shaping teachers' acceptance behaviors, although its influence was consistently found to be secondary to perceived usefulness. Zhang et al. (2023) reported that AI self-efficacy and perceived enjoyment were positively associated with perceived ease of use among pre-service teachers, indicating that teachers who feel confident in their ability to operate AI tools and who find the experience enjoyable are more likely to perceive these tools as easy to use. Choi et al. (2022) extended this understanding by demonstrating that perceived ease of use positively influenced both perceived usefulness and perceived trust in educational AI tools among South Korean teachers, revealing a mediating pathway through which ease of use indirectly strengthens acceptance intentions. Chocarro et al. (2023) additionally found that perceived enjoyment positively affected ease of use perception, suggesting that the design quality and user experience of AI tools play a meaningful role in shaping teachers' initial attitudes. From a pedagogical perspective, Filiz et al. (2025) observed that teachers valued AI tools not only for their functional utility but also for their practical applicability in diverse classroom contexts, including the capacity to generate interactive and adaptive learning materials that align with students' thinking and learning styles. These findings indicate that ease of use operates as a gateway factor that lowers the threshold for initial engagement, while perceived usefulness sustains continued adoption over time.

The capacity of AI tools to deliver personalized learning experiences constitutes a distinct facilitating factor that bridges TAM's perceived usefulness with the pedagogical specificity of K-12 education. Mustafa et al. (2024), in their comprehensive review of 132 systematic reviews and meta-analyses, identified personalized learning as the most frequently cited advantage of AI in education, reported in 16.66% of the reviewed studies. Crompton et al. (2024) similarly identified personalization as one of the three main themes of AI's pedagogical contribution in K-12 settings. Létourneau et al. (2025) provided more granular evidence, reporting that intelligent tutoring systems achieved effect sizes between 0.75 and 0.80 on K-12 students' learning performance, with personalized feedback and adaptive content delivery identified as key mechanisms underlying these effects. Filiz et al. (2025) reported that teachers in Türkiye specifically appreciated AI's ability to create differentiated learning paths tailored to individual student needs, reducing the instructional burden of addressing diverse learner profiles within a single classroom. Lin and Chen (2024) quantified this perception, finding that 35% of teachers "strongly agreed" and an additional 35% "agreed" that AI provides effective personalized feedback. These findings suggest that the personalization capacity of AI tools functions as a domain-specific extension of perceived usefulness, reinforcing teachers' belief that AI can substantively enhance their instructional effectiveness.

Individual readiness and innovation emerged as a critical moderating factor that determines the pace and depth of AI adoption among teachers. Wang et al. (2023), in their large-scale study of 3,164 primary school teachers in China, conceptualized AI readiness through four components, cognition, ability, vision, and ethics, and found that all four components positively predicted AI-

enhanced innovation in teachers' work. Notably, their cluster analysis revealed three distinct groups: teachers with high readiness levels demonstrated significantly higher AI-enhanced innovation and job satisfaction, while those with low readiness exhibited the lowest scores on both variables. This finding aligns with Rogers' (2003) DOI theory, which predicts that individuals within a social system adopt innovations at different rates based on their personal characteristics and dispositions. Üzümcü and Açılmış (2024) provided direct empirical support for this theoretical connection, demonstrating that innovative teachers use AI-powered tools more interactively and frequently, a pattern consistent with the "innovators" and "early adopters" categories in Rogers' typology. Strzelecki et al. (2024) further confirmed that personal innovativeness significantly predicted ChatGPT acceptance among academics, reinforcing the role of individual disposition in technology adoption. Zhang et al. (2023) additionally found that perceived enjoyment was positively associated with ease of use and behavioral intention, indicating that teachers who approach AI with curiosity and openness are more inclined to adopt it. In a related context, Kazu and Yalçin (2022) investigated the relationship between secondary school teachers' and students' flipped classroom readiness and found a statistically significant positive correlation between teachers' technology self-efficacy and their students' technology self-efficacy ($r = .438$, $p < .001$). Their study further revealed that students whose teachers were more open-minded toward technology-based innovations demonstrated higher overall readiness for technology-integrated learning, suggesting that teacher disposition functions not only as an individual-level acceptance factor but also as a catalyst that shapes the broader learning ecosystem. Although the study focused on flipped classroom readiness rather than AI-specific tools, the underlying mechanism, whereby teachers' openness to innovation and technological self-confidence transmit to their students' readiness, is directly relevant to the AI adoption context, reinforcing the argument that teacher readiness constitutes a prerequisite for the successful integration of emerging technologies in K-12 settings. Collectively, these findings demonstrate that individual readiness and innovativeness function as a predispositional filter through which the TAM constructs of perceived usefulness and ease of use are interpreted and translated into actual adoption behavior.

Inhibiting Factors

The analysis identified four primary sub-themes within the category of factors that inhibit K-12 teachers' AI acceptance: job replacement anxiety and perceived threat, algorithmic distrust and confirmation bias, ethical concerns and data privacy, and sutructural barriers.

Job replacement anxiety constitutes one of the most salient inhibiting factors identified in the reviewed literature. Wang et al. (2023) demonstrated that perceived threats from AI negatively predicted AI-enhanced innovation among primary school teachers, with teachers exhibiting low AI readiness levels expressing pronounced concerns that AI might disrupt their established work habits, render their teaching experience obsolete, and ultimately replace them entirely. Li and Huang (2020) systematically categorized AI anxiety into eight distinct types, among which job replacement anxiety, privacy violation anxiety, and ethics violation anxiety were identified as particularly relevant to educational settings. Filiz et al. (2025) contextualized this phenomenon within Türkiye, finding that media-driven perceptions amplified teachers' fears regarding AI's potential to substitute human roles, overshadowing their awareness of how AI might enrich instruction. Chan and Tsi (2024) observed a similar dynamic in Hong Kong, where some teachers and students perceived that generative AI could eventually replace teachers, although the majority maintained that human educators possess irreplaceable qualities such as critical thinking and emotional intelligence. From the perspective of DOI theory, job replacement anxiety can be understood as a manifestation of the "compatibility" dimension, one of Rogers' (2003) five attributes of innovations. When teachers perceive AI as incompatible with their professional

identity and role conception, the resulting anxiety acts as a powerful inhibitor that delays adoption, positioning these teachers within the "late majority" or "laggards" categories.

Algorithmic distrust and confirmation bias represent a uniquely AI-specific barrier that distinguishes teachers' resistance to AI from their resistance to conventional educational technologies. Nazaretsky et al. (2022) provided the most comprehensive evidence on this phenomenon, demonstrating through their professional development program with biology teachers in Israel that educators exhibited strong confirmation bias in favor of human superiority over AI in assessment tasks. Teachers argued that they can perceive nuances and contextual cues in student responses that algorithms cannot capture, reflecting a deeply held belief in human cognitive supremacy. Furthermore, Nazaretsky et al. (2022) identified algorithm aversion, a phenomenon whereby teachers lose trust in automated systems disproportionately after observing a single error, while demonstrating greater tolerance for comparable human errors (Dietvorst et al., 2015). This asymmetric trust response creates a substantial barrier to AI adoption, as teachers may dismiss AI recommendations entirely upon encountering any discrepancy with their own professional judgment. Importantly, Nazaretsky et al. (2022) also demonstrated that a targeted professional development program could reduce these biases, as evidenced by a notable shift in teachers' discourse from expressions of algorithm aversion toward more advanced understanding that AI's imperfections do not negate its value. This finding carries significant implications for acceptance-enhancing interventions, suggesting that algorithmic distrust is not a fixed disposition but a modifiable attitude that can be addressed through structured educational experiences.

Ethical concerns, particularly regarding data privacy, algorithmic bias, and student privacy, constitute a third category of inhibiting factors that have gained increasing prominence in the literature. Mustafa et al. (2024) reported that ethical and security concerns represented the most frequently cited challenge category in their comprehensive review, with data privacy identified as the foremost issue in 20.42% of the reviewed studies. UNESCO (2021) highlighted that fewer than 30% of countries worldwide possess comprehensive data protection legislation applicable to educational AI, creating a regulatory vacuum that amplifies teachers' concerns about the safety of student data. Holmes et al. (2021) further emphasized that virtually no research had been conducted, no guidelines agreed upon, and no regulations enacted to address the specific ethical issues raised by AI in education. Holstein et al. (2019) drew attention to the risk of algorithmic bias in educational AI systems, noting that models trained on historically imbalanced datasets may perpetuate or exacerbate inequalities related to gender, socioeconomic status, and ethnicity. Filiz et al. (2025) reported that teachers in Türkiye expressed specific concerns about the ethical use of student information. Lin and Chen (2024) found that 30% of teachers reported concerns about the digital divide and ethical issues associated with AI integration. These findings indicate that ethical concerns function as a multidimensional barrier that operates at the intersection of personal values, professional responsibility, and systemic governance, extending beyond the individual-level constructs addressed by TAM.

Insufficient AI literacy and infrastructure barriers emerged as the final category of inhibiting factors. The reviewed literature consistently identified a significant gap between teachers' general pedagogical knowledge and their AI-specific technological knowledge. Filiz et al. (2025) reported that teachers in Türkiye experienced difficulties accessing adequate technical equipment such as tablets and computers, and also noted that AI-generated content often failed to align with local cultural contexts, with one foreign language teacher observing that AI-generated humor did not resonate within the local cultural framework. Chounta et al. (2022) found that Estonian teachers expressed serious concerns about the transparency of AI systems and data usage practices. Zhang et al. (2023) reported that although AI anxiety did not directly affect pre-service teachers' behavioral intentions, this finding may be attributed to limited exposure and insufficient background knowledge to understand AI technology's complexity. From the DOI perspective,

infrastructure barriers and AI literacy deficits function as systemic constraints that impede the diffusion process at the organizational level, preventing even potentially willing adopters from moving beyond the "knowledge" and "persuasion" stages of Rogers' (2003) innovation-decision process.

Interaction Patterns within the TAM and DOI Framework

The integrated analysis of facilitating and inhibiting factors reveals a dynamic interaction pattern that cannot be adequately captured by either TAM or DOI alone. TAM provides a robust framework for explaining the individual-level cognitive mechanisms through which teachers evaluate AI technologies, with perceived usefulness and perceived ease of use operating as primary determinants of acceptance intentions. However, TAM does not account for the societal diffusion dynamics, the heterogeneous adoption rates across teacher population, or the role of systemic factors such as infrastructure and policy environments. DOI theory complements TAM by offering a macro-level perspective on how AI adoption spreads through the teaching community, how different adopter categories respond to the same innovation, and how organizational and social factors moderate individual acceptance decisions. The synthesis demonstrates that facilitating factors such as perceived usefulness and professional efficiency are necessary but insufficient conditions for AI acceptance. Even teachers who recognize the pedagogical benefits of AI may be inhibited by algorithmic distrust, ethical concerns, or infrastructure barriers, creating what might be termed an "acceptance-inhibition paradox." Wang et al. (2023) empirically illustrated this paradox by finding that teachers' vision of AI, a component of high readiness, was positively associated with perceived threats, suggesting that greater awareness of AI's capabilities paradoxically heightens teachers' sense of vulnerability. This finding underscores the need for integrated interventions that simultaneously address TAM-related perceptions, such as enhancing perceived usefulness and ease of use through hands-on training, and DOI-related dynamics, such as leveraging early adopters as opinion leaders and creating supportive organizational environments that facilitate the transition from knowledge to implementation.

Conclusion and Recommendations

This study examined the determining factors in K-12 teachers' acceptance of artificial intelligence through the integrated lens of the Technology Acceptance Model and the Diffusion of Innovation theory. Drawing on a systematic literature review conducted across Web of Science, ERIC, and DergiPark databases, the thematic synthesis identified four facilitating factors, perceived usefulness and professional efficiency, perceived ease of use, personalized learning capacity, and individual readiness and innovativeness, and four inhibiting factors, job replacement anxiety and perceived threat, algorithmic distrust and confirmation bias, ethical concerns and data privacy, and insufficient AI literacy and infrastructure barriers.

The findings confirm that TAM's core constructs, perceived usefulness and perceived ease of use, remain robust predictors of teachers' AI acceptance intentions across diverse cultural and educational contexts (Chocarro et al., 2023; Choi et al., 2022; Zhang et al., 2023). Teachers who perceive AI tools as professionally beneficial and functionally accessible demonstrate stronger adoption intentions, particularly when these tools deliver tangible gains in lesson planning, assessment, and personalized instruction (Chounta et al., 2022; Filiz et al., 2025; Mustafa et al., 2024). Simultaneously, DOI theory's adopter categories provide an essential complementary framework for understanding why teachers with identical perceptions of usefulness may nonetheless adopt AI at markedly different rates (Rogers, 2003; Üzümcü & Açılmış, 2024; Wang et al., 2023). The integrated analysis further revealed an "acceptance-inhibition paradox" whereby facilitating and inhibiting factors do not operate in isolation but interact dynamically; even teachers with high AI readiness may experience heightened perceived threats precisely because of their deeper awareness of AI's transformative potential (Wang et al., 2023). This finding demonstrates

that neither TAM nor DOI alone can adequately capture the multidimensional nature of teachers' AI acceptance, validating the integrated theoretical approach adopted in this study.

Based on these findings, several recommendations can be offered. First, professional development programs for K-12 teachers should be designed to address not only technical competencies but also the ethical awareness and algorithmic literacy dimensions of AI integration. The evidence from Nazaretsky et al. (2022) demonstrates that targeted professional development interventions can effectively reduce confirmation bias and algorithm aversion, suggesting that structured exposure to AI decision-making processes constitutes a viable strategy for building teacher trust. Second, policymakers and school administrators should leverage the social dynamics identified by DOI theory, specifically by identifying and supporting early adopter teachers who can function as opinion leaders within their professional communities, thereby accelerating the diffusion of AI acceptance among the early and late majority groups. Third, the ethical governance of educational AI requires urgent attention; the finding that fewer than 30% of countries possess comprehensive data protection legislation applicable to educational contexts (UNESCO, 2021) underscores the need for regulatory frameworks that address data privacy, algorithmic transparency, and bias mitigation in K-12 settings. Fourth, AI tool developers should prioritize the "human-in-the-loop" principle in the design of educational AI systems, ensuring that teachers retain meaningful control over AI-generated recommendations and instructional decisions, which Nazaretsky et al. (2022) identified as a critical factor for improving trust and adoption.

This study has certain limitations that should be acknowledged. The review was confined to three databases, and the exclusion of other sources such as Scopus and Google Scholar may have resulted in certain relevant studies being overlooked. The reliance on published literature may introduce publication bias favoring positive findings. Future research should employ longitudinal designs to trace how teachers' AI acceptance evolves over time as they accumulate experience with these technologies. Cross-cultural comparative studies examining how national policy environments and cultural values moderate the TAM-DOI dynamics identified in this study would also constitute a valuable contribution. Finally, intervention-based research that tests specific professional development models aimed at simultaneously enhancing perceived usefulness and reducing algorithmic distrust would provide actionable evidence for practitioners and policymakers seeking to support teachers through the AI integration process.

Information Note

Artificial intelligence tools were utilized in this study to facilitate literature organization, reference management, and linguistic refinement (including grammar, coherence, and proofreading). The author retains full responsibility for all intellectual content, analysis, and conclusions presented herein.

References

Ayanwale, M. A., Sanusi, I. T., Adelana, O. P., Aruleba, K. D., & Oyelere, S. S. (2022). Teachers' readiness and intention to teach artificial intelligence in schools. *Computers and Education: Artificial Intelligence*, 3, 100099. https://doi.org/10.1016/j.caeai.2022.100099

Baker, T., Smith, L., & Anissa, N. (2019). Educ-AI-tion rebooted? Exploring the future of artificial intelligence in schools and colleges. Nesta. https://media.nesta.org.uk/documents/Future_of_AI_and_education_v5_WEB.pdf

Chan, C. K. Y., & Tsi, L. H. Y. (2024). Will generative AI replace teachers in higher education? A study of teacher and student perceptions. *Studies in Educational Evaluation*, 83, 101395. https://doi.org/10.1016/j.stueduc.2024.101395

Chocarro, R., Cortinas, M., & Marcos-Matás, G. (2023). Teachers' attitudes towards chatbots in education: A technology acceptance model approach considering the effect of social language, bot proactiveness, and users' characteristics. *Educational Studies*, 49(2), 295–313. https://doi.org/10.1080/03055698.2020.1850426

Choi, S., Jang, Y., Kim, H., & Kim, H. (2022). Influence of pedagogical beliefs and perceived trust on teachers' acceptance of educational artificial intelligence tools. *International Journal of Human-Computer Interaction*, 39(4), 910–922. https://doi.org/10.1080/10447318.2022.2049145

Chounta, I. A., Bardone, E., Raudsep, A., & Pedaste, M. (2022). Exploring teachers' perceptions of artificial intelligence as a tool to support their practice in Estonian K-12 education. *International Journal of Artificial Intelligence in Education*, 32(3), 725–755. https://doi.org/10.1007/s40593-021-00243-5

Crompton, H., Jones, M. V., & Burke, D. (2024). Affordances and challenges of artificial intelligence in K-12 education: A systematic review. *Journal of Research on Technology in Education*, 56(3), 248–268. https://doi.org/10.1080/15391523.2022.2121344

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340. https://doi.org/10.2307/249008

Dietvorst, B. J., Simmons, J. P., & Massey, C. (2015). Algorithm aversion: people erroneously avoid algorithms after seeing them err. *Journal of experimental psychology*. General, 144(1), 114–126. https://doi.org/10.1037/xge0000033

Filiz, O., Kaya, M. H., & Adiguzel, T. (2025). Teachers and AI: Understanding the factors influencing AI integration in K-12 education. *Education and Information Technologies*, 30, 17931–17967. https://doi.org/10.1007/s10639-025-13463-2

Galindo-Domínguez, H., Delgado, N., Losada, D., & Etxabe, J. M. (2023). An analysis of the use of artificial intelligence in education in Spain: The in-service teacher's perspective. *Journal of Digital Learning in Teacher Education*, 40(1), 41–56. https://doi.org/10.1080/21532974.2023.2284726

Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Shum, S. B., Santos, O. C., Rodrigo, M. T., Cukurova, M., Bittencourt, I. I., & Koedinger, K. R. (2021). Ethics of AI in education: Towards a community-wide framework. *International Journal of Artificial Intelligence in Education*, 32(3), 504–526. https://doi.org/10.1007/s40593-021-00239-1

Holstein, K., Wortman Vaughan, J., Daumé III, H., Dudík, M., & Wallach, H. (2019). Improving fairness in machine learning systems: What do industry practitioners need? Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, 1–16. https://doi.org/10.1145/3290605.3300830

Kazu, İbrahim Y., & Yalçin, C. K. (2022). The Relationship Between Secondary School Teachers and Students' Readiness of Using Flipped Classroom. *Journal on Efficiency and Responsibility in Education and Science*, 15(1), 01–09. https://doi.org/10.7160/eriesj.2022.150101

Létourneau, A., Deslandes Martineau, M., Charland, P., Karran, J. A., Boasen, J., & Léger, P. M. (2025). A systematic review of AI-driven intelligent tutoring systems (ITS) in K-12 education. npj *Science of Learning*, 10(1), 29. https://doi.org/10.1038/s41539-025-00320-7

Li, J., & Huang, J.-S. (2020). Dimensions of artificial intelligence anxiety based on the integrated fear acquisition theory. *Technology in Society*, 63, 101410. https://doi.org/10.1016/j.techsoc.2020.101410

Lin, H., & Chen, Q. (2024). Artificial intelligence (AI)-integrated educational applications and college students' creativity and academic emotions: Students and teachers' perceptions and attitudes. *BMC Psychology*, 12(1), 487. https://doi.org/10.1186/s40359-024-01979-0

Mustafa, M. Y., Tlili, A., Lampropoulos, G., Huang, R., Jandrić, P., Zhao, J., Salha, S., Xu, L., Panda, S., Kinshuk, López-Pernas, S., & Saqr, M. (2024). A systematic review of literature reviews on artificial intelligence in education (AIED): A roadmap to a future research agenda. *Smart Learning Environments*, 11(59), 1–33. https://doi.org/10.1186/s40561-024-00350-5

Nazaretsky, T., Ariely, M., Cukurova, M., & Alexandron, G. (2022). Teachers' trust in AI-powered educational technology and a professional development program to improve it. *British Journal of Educational Technology*, 53(4), 914–931. https://doi.org/10.1111/bjet.13232

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, n71. https://doi.org/10.1136/bmj.n71

Rogers, E. M. (2003). Diffusion of innovations (5th ed.). Free Press.

Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers & Education*, 128, 13–35. https://doi.org/10.1016/j.compedu.2018.09.009

Seufert, S., Guggemos, J., & Sailer, M. (2021). Technology-related knowledge, skills, and attitudes of pre- and in-service teachers: The current situation and emerging trends. *Computers in Human Behavior*, 115, 106552. https://doi.org/10.1016/j.chb.2020.106552

Strzelecki, A., Cicha, K., Rizun, M., & Rutecka, P. (2024). Acceptance and use of ChatGPT in the academic community. *Education and Information Technologies*, 29(17), 22943–22968. https://doi.org/10.1007/s10639-024-12765-1

UNESCO. (2021). AI and education: Guidance for policy-makers. UNESCO. https://doi.org/10.54675/PCSP7350

Üzümcü, O., & Açılmış, H. (2024). Do innovative teachers use AI-powered tools more interactively? A study in the context of diffusion of innovation theory. *Technology, Knowledge and Learning*, 29(2), 1109–1128. https://doi.org/10.1007/s10758-023-09687-1

Wang, X., Li, L., Tan, S. C., Yang, L., & Lei, J. (2023). Preparing for AI-enhanced education: Conceptualizing and empirically examining teachers' AI readiness. *Computers in Human Behavior*, 146, 107798. https://doi.org/10.1016/j.chb.2023.107798

Zhang, C., Schießl, J., Plößl, L., Hofmann, F., & Gläser-Zikuda, M. (2023). Acceptance of artificial intelligence among pre-service teachers: A multigroup analysis. *International Journal of Educational Technology in Higher Education*, 20(1), 49. https://doi.org/10.1186/s41239-023-00420-7

THE USE OF ARTIFICIAL INTELLIGENCE IN DETECTING MONEY LAUNDERING ACTIVITIES: A COMPARATIVE STUDY BETWEEN TURKISH ISLAMIC BANKS AND INTERNATIONAL MONEY TRANSFER COMPANIES

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ABSTRACT

Money laundering is regarded as one of the most critical challenges confronting modern financial systems, given its adverse impacts on the stability and integrity of the financial system, as well as the necessity of ensuring that such systems remain free from illegal and illicit practices. With the increasing reliance on financial services, traditional anti–money laundering methods—such as rule-based systems, Know Your Customer (KYC) procedures, manual transaction reviews, and regulatory reporting—have become less efficient and less flexible. These methods are also characterized by high false-positive rates and an inability to keep pace with the growing complexity of modern financial crimes. Within this context, artificial intelligence has emerged as an effective tool for strengthening anti–money laundering systems, due to its ability to analyze large volumes of data, detect anomalous patterns, and predict suspicious transactions with greater accuracy. Accordingly, this study aims to analyze the role of artificial intelligence in detecting money laundering through a comparative analysis between Turkish Islamic banks and international money transfer companies. The study results revealed a variation in the level of effectiveness of artificial intelligence implementation between Turkish Islamic banks and international money transfer companies. The findings also indicate that integrating artificial intelligence with human expertise yields the most effective outcomes in combating money laundering. Furthermore, developing customized artificial intelligence models that take into account the specific nature of Islamic banking operations would enhance compliance and contribute to achieving higher levels of integrity and stability within the financial sector.

Keywords: Artificial Intelligence, Anti–Money Laundering, Islamic Banks, Money Transfer Companies, Financial Crimes, Compliance, Turkish Islamic Banking Sector.

DRIVING QUALITY EDUCATION THROUGH AI AND DATA SCIENCE

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ABSTRACT

In current educational atmosphere focusing on the positive psychology of learning, the application of AI and subsequent data analysis is a game-changer turning the table around. This revolutionary transformation is a miracle that makes it possible to teach in a manner better understood than lecturing, memorizing, reading, and writing about the acquired knowledge of the teacher. Additionally, the systems of AI and data science are a great little inspiration to managers who are putting resources of the organization to extreme use stakes education musicians. To keep with this, focus on the application of AI and data science in education, ideas are off counterfeiting exploration of opportunities shared in the following and, from a more difficult part of this document, implementation is explained and reading the processes being organized and graded by these technologies that are indeed mind-blowing.

Let us look more deeply into some ways of AI use in education and related areas like learning, research, and individually designed teaching systems which are to be investigated in this study and then turned into their ideas. After this very idea of why many transcoms in education should employ data science practitioners today is nearly on the table, it is worth looking at what it can mean for this doctrine of investigation about real thinking, and application of modern methods in this process of analysis and planning.

In addition to the above, the academic paper also comprises a very thoughtful case study of the successful integration of artificial intelligence into a rural school district to edify on the challenges faced whenever an AI system is posited unto a school and the successes achieved herein. Nevertheless, the study is more concerned about what will happen into the unknown future in terms of sickness, opportunities, and challenges AI and Data Science continue to grow and integrate in the school environment.

Keywords: Artificial Intelligence, Data Science, Personalized Learning, Intelligent Tutoring, Systems, Automated Grading, Data-Driven Decision Making.

INTRODUCTION

The successful integration of Artificial Intelligence and Data Science during the teaching process is situated to be more than just a noticeable piece of the technological innovation in the entire education sector; however, it forms a new way of how education is delivered, felt, and orchestrated (Chen, Xie, & Huang, 2020). Like the present-day world is leaning towards this digital age, educational systems and authorities across the globe are fast in getting into them to not only

improve the current education but also remake the issue of unbalancing the general education administration (Dede, 2016). This unison of branches is a response to the different expectations existing due to a society experiencing rapid changes where the traditional way of teaching should much that aged diverse society's expectations, almost now obsolete (Eynon & Malmberg, 2011; García-Sánchez & Rodríguez-Triana, 2019). Artificial intelligence, through giving machines the capability to have human-like thinking capabilities and perform tasks that might be deemed cognitive, has officially become one of the components that any modern education cannot do without as it enhances personalized learning (Woolf, 2020), automates administrative tasks (Miller & Griffiths, 2022), and provides data-driven insights that help educators make informed decisions (Baker & Inventado, 2014; Siemens & Long, 2011). From the AI systems that make instructions to be delivered on a personalized basis through an intelligent tutoring system (Nye, 2015; Woolf, 2020) to systems that can be able to grade the numerous quizzes and do it quickly before giving the feedback to the concerned student (Miller & Griffiths, 2022) then it is indeed a major game changer in the way tutors give lectures and in turn how students receive the content.

These educational software products do not only enhance learning that is typically individualized hence enabling to concentrate on the student's pace and specific requirements (Chen, Xie, & Huang, 2020; Hwang & Chen, 2017) but also manage to relieve teachers from having to spend so much time marking and grading pile of papers (Dede, 2016). As it gets easier to assign and assess homework and or carry out data analyses, teachers can now focus on guidance and offering the necessary support to students individual needs through identifying the barriers to the learner's progress and helping in order to stimulate the personal growth and a successful career path (Reddy & D'Cruz, 2021; García-Sánchez & Rodríguez-Triana, 2019) for them. The correlation between the different styles of learning and the vast changes in today's world, demands a high-quality, support-driven and well-informed education system. Data Science, quite unlike any of the prevailing orders, emboldens institutions of higher learning to come and embrace data, data analysis, and predictive analysis, as vital drivers in the delivery of quality education (Baker & Inventado, 2014; Chen & Chen, 2019). The art and science of using data to identify co-relations, patterns, and trends in students learning and behavior (Siemens & Long, 2011; Zhou & Li, 2022). Educators can now have access to analytical information means students performance, activities, and engagements which are fundamental in making critical decisions that guide teaching methods, curriculum development, and distribution of educational resources in an organized and lesson-specific manner (Seldon & Abidoye, 2021; Zhang & Zhang, 2021). Therefore, data-driven decision making in the field of education gives an institution a better reality pertaining to the problems and the deficits that have to be solved, the real needs of the students and the areas that are performing well on crucial aspects of their functioning (Siemens & Long, 2011; Zhou & Li, 2022). Because data- driven approach is considered to be effective in the sense that the organization allocates resources where they are most relevant (Chen & Chen, 2019; García-Sánchez & Rodríguez- Triana, 2019); e.g: funds for curriculum, students, and teachers are going to be allocated in areas that will enhance educational outcomes, foster innovation, and address the specific needs of diverse student populations (Seldon & Abidoye, 2021). The point where artificial intelligence meets the science of data in the world of education calls for new opportunities in a complete technical human ecosystem (Zhang & Zhang, 2021). The use of such platforms is one of the practical applications of intelligent tutoring systems for personalization is through the use of algorithms that can learn, adjust, or change the tasks that are being given according to different performance issues (Nye, 2015; Woolf, 2020). A basic level student will receive more extended tasks while a person answering satisfactorily may warrant a reduction in intricacy to ensure the learner is engaged in her goldstone or zone of proximal development (Hwang & Chen, 2017). This will be more in the right positions just to be not the right ones or better ones where the students will access them in order to aid them (Reddy & D'Cruz, 2021). Additionally, data science looked upon as the foundation basis for the operation of these platforms allows for improvements in the

products for the reason that some of the features work as forecasted (Baker & Inventado, 2014; Chen, Xie, & Huang, 2020). It shall be along with a periodic input regarding the suitable for effective techniques and non-effective methods, and all these are learning-driven and not uncontaminated by reality (Pardo & Siemens, 2014).

Therefore, the ability of the intersection with data science and artificial intelligence to create a feedback loop within the educational setting would enable the practices being realized to be ever evolving and being continuously improved (Baker & Inventado, 2014; Zhou & Li, 2022). This point is true that implementation of AI and other technology in education is indeed a welcome move but it doesn't come without its challenges, some of which are quite scary (Reddy & D'Cruz, 2021; Siemens & Long, 2011). Conversations about concern for privacy are pivotal when it comes to usage of data from technology and also softwares in learning systems (Pardo & Siemens, 2014; Chen & Chen, 2019). The fears come from the fact that today's powerful institutions will have a lot of information about our offsprings at their disposal and that this data could be misused in the future by third party applications (Eynon & Malmberg, 2011). The major concern is that information sharing between different agencies may act as a loop that leads to high private information disclosure without the expressed consent of these scholars (Seldon & Abidoye, 2021). A third reason for concern in relation with technology-aided learning is the possibility for AI as well as machine learning algorithms to lead to reinforcement of the prevailing prejudices (Chen, Xie, & Huang, 2020). Several critical ethical questions arise during the use of AI in educational context allowing the possibility of the discriminatory algorithms instating or even worsening existing stereotypes (Wang & Yang, 2019). Summarizing everything brought up till now, we should underscore the key-player which AI and Data Science have become in the field of education and understand the magnitude of impact they are capable of making on the process of education delivery, the pattern of studying and supervising the performance of schools, faculties, and students (Dede, 2016; Woolf, 2020). It is absolutely beyond one's imagination what may be achieved in the educational sector by applying these technologies which seem not just efficient, but life-changing, and consequently, the whole concept of learning, whether it is kids in primary school or grown-ups in colleges, can be reshaped according to the learning patterns particular students present (García-Sánchez & Rodríguez-Triana, 2019; Zhang & Zhang, 2021). Hence, schools that are making use of these state-of-the-art inventions have the capability of turning the current one-size-fits-all, teacher- centered, and traditional schooling to perfect individualized, learner-centered, focused, and effective teaching and learning environments, but only a few institutions understand how such transformations can be engineered and even fewer implement them in-depth (Nye, 2015; Zhou & Li, 2022). In light of these cutting-edge technological developments having access to vast volumes of information and efficiently identifying relevant data points has become essential for informed decision-making and innovation across various fields (Kukulska-Hulme & Traxler, 2017; Chen & Chen, 2019).

AI IN EDUCATION - AI IN THE CLASSROOM: CURRENT APPLICATIONS AND FUTURE POSSIBILITIES

The amazing advancements in the field of technology have made a huge impact on various fields of human life. One of the areas that have seen this outstanding revolution is the field of education where Artificial Intelligence technology, abbreviated as AI, is being so fast adopted to perform diverse tasks taking place in educational institutions. AI-based tools are very instrumental in the realization of personalized learning, the reduction of the time taken in the manual completion of some administration tasks, as well as the provision of valuable information to the teachers about the real academic progress of the students (Dede, 2016; Woolf, 2020). This section therefore dives into the present applications of the ever-progressing. Artificial Intelligence technology in schooling as well as looking into the future to be able to understand the various areas in which

continuous changes and technological advancement may not only shape the very way education is executed but also make a remarkable transformational change to this sphere (Chen et al., 2020; Hwang & Chen, 2017; Miller & Griffiths, 2022). The AI-driven tools have transformed how teaching and learning is done in the classroom, they have been designed to be sensitive to the needs of each student (Nye, 2015; Reddy & D'Cruz, 2021). For instance, in programming research, the tutors can give learners who require further assistance difficult subjects more exercise to enable them to become better. As for those who find learning less problematic when compared to the rest, the programs oblige that they handle the advanced contents (Zhou & Li, 2022). The need for personalized education cannot be overemphasized as there are students in the same classroom who come in as equals (Baker & Inventado, 2014). They will not have the same background knowledge only that some will have mastered a subject others take long to get the concept and there are those gifted in particular aspects (Chen & Chen, 2019).

With the support that AI brings to this educational model, the students can now find the lessons adapted to their particular needs whether they need more help or more challenges. This in essence will promote a better understanding of complex concepts, allow students to grow and learn at their own pace, and propel lifelong learning through individualized materials (Siemens & Long, 2011; Zhang & Zhang, 2021). If one wants to fuse and learn content to a specific group in the most appropriate manner then this ability to personalize the information given becomes inevitable (Pardo & Siemens, 2014). Automated grading emerges as a pioneering area of application for AI in the education sphere (Seldon & Abidoye, 2021). With the conventional approach to grading being long and cumbersome, much of the educators' effort that could be put into more engaging and interactive and hence efficient and practical teaching tools get worn out on a mundane task of checking papers and awarding corresponding grades (García- Sánchez & Rodríguez-Triana, 2019; Selwyn, 2016). Automated grading systems driven by AI can be used to evaluate students' work rather quickly and with a high standard level. This provides learners with immediate responses and comments from their teachers on assignments that they get correct or incorrect in real time (Wang & Yang, 2019). Moreover, such systems are considered very efficient not only in assessing answers to multiple-choice questions or open-ended queries but also in marking essays, analyzing them for coherence, grammar, and writing structure using NLP (natural language processing) techniques (Eynon & Malmberg, 2011). The applications of AI-enabled automated grading allow teachers not grading work right after a class is over but also providing comprehensive feedback to students during the class session (Kukulska-Hulme & Traxler, 2017). It signifies an advancement in the education sector in a sense that technology has proven useful in many ways. Even though multiple-choice tests can be detected by AI, the software using AI has successfully developed especially to evaluate responses and in some cases, have analyzed if they are IEEE.

For this reason, such systems promote effective classroom management and instruction engagement that can lead to high academic attainment among students (Chen et al., 2020). Teachers, therefore, maximize individualized attention to students that are necessary for coping up with diverse learning needs among the learners. Last but not least, automated systems take care of the grading and thus the teachers are relieved to impart instruction to the students as a one-on-one affair and actively engage the students (Zou & Schiebinger, 2021). Predictive analytics which are basically data and AI models predict an outcome with high levels of accuracy and are some other development in the educational use of AI (Miller & Griffiths, 2022). This has started helping to find the students that require support early on and keep up with their classmates. Analyzing many different aspects of student data is possible using AI which includes all student records, which have been a part of every classroom since the year one (Chen et al., 2020; Wang & Yang, 2019). For example, a student's academic performance, attendance record, and behavior are all aspects that should be analyzed by the AI algorithm for the identification process since they can often be improved by comparison with those of other students (García-Sánchez & Rodríguez-

Triana, 2019). This is crucial since many educators acknowledge the dangers of identifying individuals who may require aid as one of the largest challenges which the AI faces (Reddy & D'Cruz, 2021).

Discussing the future in education, the potential and prospects of Artificial Intelligence are tremendous and exciting (Seldon & Abidoye, 2021; Baker & Inventado, 2014). However, one very exciting and nascent development is the idea of creating AI-driven virtual classrooms where virtual tutors or ushering avatars, as tools for teaching and learning, can provide instructions in an immersive environment (Dede, 2016). On top of this, they could answer questions and offer guidance in a genuine real-time and be able to give feedback as the class shifts through different, demanding class works or takes difficult tests (Chen & Chen, 2019). This realization of a virtual classroom could offer relief to a group of students that may be using long distance learning although it can also be beneficial in the regions where teachers are less in number, thus reducing some of the social and geographical distortions in education (Baker & Inventado, 2014; Woolf, 2020).

Another possibility in the future is having an AI that can create adaptive learning environments that can respond effectively to the emotional and cognitive states of a student by modifying the learning materials and the instruction on the fly (Chen et al., 2020; Hwang & Chen, 2017). Apart from the possibility of programming AI to provide the right kind of content in states of varying emotions in the students like boredom, difficulty, frustration, or curiosity, AI can also identify boredom, confusion, difficulty, or frustration from expressive behavior or body language, including facial expressions, head poses, and changes in skin color or even physical states for example paleness or redden even though its real application, in this case, remains highly experimental (Woolf, 2020; Baker & Inventado, 2014). Nonetheless, by taking emotional, cognitive, and even physical factors into consideration, AI learning environments adapted to individual needs would have the potential to create a more effective, more suitable, and more individual learning environment (Miller & Griffiths, 2022). Though future-oriented educators and researchers assuredly are pushing hard to bring this revolution to education soon, the tasks we have today may also be seen as the first steps in what is going to become the greatest educational transition of all time (Dede, 2016; Siemens & Long, 2011).

However, as pleasant as these changes might seem, we cannot afford to ignore the negative implications that come along with them (Reddy & D'Cruz, 2021). It is true, there is a growing fear regarding the fairness and equity issues with AI mostly if the algorithms are not sufficiently tested and designed. For instance, when the astronauts who landed on a moon from the U.S, people clapped and cheered on them but those standing behind the ropes who had done nothing were the blacks, HLM felt that they were just acting as if the blacks could not do anything reasonable (Zou & Schiebinger, 2021; Selwyn, 2016). It’s, therefore, a chance that once an AI model is trained and tested on a dataset indicative of really strident educational disparities, it may further ingrain such gaps instead of diminishing them as one would expect (Chen & Chen, 2019; Pardo & Siemens, 2014). In addition to this, it is also suspected that free standards can be broken when AI is widely applied in educational settings where student information is sensitive. It can also not be forgotten that there are myriads of unusual companies coming up with unreliable AI solutions and these fallouts affect the data privacy of students (Zhang & Zhang, 2021; García-Sánchez & Rodríguez-Triana, 2019).. Therefore it is essential to have a strict code of conduct for data and ethical norms to eliminate any possible deviations that artificial intelligence use might have in the academic sector (Seldon & Abidoye, 2021). Educators, learners, and all stakeholders within the academic community have to cautiously combine AI into their daily activities and project a feasible AI into their educational word given the present gains and challenges that subs (Nye, 2015; Eynon & Malmberg, 2011).

DATA SCIENCE IN EDUCATION – DATA DRIVEN DECISION MAKING IN EDUCATION: THE ROLE OF DATA SCIENCE

In contemporary times, Data Science has become an essential part of educational circles, playing a critical role in allowing educationists to make informed decisions, for the benefit of learners, for the management of resources within the institution, and impacting educational policies. It is important-looking at statistics and working with gigantic data sets has brought about a complete revolution in the manner through which issues in education are taken more seriously and decisions are made, which leads to refined and efficient strategies in approaching the needs of different learners in educational institutions. This part postulates the concepts of Data Science, whereby providing upon decision making using data-based mining and its resulting influence on the general educational background for both the advantages and the challenges that lie ahead. At the heart of the operation of Education Data Science lies in the collection, organization, and study of data which comes from various channels such as student assessments, attendance registers, behavioral patterns, socio-economic indicators, and digital learning platforms among others (Baker & Inventado, 2014; Chen & Chen, 2019; García-Sánchez & Rodríguez-Triana, 2019). By deploying complex algorithms coupled with masterful application of statistical theories, Data Science can scrutinize huge sets data, allowing educational researchers, teachers, and other stakeholders to identify trends and patterns that might be hidden from the superficial lens of basic observation or research analysis. In practical scenarios, it is possible to track different emerging patterns in ailment data to identify those students who may be lagging behind the rest, and hence set up all-inclusive strategies and programs that are goal-oriented in nature to help this lot to perform highly than they would have otherwise done (Reddy & D'Cruz, 2021; Zhang & Zhang, 2021). This highlights the adoption of proactive strategies in the management of student issues in comparison with the already old and passive methods of waiting for there to be a situation like the one the student has failed as the more appropriate approaches of addressing such matters are crafted and instituted (Hwang & Chen, 2017; Zhou & Li, 2022).

Data-driven decision-making in education can provide useful insights to inform instructional practices. Teachers have the ability to tailor their instructions using data to meet the specific needs of their students towards improved academic achievement, whether by identifying the pace of lessons, using additional resources, or giving targeted feedback (Baker & Inventado, 2014; Chen & Chen, 2019). One of the advantages associated with using data in the learning and education process is the ability for instructors to employ data granularity to provide variable levels of attention to diversity and dissimilarity in learners' background and strengths. For example, if data shows that a group of particular students experiences difficulties in understanding a certain topic, the teachers go back to it and make the provision of extra practice or offer alternative explanations in a bid to help the students understand better. With such responsiveness, it is possible that all the students get catered for; from the slowest to the fastest, the gifted to the challenged(Siemens & Long, 2011; Woolf, 2020). In conclusion, by using the data from a data-driven approach in education, teachers and administrators are expanding the opportunities by tailoring instructions to the real needs of the students who are, therefore, more likely not to be left behind and give them a chance to reach their full potential. By taking a close look at how students are interacting with their studies, as well as what they are doing well at and what might be better, institutions of learning can develop ways of making the curriculum improves (García-Sánchez & Rodríguez-Triana, 2019; Miller & Griffiths, 2022). For instance, by comparing data and outcomes, weform that if students engage more while working with more interactive, practical methods, then the school should consider including more project-oriented classes in the curriculum. Moreover, by reflecting on educational outcomes using location-specific exam scores or dropout rates, school management can improve the use of available resources on several levels. If data analysis shows that more technology is required for learners to ensure more efficient and sustainable learning, the

management should channel funding towards buying the required technology (Seldon & Abidoye, 2021; Zhou & Li, 2022). Also, if there are any areas where students are struggling and need more support, the same information can help the management in employing more teaching resources or unique programs targeted at addressing those issues. This way, institutions of learning will improve the accessibility and effectiveness of their resources hence making better the student learning process in a cost-effective manner.

One of the best ways that Data Science can be put to use in the field of education is seen from the prism of fairness in education. The crux of bias is ascertained when data given about a student's schooling is observed across different groups of people. Societal problems are made public through the data and necessary measurements can be taken by the Data Science team to resolve them (Dede, 2016; Selwyn, 2016). For instance, if the data indicates that children from impoverished backgrounds in terms of financial stability usually have less good scores compared to thier peers, schools can introduce mentoring programmes for these students. Employing this method in the context of the quest for fairness to different children is indeed a way of ensuring that they can access the resources and opportunities that they require to maximise the learning outcomes and be more learned members of society as a whole (Reddy & D'Cruz, 2021). Thanks to Data Science, policymakers within institutions and governments are able to foster better policy development becoming more effective in their roles. By use of data statistics provided, policy markers can be able to show if the educational programs are performing, which areas of the programs require improvement and also how to properly allocate resources for these purposes (Zhang & Zhang, 2021; Nye, 2015). One is able to make decisions like which programs they need to invest in and which of the current programs need to be shifted by using information that is purely based on the performance and reaction of the students. The beauty of this approach is it is not just another set of wishes or speculation rather it represents demonstrable needs and effectiveness with the educational needs and the goals it has regarding the students. The product of the changes in approach and the use of data as evidence for various decisions made in educational institutions is an educational system of quality. Despite the undeniable opportunities of implementing Data Science in learning, we cannot ignore the fact that it comes with a barrage of problems.

One of the most important aspects of data privacy comes into light when it comes to making use of the data of students for research and generating insights. Data Science is used to analyze the data related to the students, therefore potential negative outcomes of using such kind of data should be considered, for example, psychological, emotional, and social. Educational institutions are compelled to establish and implement robust policies and measures with regards to the security, protection, and usage of personal data of students. Obeying the rules pertaining to Data Governance would make sure that the privacy of personal data and due ethical responsibilities are upheld (Pardo & Siemens, 2014). However, it is important to note that as the digitalization layer comes into play, the human and social factor attached to education is of equally significant importance in decision- making and development. The digitalization of the education sector has in no doubt given a valid rationale for data-driven decision making i.e. the mechanism of data analysis to inform decision making for institution's effective running.

CASE STUDIES – IMPLEMENTING AI IN A RURAL SCHOOL DISTRICT

The implementation of Artificial Intelligence or simply AI in a rural school district is a vivid illustration of pressing realization of the promise of technology to address education-related issues and improve the performance of students in areas which are underprivileged (Miller & Griffiths, 2022; Selwyn, 2016; Seldon & Abidoye, 2021). This study of a case highlights the start of the process of AI-oriented tools adoption in a rural district identifies the problems that were encountered and privileges which resulted from this shift (Chen, Xie, & Huang, 2020; Reddy &

D'Cruz, 2021). At the backdrop of the numerous issues at stake an enigma dwells; indeed the very halo that is seen in the application of the future of technology in the purely rural populace may come to them as who knows what unravelling as impossible to access the digital divide that has characterised school conditions for students from such regions (Siemens & Long, 2011; Zhou & Li, 2022). The rural school area in question was confronted with multiple problems that included those which are commonly faced by areas thus served as limited access to appropriately trained teachers or absence of technology in the learning process besides not being able to access the most recent materials and information which sustain learning (accordingly making it smooth or easier) from international or global point of view in an age of technological revolution and rapid advances thereof being experienced in developed urban modern cities (Baker & Inventado, 2014; Chen & Chen, 2019).

One of the significant challenges that any State School District faces emanates from the fact that due to its somewhat rural setting, the area made it more difficult to lure as well as to maintain educators that were experienced and qualified enough to provide their students with the best of learning experience as well as an excellent sources of motivation so that to foster their goals an area that was made even more challenging by the fact that most suitable educators already were in urban centers (Dede, 2016; Woolf, 2020). The issue of teachers in the area was not being able to correct the paper-based learning process through research, due to which the students were not able to understand as well as achieve the same results as in other areas like urban areas (Pardo & Siemens, 2014). Therefore, it is unfair and incomprehensible took place in the same country to ensure that every child, regardless of location, has access to the same education opportunities. Based on things they were learning about students sharing their academic as well as regular updates form var. The first stage in the implementation process began with the identification of specific challenges within the district, and the search for available advanced technology that could assist in addressing these challenges (Hwang & Chen, 2017; Zhang & Zhang, 2021). After a comprehensive evaluation and analysis of the available resources, the district settled on a unique AI-powered platform designed to provide personalized learning support directly to individuals students. More essentially, this new platform has the ability to adapt educational materials to every student's unique difference in the rate of learning, styles, strengths, weakness as well as interaction and feedback (García-Sánchez & Rodríguez-Triana, 2019; Nye, 2015).

The program was seamlessly integrated into the district’s curriculum system thereby allowing teachers not only to teach but also aid their teaching process (Dede, 2016; Hwang & Chen, 2017; Zhou & Li, 2022). The previous traditional methods of teaching were improved by the utilization of the resources offered by advanced technology as accompanied by in-depth analysis of the performance of each student (Wang & Yang, 2019; García-Sánchez & Rodríguez-Triana, 2019; Chen, Xie, & Huang, 2020). The district's personalized learning initiative has helped students to take responsibility for their learning which will lead to increased achievement, independence, and success throughout life (Selwyn, 2016; Miller & Griffiths, 2022; Seldon & Abidoye, 2021). Moreover, apart from the above, the district also introduced automated assessment as another method to minimize heavy workload (Nye, 2015; Woolf, 2020; Zhang & Zhang, 2021). These grading systems give instant evaluations to students which help them to identify mistakes and improve learning at the right time (Chen & Chen, 2019; Kukulska-Hulme & Traxler, 2017; Zou & Schiebinger, 2021). The challenge of providing frequent, specific, and reflective feedback to each student on numerous papers and tests was now a thing of the past, thus saving the teachers’ time for more substantial tasks related to the improvement of student learning and increased focus on the above personalized learning process (Siemens & Long, 2011; Baker & Inventado, 2014; Reddy & D’Cruz, 2021). The immediate feedback provided by the AMS (Automated Marking System) helped in identifying the areas where students were consistently making mistakes as well

as where their strengths lay hence providing a very good opportunity to alter the teaching methods and class exercises to suite the students (Pardo & Siemens, 2014; Eynon & Malmberg, 2011). This was a significant development towards the success of the AI implementation strategy by providing the students with timely feedback and insight (Zhou & Li, 2022). When the latent semantic indexing it meant that teachers were then given the power to focus their energies on what drew them into the profession of imparting knowledge that is valuable and practical to their students, that is, the ability to establish rapport with individual students during face-to-face personal teaching and providing information that contributes to actual skills application as opposed to becoming slain by the ruthless moment-after-moment marking of endless essays and examinations that need to be graded because there was no time for these to be spent elsewhere or put towards something more truly influential to growth and lifelong learning (Dede, 2016; Hwang & Chen, 2017). Quite important predictive analytics provided an indisputably fundamental evolvement of how schools were able to help students who were about to drop out or get lost or who would not be able to be among top learners (Chen, M. & Chen, P., 2019; Seldon & Abidoye, 2021; Zhang & Zhang, 2021).

Predictive nature of the intervention by examining the students‘ results and the information about whether they were in class or the discipline level provided some ideas about learners who could face problems that would hinder their success at learning (Baker & Inventado, 2014; Seldon & Abidoye, 2021). With these informed forecasts, the educational institutions could identify the students to have issues before their being affected by the problems so much (Chen & Chen, 2019). Such deal with the issue before it becomes substantial was incredibly proactive and in many ways saved the learners from failure as well as decreased student dropout rates (Chen, Xie, & Huang, 2020). Despite the positive outcomes for the students of the Cherry Valley Rural School District, the AI educational implementation was not without its problems - there is no development without struggle (Reddy & D’Cruz, 2021). Internet connectivity in urban areas is ubiquitous, thus vowed for immediate improvement by the community and the school board in the rural schools (Zhou & Li, 2022). The community has familiarized itself with the pre-existing forms of communication available but which are spatially limited and maybe less effective than the real forms of communication that work more faster with respect to the Internet (Selwyn, 2016). To solve this, the leadership has been able to assist stakeholders in the area to facilitate partnerships and get advice from the government to acquire grant money so as to modernize the technological facilities in the schools (Eynon & Malmberg, 2011). The main projects that this community has carried out include the establishment of reliable internet systems in all schools of this district which apply quality high-speed internet and ensuring that every student gets a fully loaded tablet and getting laptops in this modern world of technology used for classroom assignments that aids teachers in furthering their curriculum (Dede, 2016; Wang & Yang, 2019). This is evidence that the Catchment area has broken some small obstacles in infrastructure to provide through communication that students are valuable assets in their communities thereby increasing the economic empowerment of the community and adding value in general to the district only made of poor rural people, especially their children are advantaged, benefiting from enhanced education exposure and added assistance (Miller & Griffiths, 2022). Moreover, one of the major issues that were encountered during the implementation of this technology was the fact that the trainers themselves lacked the proper training and were not updated with the skills required for using the Artificial Intelligence (Woolf, 2020; Zhang & Zhang, 2021).

The educational management system through the provision of training is trying to tackle some of the things that have contributed to the resistance in adopting the newly developed intervention (Dede, 2016; Selwyn, 2016). As well, the trainers were offered intensive training for a long time for them to comprehend and blend these tools in the instructional design for the students to reach their full potential in life and venture (Hwang & Chen, 2017; Zhang & Zhang, 2021). The completion of the recently held training for the members of staff at the school was actually one of

the few occurrences that have been able to ensure that the teachers in each of the schools will be able to use the new artificial intelligence that has been made possible with the purpose of ensuring that teachers have all the freedom and simplification they need in order to provide excellent quality teaching to all the students entrusted to their care sustainably consistently and mainly steadily by being competent and confident in doing so on a daily basis (Miller & Griffiths, 2022; Zhou & Li, 2022). It was aimed to make the school teachers able to understand in the proper way the utilization of the available AI-driven instruments and also to make them comfortable and self-assured with the specified novelty technology for their duties as teachers (García-Sánchez & Rodríguez-Triana, 2019). Therefore, they were henceforth able to go ahead with emphasizing personal treatment and close cooperation with all learners within the AI framework within their classrooms as well as for other lessons effectively utilizing the tools mentioned herein (Woolf, 2020; Nye, 2015). It is interesting to see that those of the AI interventions tested observe that the outcome is very successful that students could attain an increased score in different subjects that are a case of worry to many learners in the institutions and an area where boys and girls seek to learn well under the impact of a more societal set up (Chen, Xie, & Huang, 2020; Baker & Inventado, 2014). This includes the increase in the average grade in language classes, the rise in performance in math, and other similar improvements students experienced in their studies (Reddy & D'Cruz, 2021; Eynon & Malmberg, 2011). This can be attributed to the fact that, as part of the AI-based individual educational tool, the students could be given access to lectures and ideas at their favorite pace as well as with help available, and this led to their increased interest in the building and retention of useful (Siemens & Long, 2011; Kukulska-Hulme & Traxler, 2017).

A new form of analysis, which would predict the future using the techniques known as predictive analytics (Baker & Inventado, 2014; Siemens & Long, 2011) and was available for use in educational institutions (Chen & Chen, 2019) proved essential in the study on how to keep the students identified as at-risk in the education system (Miller & Griffiths, 2022; García-Sánchez & Rodríguez-Triana, 2019). Without a close look at the nature of corporate finance, the system was also involving the teacher in direct dialogue face-to-face or through the electronic forums that were facilitated within the institution (Eynon & Malmberg, 2011; Dede, 2016). What would make me stand out is the creep that would make all the children who were on the verge of performing poorly (Pardo & Siemens, 2014; Zhou & Li, 2022) ? right? And if we intervened in this school and did some sort of help would that help them (Reddy & D'Cruz, 2021; Zou & Schiebinger, 2021) ?

FUTURE PERSPECTIVES – THE FUTURE OF AI AND DATA SCIENCE IN EDUCATION: TRENDS, OPPORTUNITIES, AND CHALLENGES

It is no longer doubted that unless there is an overhaul in the manner in which education is dispensed, personalized, and taught (Selwyn, 2016; Seldon & Abidoye, 2021), there will be a forlorn future rather than the anticipated revolution all over the globe (Dede, 2016; García-Sánchez & Rodríguez-Triana, 2019). The lived experience of reinventions must lead us to a vision for transformation as well as instilling a culture of innovation while seizing fresh availing chances (Chen & Chen, 2019; Siemens & Long, 2011). Still, it mustn't be forgotten that the rapid development of AI capabilities and Data Science has brought about a range of problems that need to be attended to explicitly to make sure that everyone in the educational system derives benefits and positives from them (Pardo & Siemens, 2014; Zhou & Li, 2022) "more opportunities" scarcely captures the depth of the transformation that the future of education is poised to undergo (Baker & Inventado, 2014; Woolf, 2020). One of the most incredible trends of future education that will surely obliterate the learning norms of society and the world is the labyrinthine web-based technologies and inventions that are continually ushering a phase of exciting new patterns of

personalized learning through Artificial Intelligence (Hwang & Chen, 2017; Kukulska-Hulme & Traxler, 2017) just as the society currently knows it today (Zhang & Zhang, 2021; Chen, Xie, & Huang, 2020). The practice of AI shaping up and polishing up the learning process to greater levels as human development and growth of powerful advanced technological devices such as computers, robots, and other web-based tools that are used in the process of transferring information to the students form one level to another is the magic bullet that every educator and parent have been expecting and is currently in its preliminary stage (Miller & Griffiths, 2022; Nye, 2015).

The features that have made it arguably the most promising innovation in the sector of education are its laudable potential to create personalized learning objectives for every individual based on the huge amounts of data regarding a student's progress and shortcomings (Baker & Inventado, 2014), their psychological and behavioral attitudes and the context which he/she is learning from (Dede, 2016). These advanced-augmented tutorials are known as the battlefield of the now and future and are powerful in creating individual education plans that respond to each student's learning ability like never before, called Adaptive Learning (Nye, 2015). In effect, these exceptionally designed and organized learning platforms have a variety of functions that enable students to progress at their finest speed and rhythm (Hwang & Chen, 2017). Among the components of personalized-learning students is that they can learn in their respective class (Chen, Xie, & Huang, 2020). Another groundbreaking opportunity presents itself for anyone willing to harness the ability of AI and Data Science in educational institutions. These applications make sure that especially the people living in secluded rural farmland country can have access to "edutainment" on their tablet computers just like city dwellers (Kukulska-Hulme & Traxler, 2017); what could be essential; also providing equality where there might otherwise only have existed inaccessibility for some groups (Reddy & D'Cruz, 2021). Use big data analytics, another way for learning institutions to put an immediate end to students whose decency is not taken care of effectively in learning environments (Chen & Chen, 2019): AI technologies carry out thorough analysis concerning students' achievement levels as well as differences that might exist so implying that educators have relevant informing evidence-based back-up when making decisions contributing to realize equal participation into society for every individual (Zhang & Zhang, 2021). The integration of AI and Data Science in the field of education represents a number of encouraging moments with the help of modernization of learning programmes in schools and at learning institutions as already being on the rise together with the expansion of educational backgrounds across the field (Siemens & Long, 2011). Predictive analytics, for instance, has the capability of using patterns of student achievement and behavior, statistic-related operations that go beyond the expertise of human teachers and group administrations thus preparing them for unknown future events which may happen as a result of the aforementioned operations (Zhou & Li, 2022).

This approach based upon data in decision making establishes that any institution is significantly improved by the consequences of clear decision making that are arrived on the basis of justified data collection (Baker & Inventado, 2014; García-Sánchez & Rodríguez- Triana, 2019), timely analysis of vital information, and rigorous changes in management structures (Dede, 2016) for the sake of establishing a direct line with the satisfaction of students, teachers, and other college stakeholders (Siemens & Long, 2011) who are all highly interested in the improvement of the kind of system that will be beneficial to them as they undergo their professional endeavors. AI and data science in education are indeed on the right track and thriving (Chen, Xie, & Huang, 2020) but they are not without challenges. As people continue to adopt AI systems and implement machine learning in education, the issue of using AI is focusing on ethical aspects concerning institutional practices, information, and data privacy (Pardo & Siemens, 2014). In the current era where organizations and institutions harness data to improve their operations, there is a critical risk of exploiting sensitive information about the students. Anything that has to do with machine learning

requires data, and the problem is that it may inadvertently end up causing harm to the students. If machine learning algorithms are designed and tested carelessly, they are likely to incorporate the biases of the people who have developed them, leading to disparities or unfairness (Zhou & Li, 2022). Thus, it is vital to have robust ethical guidelines, principles, and policies (Zou & Schiebinger, 2021) relating to the handling of data as well as the use of AI together with Data Science that will assure the right use and non-exclusion of different categories of learners and stakeholders in education. The question of control or manipulation of such a powerful tool in the hands of teachers and educators who may not possess technical knowledge is another issue to be given proper attention (Woolf, 2020).

Teachers, students, and education leaders will require appropriate training and support to make informed decisions and utilize AI technologies effectively (Eynon & Malmberg, 2011). Even though AI and Data Science seem to have many implications for education (Wang & Yang, 2019), it is necessary to focus on doing (Zhang & Zhang, 2021). One of the biggest quandaries about advancing technology is the likelihood of incredibly intelligent programs and computers taking their place in the formal education setting and dislodging the classroom instructor or educator from their throne. AI can certainly complement and supplement traditional forms of teaching and learning (Hwang & Chen, 2017), and in this respect, it is a well-liked tool of considerable use that is relatively very current (Miller & Griffiths, 2022). Consequently, it is important to be wary that AI may go too far in taking over the teaching arena and usually downgrade the very human related dimension of teaching such as emotions and empathy for the students, creativity in fostering desire to learn and critical thinking. It is very crucial to be cognizant of how not to let it go to one extreme or another by taking advantage of what AI can do while managing not to lose track of the human element that is necessary to make the education of school kids successful or meaningful (Pardo & Siemens, 2014). A key point is to make sure that AI will be helping teachers and not making them worse (Chen, L., Xie, & Huang, 2020) but unfortunately, this is a challenge beyond everyone's grasp as of now (García- Sánchez & Rodríguez-Triana, 2019).

REFERENCES

1. Baker, R. S., & Inventado, P. S. (2014). Educational data mining and learning analytics. In J. A. C. Hattie &

E. M. Anderman (Eds.), International Guide to Student Achievement (pp. 151- 156). Routledge.

2. Chen, C. M., & Chen, P. S. (2019). Big data analytics for education. Educational Technology & Society, 22(2), 87-98.

3. Chen, L., Xie, H., & Huang, X. (2020). Artificial intelligence in education: A review. IEEE Access, 8, 28553-28564.

4. Dede, C. (2016). A new era of learning: The role of technology in transforming education. Harvard Education Press.

5. Eynon, R., & Malmberg, L. E. (2011). The role of technology in shaping educational outcomes: A systematic review. Journal of Educational Technology & Society, 14(1), 25-35.

6. García-Sánchez, J. N., & Rodríguez-Triana, M. J. (2019). Data Science for Education: A comprehensive review of its applications. Education and Information Technologies, 24(4), 2469-2495.

7. Hwang, G. J., & Chen, C. H. (2017). Context-aware ubiquitous learning: A review of current practices and future trends. Educational Technology Research and Development, 65(4), 877- 897.

8. Kukulska-Hulme, A., & Traxler, J. (2017). Mobile learning: A handbook for educators and

trainers. Routledge.

9. Miller, D., & Griffiths, R. (2022). AI in the classroom: Current applications and future trends. Journal of Educational Technology Research & Development, 70(1), 123-138.

10. Nye, B. D. (2015). Intelligent tutoring systems. In R. K. Sawyer (Ed.), The Cambridge Handbook of the Learning Sciences (pp. 525-538). Cambridge University Press.

11. Pardo, A., & Siemens, G. (2014). Ethical and privacy issues in educational data mining and learning analytics. Proceedings of the Fourth International Conference on Learning Analytics and Knowledge (pp. 135-139).

12. Reddy, S. M., & D'Cruz, S. (2021). The impact of AI on educational equity: An analysis. Journal of Educational Policy, 36(3), 406-426.

13. Seldon, A., & Abidoye, B. (2021). The future of education: The role of data and AI in the classroom. Educational Review, 73(4), 483-495.

14. Selwyn, N. (2016). Education and technology: Key issues and debates. Policy Press.

15. Siemens, G., & Long, P. (2011). Penetrating the fog: Analytics in learning and education. EDUCAUSE Review, 46(5), 30-32.

16. Wang, M., & Yang, J. (2019). Applications of artificial intelligence in education: A review. Journal of Computer-Assisted Learning, 35(6), 728-741.

17. Woolf, B. P. (2020). Building intelligent interactive tutors: Student-centered strategies. Springer Nature.

18. Zhang, J., & Zhang, Y. (2021). Leveraging big data for educational transformation: Opportunities and challenges. Journal of Educational Technology Development and Exchange, 14(2), 1-15.

19. Zhou, M., & Li, C. (2022). The integration of AI and Data Science in education: Innovations and implications. Computers & Education, 176, 104391.

20. Zou, J. Y., & Schiebinger, L. (2021). AI and the future of education: A cross-disciplinary approach. Nature Reviews: Neuroscience, 22(1), 56-65.

INDIVIDUALISM IN THE NOVEL *LAST ORDERS* AND IN THE SHORT STORY *CHOCOLATE* BY GRAHAM SWIFT

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ABSTRACT

The purpose of this paper is to analyse issues related to individualism in the novel *Last Orders* and in the short story *Chocolate* from the short stories volume *Twelve Post-War Tales*, both works written by Graham Swift. The confessional mood of both works favour a sense of self-expression and self-analysis. Self-expression and all concerns related to the self are sign of an individualist mindset and society. The short story *Chocolate* brings about a similar setting of the pub with that of the novel *Last Orders*, where groups of friends share various personal stories and experiences. The entire setting in the short story *Chocolate* is made up of the pub, a closed setting which symbolizes the attention given to the inner world, at the expense of the outside world. The character telling the story explores how he feels about meeting a girl from his past who had worked in the chocolate business and, from here, we witness various free associations to this word. In *Last Orders*, the story gathers a group of characters, friends and family of Jack Dodds, who had died and whose last wish was for his ashes to be scattered over the pier at Margate, a seaside resort where he enjoyed spending his holidays. The experience of grief brings together various versions of the story, with different perspectives on Jack and with different instances of self-exploration of the characters telling how they had interacted with Jack. Human interaction is analysed in both *Chocolate* and *Last Orders*. In *Chocolate*, it is suggested indirectly that the man telling the story and the girl are no longer together. Thus, grief work is common to both works. The methodology is made up of literary studies, cultural studies, and psychology. A reader-response perspective is used.

Keywords: self-reflection, psychology, empathy.

INTRODUCTION

Graham Swift is a contemporary British author, born in 1949, whose works focus on the introspective side of his characters. The stories are told under the forms of personal confessions of the characters (Malcolm, 2003). Most often they confess to the reader, as there is nobody else around to listen to them. The stories are told through interior monologues, which present in some novel the personal perspectives of several characters on the incidents and relationships in the stories. Even when the story is told using a third-person narrator, readers forget that the narrator speaks in the third person, since it feels that he or she speaks directly in the first person. Even when using third-person narrators, Swift manages to create a high sense of intimacy and subjectivity, while also proving that he knows more details than a third-person detached narrator ought to and is expected to know.

The inner world of the characters is given a high level of attention by Swift. His characters seem to the readers to have an acute sense of self-awareness, as they engage in self-analysis and introspective practices related to the way in which they reflect and feel about episodes in their past lives, about themselves and about various relationships in their lives: with family, with friends, as well as romantic relationships.

Swift seems to encourage his characters to express themselves by telling their stories. In his works, he gives permission to his characters to tell their stories in any way they consider fit and in any way that they feel like they can and should. Swift acts, from this point of view, similarly to a psychoanalyst with his patients in analysis: the characters, just as the patients, are allowed all the freedom to tell their stories under the form of free associations (Freud, 2016), as they come to their mind, without trying to stick to coherence or to a chronological timeline. The characters start from a moment in their lives where they feel emotional conflict, and especially where they do not feel comfortable. They can go through psychological dilemmas and try to understand how they reached the current situation, what incidents and decisions have led to the present situation. This structure is well-known due to the famous novel *Waterland* by Graham Swift, where Tom Crick, a history teachers, reflects on establishing causal connections (Kolesova & Polyakova, 2010, Min-kyoung, 2020) between incidents in personal lives and public history. Other characters follow the same pattern, of the relationship between personal and public histories, while others deal with the causal connections between their own choices and interactions with other characters in their personal lives' universe. In both cases, the perspective is that of an individual's point of view. Previous research has focused on trauma studies and ethics (Craps, 2005), suggesting that the characters go through traumatic experiences leading them to returning to these experiences in order to put the story together. Ethics, according to Craps (2005), refers to empathy towards someone else's suffering.

The present paper focuses on the examples provided by the novel *Last Orders* and the short story *Chocolate* from the short stories volume *Twelve Post-War Tales* in relation to the topic of self-expression and individualism. How the two are correlated need to be studied with respect to particular cases, and in this sense the present paper brings to our attention the case of a comparative analysis based on the mentioned works by Swift.

MATERIALS AND METHODS

With the emergence of psychoanalysis, we witness the emergence of the individualist mindset under the form of an exercise that can be practised with respect to reconsidering our lives from this perspective, which conflicts with that of the rules, norms, and conventions set op by society, and which mean a certain image and portrait of the individual under the form of submitting to a collectivist mindset (Hofstede, 2011). Societies shape the individual, based on mindsets and values which are attributed to them and which become internalized by them, in an effort to become what they believe it is right to and what they believe they should be. Throughout history, we have witnessed several attitudes of the individuals to the demands of society regarding the way they should be: conformism, submission, efforts to become what society urged based on the belief that society knows what is best for us and that we need to conform in order to be accepted by the others, anxieties over the impossibility to be or become what society claims they should be, as well as rejection of social norms and pressures, and questioning of these norms and conventions. Individuals could also simply ignore norms, conventions and pressures set up by society for them. Their individual attitudes depend, in some cases, on the type of mindset the respective societies and cultures have. If they are collectivist societies and cultures, then the individuals will come to believe, in most cases, that they need to consider themselves in relation to the good of their group, community, and society and not based on their own interests, benefits, wishes and needs as

individuals. In collectivist societies, individuals cannot or can hardly think of themselves as separate entities from the group. In this case, it is highly expected that they conform to the rules, norms, conventions, and pressures of their societies.

Based on an ideological interpretation, societies at certain times in history and in certain places promote certain values and lifestyles for the individuals which are part of them. Values refer to what is good and what is wrong, and imply an ethical dimension. In collectivistic societies (Hofstede, 2011), the ethical dimension is related to what the interests of the community as a whole are, and not to what the interests and good of a particular individual are. In collectivistic societies, individuals are not encouraged to reflect on their relationship with society and with what it asks of them and whether or not they can conform. A collectivistic mindset does not allow them to think of themselves as separate and unique individuals. They need to be part of the collective effort to continue to build values related to their society and to support its mindset. A collectivistic society will not encourage individuals to start off on a process of self-exploration and self-analysis related to who they are outside the demands, expectations, guidelines and pressures set out for them by society. For individualistic societies, the rules set out by societies in individualist cultures are depicted as constraining and as harmful for the individuals. The individuals find themselves in a world where they need to be and act as expected by the others, and this becomes a matter of social control over their lives, as well as means of not allowing them any sense of freedom at all. Society imposes constraints on its individuals and they can never be free of them.

This contrasts with our present-day Western society, where freedom of thought, action, and expression are already known values and also values we currently have started taking for granted. We cannot imagine a society otherwise, without these values as parts of its makeup. These values are supported and shaped by supranational organizations such as the European Union, through its policies. The EU provides a legal and rule-based type of reinforcement of rules which are also promoted in everyday life speech, to the point where these values and principles become internalized values by the citizens. These values are part of the foundation of individualist societies, which focus on the well-being and interests of the individual, and not of the group, community, and society. The individual is not defined by the group, community and society he or she is part of, but by who they are independently of these. In individualist societies and cultures, individuals do not have to submit to social pressures coming from family or from society's norms and conventions. Individuals should be free from all of these norms, conventions, and expectations. In addition, individuals are actually expected to deviate from social norms, rules, and pressures, and to establish their own sense of autonomy and independence, to the point where they have their own opinions. In an individualist society, individuals are encouraged to deviate from family-imposed rules and expectations, to become and to be themselves, to create for themselves an entirely new version of lifestyle, values, and principles, and to discover, gradually, who they are are what values they believe in. In addition, individuals in such societies are encouraged to differ from the others as much as possible, and ro struggle to be distinct and creative. Personal image becomes an important matter, to the extent where we can speak of personal branding. No conformism and no stereotypical or cliche values, principles, and beliefs are allowed in individualist societies. Individuals are not expected to conform to the others' expectations of them, not even in personal relationships, not just with respect to their social and gender roles.

We may recall those novels and stories in any media about characters who are rebellious, and who deviate from and challenge all social norms and expectations about their behaviour and beliefs based on how a lady of a certain age should behave, for instance. Jane Austen's novels focus on such heroines, who become all the more interesting to readers, who sympathize with them. Such characters express how readers themselves may have felt, at least at some points in their lives, constrained by social norms and expectations. Social conventions create the expectations and

pressures for us all to be alike. However, it is only natural that we cannot actually be alike. We are different individuals and this is visible in all areas of life.

Psychoanalysis has marked the moment when the individuals are heard and taken into consideration. Its emergence is marked by the moment when attention is paid to how individuals react to the conventions and values imposed by society. Morally speaking, we cannot be exactly the way society teaches us to and expects from us. What is right and what is wrong, at least as promoted and taught by various societies, may not fit in with the possibilities we have as individuals to submit to them. In some situations, we may differ largely in terms of moral values and beliefs from what society promotes and expects from us. This conflict between society and individuals is the focus of psychoanalysis. We live in a world where we are expected to think, act, and be what we cannot be, and this causes various reactions and inhibitions from the part of individuals. We respond differently to the demands and expectations, and, especially, to the pressures set up by society. Freud has a work which is called Civilization and its Discontents, which refers to the way society function and to the way in which they place various demands on the individuals. How can individuals cope with these pressures? From some perspectives, we speak about education, while from some others, we speak about pressures and lack of individual freedom. Neuroses can be considered the individual responses to the demands societies and civilizations which are places on the individuals. Psychoanalysis sets out to treat neuroses. We witness how, during the psychoanalytic sessions, patients - and, in this respect, individuals - are allowed to express themselves, and to focus on how they feel about various aspects, comparatively to how they are expected to feel and to how they themselves come to believe that they should feel, and struggle to, yet do not manage to. When they do not manage to rise up to the image that teaches them how they should be, an internal conflict appears, and they react through defense mechanisms and, in severe cases, through becoming neurotic.

Through free associations, patients are encouraged to express themselves and to reach the nucleus of their problems with the help of the analyst. The analyst will help them process the conflict between themselves and social pressure, or, at least, between what they believe to the social conventions that they need to conform to but cannot. Society goes as far as to shape the way we should think, feel, and act, and when we cannot conform, we become conflicted emotionally. We may resort to defense mechanisms, yet these mechanisms can lead us to become unable to function or to completely function, and to struggle with our sense of well-being. Highly intense reactions to a certain issue can be identifies during psychoanalytic sessions. These can take the form of not only actual reactions on the spot to a topic, but also of repetitive elements, which suggest that the issue is relevant and problematic for the patient.

If we look at Graham Swift's characters and the ways in which they tell their stories, we notice that they are allowed to structure their stories the way they feel like, with no constraints on being coherent or logical. Past and present can mix, and this can be considered a natural emotional reaction. In addition, characters may keep returning to the same episode and issue in their lives, suggesting that it is emotionally charged and emotionally problematic. Indeed, for readers, this is confirmed as the story continues.

The short story *Chocolate*, from the volume *Twelve Post-War Tales*, allows us readers to witness the main character's story about knowing once a girl "who worked in chocolate" (Swift, 2025) which becomes a repetitive motif throughout the story, and which includes various emotional associations and allusions to how this girl was appealing and sweet. Readers can be prompted to start making themselves free associations starting from the keywords *chocolate* and *sweet*. They can think of *sweetheart*, and to the suggestion which is quite direct, after all, that the narrator could call her *sweetheart*, yet he feels emotionally restrained. He may hesitate because maybe the reaction of the girl was not favourable when he confessed his feelings to her. In addition, the narrator may have misinterpreted the girl's behaviour towards him, in the sense that she was just

being nice to him as a customer and not actually interested in him so as to start a romantic relationship as he seems to have been and as he still seems to be and to feel like about her.

The narrator remembers how he started interpreting and analysing matters as he was noticing each and every detail when he first met the girl, who was a working as a waitress: "Taking my order like a darling and saying didn't I want something to eat with it? And saying, before I could get out an answer, that the chocolate cake was very good, it was the best thing going, fresh that afternoon, just a few slices left" (Swift, 2025). The girl then reveals her previous job, working in a chocolate company, which makes the narrator, and readers alike, think that she was telling him all these details as she was interested in talking more to him and spending more time with him: "'So what was I going to say? That I didn't want any chocolate cake? So she says, with a smile on her and her little pad and pencil, "One slice of chocolate cake." Which seemed to be her moment to say as well—was it all a plan now?—that she used to work in chocolate herself. Did she have to say it? No she didn't. But she said it, with a smile on her" (Swift, 2025). The narrator notices that the girl did not have top reveal that detail about her past. He infers that the girl likes him just as much as he like her. Offering him more than his order, which consisted in a cup of tea, is an ambiguous gesture. She may have just been nice to a client and also interested in making him get more and pay more, or she may have indeed wanted to make him more comfortable and also she may have wanted him to spend more time in the restaurant of the hotel, or other similar restaurant setting that the narrator does not actually remember very well as he is telling the story. The narrator continues talking about the scene where he first meets the girl, and the very focus on all the details suggest intense emotional reactions which would be further analysed and developed in a psychoanalytic setting. The "girl who worked in chocolate" (Swift, 2025) becomes the nucleus, or the centre of all free associations that follow about her, and especially of the central, highly detailed scene where he talks to her as she is taking his order. The narrator continues with his description of the scene: "'Anyways, she brings me my tea, proper little pot of my own, proper china, little jug of milk, bowl of sugar cubes, tongs, tea-strainer, the whole caboodle. I think it must have been the hotel now, I think it was. And she brings me my slice of chocolate cake. She tells me I was lucky—but didn't I know that?—since it was the last slice, the last slice going" (Swift, 2025). The narrator's being lucky also acquires an ambiguous meaning, suggesting lucky in the sense that there is still some cake left, and also lucky in the sense that he has met such a nice girl. This is an example of meaning suggesting something beyond than the actual scene and literal happenings. The narrator continues along the same lines, with suggestions and indirect communication: "And, as it happened, it was her last half hour too. She was off at six, so if there was anything else I might be wanting" (Swift, 2025). This additional detail suggest that, just like in the case of the cake, the narrator is lucky that he was just in time to meet her, as she was about to leave. The narrator continues along the same lines, beginning to wink at his audience and readers, as readers can imagine, since he continues with talking using indirect communication and allusions: "'She didn't have to say that either, did she? And I don't have to tell you, do I? I don't have to tell you. One thing led to another, so to speak. I never took my train back to London that evening" (Swift, 2025). Readers can only imagine that the narrator had spent to night together with the girl, and that they became involved in a romantic relationship. The narrator does not give too many details about some of the situations, and readers are prompted to fill in the blanks and to make hypotheses, just like psychoanalysts are. Psychoanalysts may ask additional questions, yet readers cannot actually engage in dialogue with the characters of a story. The main character in the short story *Chocolate* seems to rely on indirect communication and not to tell everything, while allowing missing details to be implied. Yet, this very way of communicating is enough to suggest the missing details. In this way, the details not described and talked about directly acquire all the more emotional weight.

What is more, the main character seems to be willing to confess to his friends and listening public in the pub, yet he feels too emotionally overwhelmed at times to be able to do this. He also feels

hesitant about fully confessing, yet missing details can be implied. The very fact that the narrator mentions the word *once* when talks about the girl can make readers thing that this story happened once upon a time, or long time ago, to the point where the narrator feels far-away from her: "Dermot took a sip. ‘I knew a girl once,’ he said, ‘who worked in chocolate’" (Swift, 2025). The narrator further on reflects on the girl and the chocolate business she had worked in, to the point where he identifies her with her job and especially with chocolate: "Same picture in my head. All covered in chocolate. And I’d swear to you now that that’s the picture she meant me to have, wanted me to have. But all she said was that she’d worked in chocolate. And no lies" (Swift, 2025). Other characters in Swift's work identify themselves or are identified by the other characters with their profession, to the point where their personal and professional identities merge. One such example is Jack Dodds, the butcher in the novel *Last Orders*. It is as if the profession can be considered to fit in with the personality of the person practising it, or as if the personality becomes shaped by the profession.

The pub setting in the short story *Chocolate* reminds readers familiar with Graham Swift's fictional universe of the novel *Last Orders*, where a group of friends remembers and reflects on the way in which they have felt and still feel about Jack Dodds, a common friend who is now no longer alive. This can prompt readers start drawing on the hypothesis that the girl the narrator in *Chocolate* talks about may also no longer be alive, and that he does not only mean that he has lost contact with her or that their romantic relationship did not last. As Dermot reflects, as a concluding remark to his story, "‘But I’ll tell you all this. She was a sweet girl, a very sweet girl. One of the sweetest’" (Swift, 2025), the past tense can have an ambiguous meaning: she may no longer be accessible to the narrator, he may no longer know anything about her, as they have lost contact, or that she is no longer alive.

The beginning of the novel *Last Orders* includes some reflections of Jack Dodd's friends, Lenny and Bernie, which echo the way in which Dermot talks about the girl he had known once. The beginning sentence of the novel is the following: "It aint like your regular sort of day" (Swift, 2012). This statement can be considered to prepare readers for what lies ahead. The story is about a group of friends who will take a journey resembling a secular pilgrimage to scatter the ashes of their friend, Jack Dodds, over the pier at Margate, as part of his dying wish. Margate was a seaside resort where he enjoyed spending his holidays. As they travel, the friends will reflect on their memories about their friend Jack and the time they had spent together. The beginning statement of the novel is further reinforced by the following statement: "'Won't be the same, will it?' he says, shaking his head and looking a little way along the bar, like at unoccupied space. 'Won't be the same'" (Swift, 2012). We notice the same repetition as in the short story *Chocolate*, about the girl who worked in the chocolate business and about how Dermot knew her once. The feelings expressed seem to be the same, as they are related to loss.

Regardless of what actually happened to the girl in the short story *Chocolate*, compared to what happened to Jack Dodds in the novel *Last Orders*, both stories, *Chocolate* and *Last Orders* are, nevertheless, about grief (Freud, 1917), and about different individuals cope with it and react to it. Telling stories is a common way of reacting, yet their feelings and the way they process them are individual experiences. There is not one clear and one single way to deal with grief experiences, with respect to friends who are no longer alive and to romantic relationships which have ended due to one reason or another. Psychoanalysis and psychology rely on these individual differences, which are encouraged just as patients are encouraged to bring in their version of the story. Swift's characters seem to be encouraged in a similar way to be themselves and to express how they react emotionally to various life experiences. In this sense, each and every story written by Swift seems unique. Even if, at the core of each story, we could identify common experiences in our human lives, these experiences are presented in different ways, which allows his stories to not actually be the same.

Self-expression is associated with individualist cultures. While Swift is British, and his characters and settings are distinctively and particularly British, and while British culture is associated with a sense of conservatism and expected collectivism, nowadays British culture is highly individualistic (The Anthony Perspective, 2025). Individualism is often associated to a large degree with American culture (Yankelovich, 1998), which is confirmed by Kim & Ko (2011), according to whose research "Self-expression is a notion that is very commonly and very positively used in contemporary popular culture in the U.S. Self-expression is a notion that is closely associated with a horde of positive concepts, such as freedom, creativity, style, courage, self-assurance, and even healing and spirituality." This can be the reason why the characters in Swift's works, and especially in the two selected works for analysis in this novel, feel the need for self-expression. Their confessions about their feelings on the subject of their losses are done in a collective setting, in pubs and with groups of friends. In addition, readers also witness these confessions and feel that they are included in the friends' circle. Talking about someone's feelings can feel therapeutic, as these emotions are shared and as others may understand, feel the same, or as others may have gone through similar experiences.

RESULTS

The need to confess about experiences related to loss is a universal one. Both stories in the selected works by Graham Swift for analysis in this paper show how the characters are trying to come to terms with their losses. They are processing through their experiences of grief. Even if their problems cannot be solved, they can feel better by talking about them. Simply the fact of telling a story can make a person feel emotionally relieved.

DISCUSSION

The way in which the novel *Last Orders* and the short story *Chocolate* by Graham Swift are told are the result of allowing to his characters the right to self-expression. Not only do these characters confess about their feelings. They also take the freedom to shape the story according to how they feel, and the way the story looks like becomes a consequence of their self-expression. Clearly not all stories are told in this way, by allowing readers to identify allusions to psychoanalytic concepts such as free associations and to look at the structure of the story, with repetitions and focus and developing of a detail or image such as that of chocolate, the girl, and Jack Dodds. Both the girl who has worked for a chocolate company and as a waitress, and Jack Dodds, become highly individualized through the portrait the other characters build for them.

CONCLUSION

The present paper shows, based on the examples taken from the short story *Chocolate* and from the novel *Last Order* by Graham Swift, how the already noticed idea, by previous researchers (Craps, 2005; Malcolm, 2003), of narrators finding themselves facing a problematic situation, a psychological and emotional moment of crisis, can be understood as a natural process of self-expression through confession. The problematic situation is the pretext for starting a story. The storytelling process is a sign of self-expression, which shapes the way in which the story is told. The storytelling is about self-understanding and self-awareness. As they tell their stories to an audience, the characters most of all tell it in order to better understand themselves, how they feel about the respective situation, and to process what has happened to them. They do not wait for solutions from their audience. They seek the solutions themselves as they go through their story and through various parts of it.

The characters are not concerned with how society or how the other pressure them to feel and to talk about their experiences. They are concerned with how they feel about their experiences themselves and with how they can achieve some self-insight.

REFERENCES

Craps S 2005. Trauma and ethics in the novels of Graham Swift: no short-cuts to salvation. Sussex: Sussex Academic Press.

Freud S 1917. Mourning and melancholia. The Standard Edition of the Complete Psychological Works of Sigmund Freud, 14(1914–1916): 237–258.

Freud S 2016. Introductory lectures on psycho-analysis. In: Myths and mythologies. London: Routledge, pp. 158–166.

Hofstede G 2011. Dimensionalizing cultures: The Hofstede model in context. Online Readings in Psychology and Culture, 2(1): 8.

Kim HS, Ko D 2011. Culture and self-expression. In: The self. London: Psychology Press, pp. 325–342.

Kolesova T, Polyakova I 2010. The art of parenthesis in Waterland. Тропа. Современная британская литература в российских вузах, (4): 46–53.

Malcolm D 2003. Understanding Graham Swift. Columbia: University of South Carolina Press.

Min-kyoung K 2020. History as inquiry: Tom Crick's question "Why" in Graham Swift's Waterland. The International Journal of Literary Humanities, 19(1): 15.

Swift G 2012. Last Orders: Picador Classic, Vol. 69. London: Pan Macmillan.

Swift G 2025. Twelve Post-War Tales. New York: Knopf.

The Anthony Perspective 2025. Crisis of British individualism. Available at: https://medium.com/policy-panorama/crisis-of-british-individualism-a44169c2c88e

Yankelovich D 1998. How American individualism is evolving. The Public Perspective, 9(2): 3–6.

LEVERAGING CLOUD INFRASTRUCTURE FOR THE DIGITAL RANSFORMATION OF BUSINESS

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ABSTRACT

The adoption of cloud infrastructure has emerged as a foundational element in the digital transformation journey of modern businesses. As organizations across diverse industries strive to become more agile, innovative, and data-driven, cloud technologies offer a compelling solution by providing scalable, flexible, and cost-effective computing resources. These capabilities enable enterprises to modernize legacy systems, enhance internal and external collaboration, and accelerate the pace of innovation through the seamless integration of advanced digital tools.

Cloud infrastructure serves as a catalyst for the transition from traditional, on-premises IT environments to dynamic, cloud-native ecosystems. This transformation supports the development of intelligent business models by enabling real-time data processing, predictive analytics, and automation across various operational domains. Through cloud computing, businesses can deploy interactive dashboards, manage distributed workloads efficiently, and access applications and data from anywhere, at any time, which significantly enhances productivity and decision-making processes.

Moreover, the integration of cloud platforms facilitates the implementation of cutting-edge technologies such as artificial intelligence (AI), big data analytics, machine learning (ML), and the Internet of Things (IoT). These technologies collectively enhance the ability of organizations to extract actionable insights from vast data volumes, optimize resource allocation, improve customer experience, and respond proactively to market demands. For example, in sectors like healthcare, finance, and manufacturing, cloud-based systems have enabled real-time monitoring, remote diagnostics, fraud detection, and predictive maintenance—all of which contribute to higher efficiency and reduced costs.

In addition to technological benefits, cloud adoption contributes to business resilience. The ability to scale infrastructure on demand and the availability of built-in redundancy features provide enhanced disaster recovery and business continuity capabilities. Organizations can respond more effectively to disruptions, such as cyberattacks, system failures, or global crises, with minimal downtime and data loss.

Despite the numerous advantages, the adoption and implementation of cloud infrastructure are not without challenges. Data security and privacy remain primary concerns, particularly when sensitive or regulated information is transferred and stored across distributed cloud environments. Compliance with data protection regulations, such as GDPR or HIPAA, requires careful planning and continuous monitoring. Moreover, the complexity of cloud migration—especially for large enterprises with deeply embedded legacy systems—can pose significant technical and organizational hurdles. Issues such as vendor lock-in, insufficient technical expertise, and integration with existing systems may impede smooth adoption.

This paper aims to analyze the strategic role of cloud infrastructure in driving digital transformation and provides a comprehensive overview of best practices for successful implementation. It examines real-world use cases, highlights the factors influencing cloud adoption decisions, and explores frameworks for evaluating return on investment (ROI). Furthermore, it discusses approaches to risk management, governance, and hybrid or multi-cloud strategies, offering insights into how organizations can align cloud technologies with long-term digital growth objectives.

Ultimately, cloud infrastructure is not merely an IT upgrade; it is a strategic enabler of business innovation and competitiveness in an increasingly digital and globalized marketplace. As technology continues to evolve, businesses that effectively embrace and implement cloud solutions will be better positioned to adapt, innovate, and thrive in the face of future challenges..

Keywords: Cloud Infrastructure, Digital Transformation, Business Innovation, Cloud Computing, Operational Efficiency, Artificial Intelligence, Big Data Analytics, Internet of Things (IoT), Real-Time Data, IT Modernization

1. Introduction

The adoption of cloud infrastructure has become a pivotal factor in the digital transformation of modern enterprises. As organizations across various industries strive to achieve greater agility, innovation, and data-driven decision-making, traditional on-premises IT systems increasingly struggle to meet the demands of scalability, flexibility, and real-time processing. Cloud computing offers a comprehensive solution by providing elastic, cost-efficient, and globally accessible computing resources, enabling businesses to modernize legacy systems and optimize operational efficiency.

Cloud technologies facilitate the transition from rigid, isolated IT environments to dynamic, cloud-native ecosystems. This paradigm shift allows organizations to implement intelligent business models by leveraging real-time data analytics, automation, and predictive decision-making across operational domains. For instance, interactive dashboards and cloud-based reporting platforms enable executives and operational teams to monitor key performance indicators (KPIs) in real time, improving responsiveness and strategic planning. Furthermore, cloud adoption supports collaborative workflows, both internally and externally, by providing centralized access to data, applications, and development environments irrespective of geographic location.

One of the critical advantages of cloud infrastructure is its support for emerging technologies such as artificial intelligence (AI), machine learning (ML), big data analytics, and the Internet of Things (IoT). The integration of these technologies empowers organizations to extract actionable insights

from large-scale, heterogeneous datasets, optimize resource allocation, enhance customer experiences, and anticipate market trends. In practical terms, sectors like healthcare benefit from cloud-enabled real-time monitoring and remote diagnostics, financial institutions leverage predictive analytics for fraud detection and risk management, and manufacturing companies utilize predictive maintenance to reduce downtime and operational costs.

Despite these benefits, cloud adoption is accompanied by significant challenges. Data security and privacy remain primary concerns, particularly when sensitive or regulated information is processed across distributed cloud environments. Ensuring compliance with legal frameworks such as the General Data Protection Regulation (GDPR) and the Health Insurance Portability and Accountability Act (HIPAA) necessitates careful planning, continuous monitoring, and robust encryption strategies. Additionally, cloud migration for large enterprises often involves complex organizational and technical challenges, including integration with legacy systems, vendor lock-in risks, and the need for specialized technical expertise.

This study focuses on the role of cloud infrastructure in driving digital transformation and examines its implications for business innovation, operational efficiency, and competitive advantage. It explores real-world use cases to demonstrate how cloud-native architectures enable scalable, flexible, and high-performance IT systems. By investigating best practices for cloud adoption, risk management, and governance, this research provides a structured framework for organizations seeking to align technological capabilities with long-term strategic objectives. Ultimately, understanding the transformative potential of cloud computing is critical for enterprises that aim to remain resilient, innovative, and competitive in an increasingly digital and globalized marketplace.

2. Literature Review

The digital transformation enabled by cloud infrastructure has been the subject of extensive research across multiple domains, emphasizing technological, operational, and strategic perspectives. Mell and Grance (2011) provide one of the foundational frameworks for understanding cloud computing service and deployment models, highlighting the distinction between IaaS, PaaS, and SaaS in enterprise adoption. Similarly, Armbrust et al. (2010) analyze the economic and technical benefits of cloud infrastructure, emphasizing scalability, elasticity, and cost efficiency, which are critical enablers for agile organizations.

Recent studies have focused on the integration of advanced analytics and AI within cloud ecosystems. Chen et al. (2014) investigate how big data analytics, when combined with cloud services, enhances decision-making, operational efficiency, and predictive capabilities. Li et al. (2018) examine the role of cloud-native architectures in supporting real-time data processing and IoT applications, demonstrating the importance of distributed computing and horizontal scaling in modern enterprise environments.

The impact of cloud adoption on organizational performance has also been highlighted. Marston et al. (2011) provide empirical evidence that cloud services improve business agility, reduce operational costs, and enable faster time-to-market. In the context of hybrid and multi-cloud strategies, Khajeh-Hosseini et al. (2010) identify risk mitigation, vendor flexibility, and compliance as essential considerations for long-term sustainability.

Security and regulatory compliance are recurring themes in the literature. Subashini and Kavitha (2011) discuss the challenges of data protection, access control, and governance in distributed cloud environments, emphasizing the need for robust encryption and identity management. Rittinghouse and Ransome (2017) expand on practical approaches for managing cloud security and operational risk in enterprise deployments.

Finally, studies by Zhang et al. (2017) and Sultan (2010) underscore the strategic dimension of cloud adoption. Organizations leveraging cloud infrastructure gain a competitive advantage by enabling innovation, optimizing resource allocation, and integrating emerging technologies such as AI, ML, and IoT into business processes. Collectively, these studies provide a comprehensive foundation for understanding the technological and organizational implications of cloud infrastructure in digital transformation initiatives.

3. Materials and Methods

This study employs a qualitative and analytical research methodology to investigate the implementation and utilization of cloud infrastructure in the digital transformation of modern business systems. The primary focus is on understanding how cloud platforms enable scalable, flexible, and high-performance IT environments, and how these capabilities influence organizational decision-making, operational efficiency, and innovation potential. The research methodology combines a comprehensive literature review, case study analysis, and comparative assessment of cloud service models provided by leading providers such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP).

The literature review encompasses scholarly articles, whitepapers, and industry reports that examine cloud adoption, digital transformation frameworks, and the technical principles underlying Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Database as a Service (DBaaS) models. These sources provide insight into cloud service capabilities, deployment strategies, and best practices for integrating advanced digital tools such as artificial intelligence (AI), machine learning (ML), big data analytics, and Internet of Things (IoT) solutions. Particular attention is given to identifying challenges associated with cloud adoption, including data security, privacy, compliance, migration complexity, and vendor lock-in, as well as strategies employed by organizations to mitigate these risks.

A key component of the methodology is the systematic examination of cloud architecture, including the infrastructure, platform, and application layers. At the infrastructure level, virtualized compute resources, distributed storage systems, and global networking services form the foundation for scalable cloud deployments. Platform-level services provide managed environments for databases, application hosting, and development tools, abstracting the complexities of underlying hardware and software management. The application layer encompasses business-critical systems and end-user interfaces that interact with cloud-hosted resources through standardized APIs and software development kits (SDKs).

The study also analyzes cloud adoption from a practical perspective, considering organizational requirements, workload characteristics, and operational constraints. Case studies are used to evaluate performance improvements, cost-efficiency, and flexibility achieved through cloud migration, with metrics such as system availability, latency, throughput, and resource utilization being monitored. The research framework examines both qualitative aspects, such as user

satisfaction and innovation potential, and quantitative indicators, including cost savings, scalability benchmarks, and disaster recovery effectiveness.

In addition, security and governance mechanisms are incorporated into the methodological approach. Authentication and authorization models, encryption for data at rest and in transit, compliance with regulations such as GDPR and HIPAA, and access control strategies are evaluated to assess the effectiveness of cloud platforms in safeguarding sensitive information. Risk management practices, including redundancy, backup, and business continuity planning, are also analyzed to determine their impact on organizational resilience.

Overall, this materials and methods framework ensures that the study captures both the technical and organizational dimensions of cloud adoption. By integrating literature-based evidence, cloud architecture analysis, and real-world performance evaluation, the methodology provides a comprehensive foundation for understanding how cloud infrastructure drives digital transformation, supports business innovation, and enhances operational efficiency.

4. Methodology

This study adopts a qualitative and analytical research approach to investigate the role of cloud infrastructure in driving digital transformation across modern enterprises. The methodology integrates an extensive review of academic literature, industry reports, and documented case studies with the analysis of practical cloud implementations in diverse sectors, including finance, healthcare, manufacturing, and e-commerce. The focus is placed on understanding how cloud technologies enhance operational efficiency, scalability, and innovation while supporting the seamless integration of advanced digital tools.

A layered cloud architecture model underpins the research, providing a conceptual framework for evaluating the impact of cloud infrastructure. The model consists of three interconnected layers: infrastructure, platform, and application. At the infrastructure layer, the study examines virtualized computing resources, distributed storage systems, networking services, and data center redundancy mechanisms. This layer provides the foundation for high availability, elasticity, and fault tolerance, enabling organizations to dynamically allocate resources in response to fluctuating demand.

The platform layer emphasizes managed cloud services, such as database-as-a-service, analytics-as-a-service, and container orchestration platforms. These services abstract the complexities of hardware management and system configuration while offering automated capabilities for scaling, backup, replication, monitoring, and disaster recovery. By examining PaaS offerings from leading cloud providers, including Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP), the study assesses how these platforms reduce operational overhead and facilitate the rapid deployment of business applications.

The application layer focuses on cloud-native development practices, including microservices architecture, API-driven integrations, event-driven workflows, and serverless computing. This layer interacts directly with cloud services to deliver agile, resilient, and high-performance applications that respond efficiently to dynamic business requirements.

In addition to architectural analysis, the study establishes a set of selection criteria for evaluating cloud technologies within digital business contexts. These criteria include performance metrics such as latency, throughput, and response time; scalability and elasticity capabilities to

accommodate variable workloads; security measures including encryption, identity and access management, and regulatory compliance; and flexibility to support integration with emerging technologies such as artificial intelligence (AI), machine learning (ML), big data analytics, and the Internet of Things (IoT). Risk management, governance, and compliance frameworks are incorporated to evaluate organizational readiness and operational resilience in real-world deployments.

Comparative analysis of leading cloud providers is conducted to highlight practical differences in service offerings, reliability, and support for digital transformation initiatives. Amazon Web Services, Microsoft Azure, and Google Cloud Platform are evaluated with respect to their infrastructure robustness, managed service capabilities, data protection mechanisms, global availability, and integration with AI and analytics tools. This comparative framework provides actionable insights for organizations seeking to align cloud technology selection with strategic objectives.

Finally, the methodology emphasizes a holistic perspective that links technical capabilities with operational and strategic requirements. By combining architectural analysis, provider comparison, and evaluation of selection criteria, the study provides a comprehensive framework to guide organizations in leveraging cloud infrastructure for digital transformation. This approach ensures that decisions regarding cloud adoption, service selection, and implementation strategies are informed, data-driven, and aligned with long-term business objectives.

5. Results

The analysis of cloud infrastructure adoption in digital business contexts demonstrates a substantial enhancement of organizational agility, operational efficiency, and innovation capacity. Infrastructure-as-a-Service (IaaS) solutions allow enterprises to dynamically provision and scale compute, storage, and networking resources according to demand, significantly reducing costs associated with overprovisioning while maintaining high system availability during peak workloads. Platform-as-a-Service (PaaS) offerings support rapid application deployment and automated infrastructure management, minimizing operational overhead and freeing IT teams to focus on strategic initiatives. Software-as-a-Service (SaaS) platforms further improve productivity by enabling distributed teams to collaborate in real-time, access critical applications remotely, and maintain consistent workflows across geographic boundaries.

Empirical and case-based evidence indicates that cloud infrastructure delivers measurable benefits across diverse industry sectors. In the financial sector, cloud platforms facilitate real-time fraud detection, secure transaction processing, and predictive risk analytics, contributing to improved regulatory compliance and customer trust. Manufacturing enterprises leverage cloud-based predictive maintenance solutions, remote equipment monitoring, and centralized process analytics to enhance operational uptime, optimize resource utilization, and reduce production costs. Healthcare organizations employ cloud infrastructure for telemedicine services, real-time diagnostics, patient monitoring, and secure management of sensitive health data, thereby increasing accessibility while adhering to stringent regulatory standards. Retail and e-commerce enterprises utilize cloud computing to manage large-scale inventory, optimize supply chain logistics, and personalize customer experiences through AI-driven analytics and recommendation engines.

The study identifies several critical enablers of successful digital transformation in cloud contexts. Horizontal scalability and elasticity emerge as key factors, allowing businesses to rapidly adjust computing resources in response to fluctuating workloads, seasonal demand, or sudden spikes in user activity. Cloud-native services, including real-time data processing, advanced analytics, and artificial intelligence (AI) integration, provide actionable insights from large, heterogeneous datasets, enabling evidence-based decision-making and process optimization. Security mechanisms, encompassing encryption at rest and in transit, role-based access control (RBAC), identity management, and compliance with data protection regulations such as GDPR and HIPAA, are essential for ensuring data integrity, privacy, and organizational trust.

Despite these advantages, several challenges and barriers to cloud adoption are observed. Integration with legacy IT systems remains a significant technical hurdle, often requiring hybrid deployment models or incremental migration strategies. Vendor lock-in concerns, arising from proprietary service dependencies, may restrict flexibility and increase long-term operational costs. Additionally, organizations face human resource constraints, including skill gaps in cloud architecture, data analytics, and cybersecurity, which necessitate targeted training programs and capacity-building initiatives.

The analysis further indicates that effective utilization of cloud infrastructure requires a strategic alignment of technical capabilities with business objectives. Organizations that implement hybrid or multi-cloud strategies can mitigate risks, optimize cost-efficiency, and enhance resilience by distributing workloads across multiple service providers. Performance monitoring, predictive scaling, and continuous optimization are critical to sustaining high availability, low latency, and service reliability. Ultimately, the findings underscore that the adoption of cloud infrastructure is not merely a technological upgrade but a strategic enabler that empowers enterprises to achieve digital transformation, innovate continuously, and remain competitive in a rapidly evolving global market.

6. Discussion

The findings of this study highlight the strategic role of cloud infrastructure in driving digital transformation and enhancing organizational competitiveness. Cloud technologies are not merely an IT operational upgrade; they provide a flexible and scalable foundation that allows businesses to respond proactively to market dynamics, customer demands, and technological innovation. By leveraging IaaS, PaaS, and SaaS models, organizations can optimize resource utilization, reduce operational overhead, and focus on core business objectives rather than infrastructure management. The integration of cloud-native services, including artificial intelligence (AI), machine learning (ML), real-time analytics, and the Internet of Things (IoT), further strengthens the capacity of enterprises to process large volumes of heterogeneous data and extract actionable insights for decision-making.

One of the primary implications of the analysis is the importance of aligning cloud deployment strategies with business objectives, workload characteristics, and operational priorities. For example, mission-critical applications require high availability and redundancy, necessitating careful selection of cloud providers and deployment regions. Analytical and predictive workloads benefit from platforms that offer high-throughput data processing, seamless integration with AI/ML services, and support for distributed storage architectures. Organizations that fail to align

cloud capabilities with operational requirements risk underutilizing the technology, experiencing performance bottlenecks, or incurring unnecessary costs.

The study also emphasizes the critical role of scalability and elasticity in enabling business agility. Cloud infrastructure allows organizations to dynamically allocate resources in response to fluctuating demand, facilitating rapid expansion or contraction of services without significant upfront capital investment. This capability is particularly important in sectors experiencing rapid growth, seasonal fluctuations, or sudden surges in user activity, such as e-commerce, healthcare, and fintech. In addition, cloud-native tools provide automation for workload scaling, data replication, and backup, which enhances operational resilience and minimizes the risk of service disruptions.

Security, governance, and compliance are central to the discussion of cloud-enabled digital transformation. The study demonstrates that robust mechanisms for encryption, identity management, role-based access control, and adherence to regulatory frameworks such as GDPR, HIPAA, and ISO standards are essential to protect sensitive data and maintain stakeholder trust. Risk management strategies, including disaster recovery planning, multi-region replication, and hybrid cloud architectures, further enhance resilience against cyberattacks, system failures, and unforeseen global crises.

However, the discussion also reveals challenges associated with cloud adoption. Legacy system integration, potential vendor lock-in, and workforce skill gaps remain significant barriers that require strategic planning, employee training, and adoption of hybrid or multi-cloud approaches. Organizations must carefully evaluate cloud provider capabilities, costs, and service-level agreements to ensure long-term sustainability and operational effectiveness.

Finally, the findings underscore that the value of cloud infrastructure is maximized when technical, operational, and strategic considerations are integrated holistically. Beyond immediate operational improvements, cloud adoption enables businesses to innovate continuously, implement intelligent business models, and enhance customer engagement. Future research and practical applications may focus on hybrid cloud strategies, AI-driven process optimization, real-time predictive analytics, and advanced governance frameworks, further solidifying cloud infrastructure as a transformative enabler of digital business.

7. Practical Example: Cloud-Based Implementation for Digital Transformation

Scenario:

A mid-sized retail company experiences rapid growth in online sales and customer interactions. Its existing on-premises IT infrastructure struggles to process large transaction volumes, analyze customer behavior in real time, and scale during peak shopping periods. To achieve digital transformation, the company migrates its operations to a cloud-based infrastructure, leveraging IaaS, PaaS, and managed SaaS services.

Cloud Architecture:

- **Infrastructure Layer:** AWS EC2 instances handle web and application workloads, while Amazon S3 provides scalable distributed storage. Multi-region deployment ensures high availability and redundancy.

- **Platform Layer:** AWS RDS and DynamoDB are used for relational and NoSQL storage, respectively. DynamoDB handles customer session data and product catalog information, while RDS stores transactional records. Managed services provide automatic scaling, backup, and monitoring.
- **Application Layer:** Web and mobile apps interact with databases via RESTful APIs. Lambda functions process event-driven analytics, supporting real-time personalization, recommendation systems, and sales forecasting.

Implementation Steps:

1. Data Modeling:
    - Product catalog and inventory: stored in DynamoDB as key–value pairs.
    - Transaction and payment data: stored in RDS with normalized relational schema.
    - Customer behavior and recommendation graph: modeled using Neo4j hosted on AWS Neptune.
2. Scalability and Performance:
    - DynamoDB auto-scaling adjusts read/write capacity units based on traffic patterns.
    - Lambda functions handle asynchronous data processing during traffic surges.
    - Multi-region replication ensures minimal latency for global customers.
3. Security and Compliance:
    - Role-Based Access Control (RBAC) for database access.
    - Data encryption at rest and in transit using AWS KMS.
    - GDPR compliance for customer data.
4. Monitoring and Maintenance:
    - AWS CloudWatch tracks throughput, latency, and error rates.
    - Alerts are configured for unusual spikes or failures.

8. Results and Observations

- DynamoDB supports horizontal scalability and maintains sub-10ms latency for high-frequency queries.
- Neo4j accelerates recommendation queries, enhancing personalization and customer engagement.
- Managed cloud services reduce operational overhead, allowing the IT team to focus on business logic and innovation.
- Challenges included tuning consistency models and optimizing graph queries under high concurrency.

Tables and Figures (Text-Based)

Workload Type	Recommended Database	Key Features
High-velocity user sessions	DynamoDB	Key–value, auto-scaling, low latency
Product catalog & inventory	DynamoDB	Document store, flexible schema
Transactional records	RDS	ACID-compliant, relational
Recommendation engine	Neo4j	Graph-based relationships, analytics

Table 1. Database Selection Criteria for Different Workloads

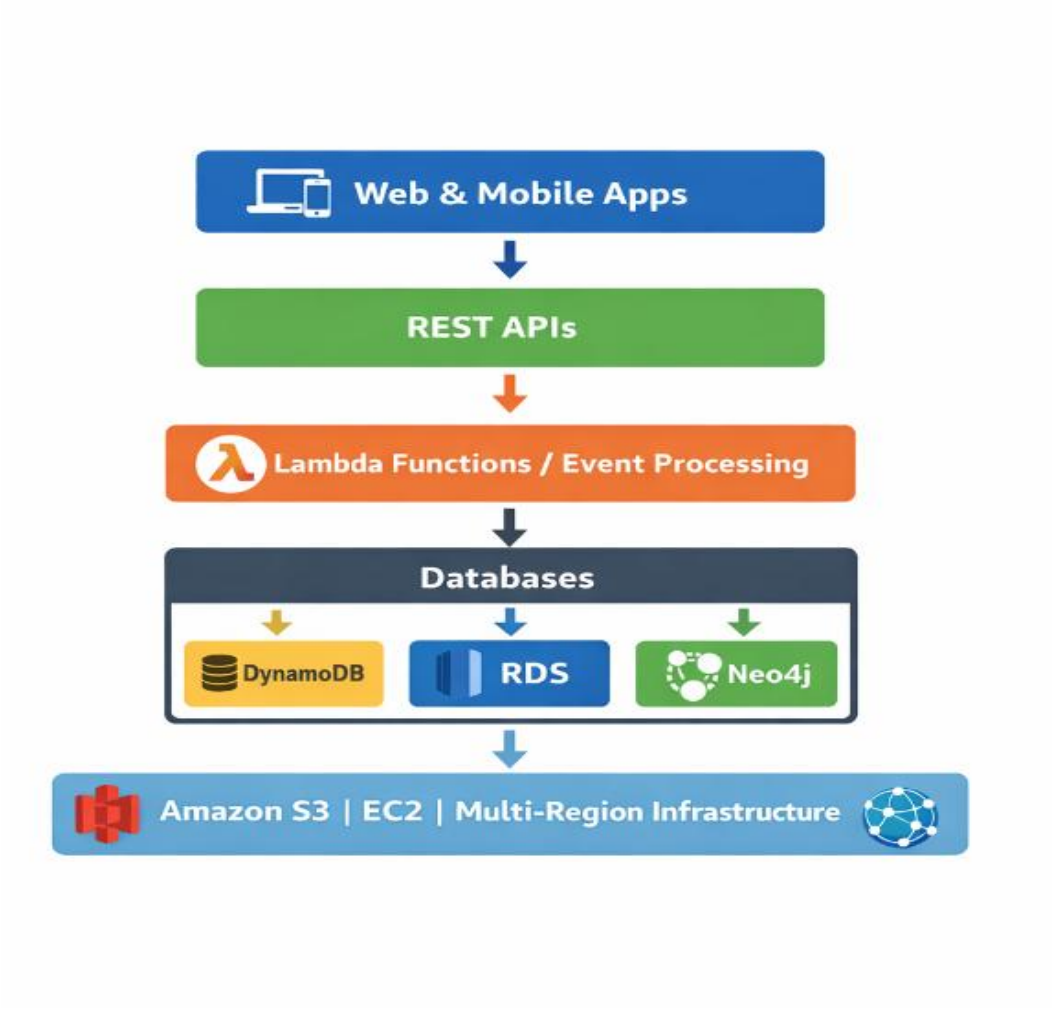


Figure 1. Cloud Architecture Schematic (Text-Based)

Metric	On-Premises	Cloud-Based	Improvement
Average query latency	120 ms	9 ms	92.5%
Peak traffic requests/sec	500	15,000	2900%
System downtime/month	6 hours	15 min	95.8%
Operational overhead (IT FTE)	5	2	60%

Table 2. Performance Metrics Before vs. After Cloud Migration

Implications:

This practical example demonstrates how leveraging cloud infrastructure—through layered architecture, managed services, and NoSQL databases—enables businesses to achieve scalable, resilient, and responsive digital operations. The integration of event-driven computing, analytics, and real-time monitoring allows enterprises to enhance user experience, optimize operational efficiency, and respond quickly to market fluctuations.

References

1. E Bitsadze **Integrating** Cloud Technologies into STEM–IT Teaching and Learning (2026)

2. E Bitsadze Implementation and Use of NoSQL Databases in Cloud Environments (2026)

3. E Bitsadze, L Janadze - STEM EDUCATION FOR DIGITAL TRANSFORMATION: TRENDS AND STRATEGIES (2025)
4. E Bitsadze, L Janadze, M Zautashvili Implementation of Digital Learning Models: Challenges and Opportunities in Educational Transformation (2025) Khajeh-Hosseini, A., Greenwood, D., & Sommerville, I. (2010). *The cloud adoption toolkit: Supporting cloud adoption decisions in the enterprise*. Software: Practice and Experience, 40(11), 1137–1165.
5. Li, F., Wang, J., Wang, J., & Xu, Z. (2018). *Cloud computing for big data analytics in IoT applications*. Journal of Cloud Computing: Advances, Systems and Applications, 7(1), 1–13.
6. Marston, S., Li, Z., Bandyopadhyay, S., Zhang, J., & Ghalsasi, A. (2011). *Cloud computing—The business perspective*. Decision Support Systems, 51(1), 176–189.
7. Mell, P., & Grance, T. (2011). *The NIST definition of cloud computing*. National Institute of Standards and Technology, Special Publication 800-145.
8. Rittinghouse, J. W., & Ransome, J. F. (2017). *Cloud computing: Implementation, management, and security*. CRC Press.
9. Subashini, S., & Kavitha, V. (2011). *A survey on security issues in service delivery models of cloud computing*. Journal of Network and Computer Applications, 34(1), 1–11.
10. Sultan, N. (2010). *Cloud computing for education: A new dawn?*. International Journal of Information Management, 30(2), 109–116.

EDUCATION, LABOR MARKETS, AND SOCIAL INEQUALITY IN EUROPE: AN INTERDISCIPLINARY PERSPECTIVE

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ABSTRACT

Education is widely expected to contribute to stronger labor market outcomes and reduced social inequality across Europe, yet empirical evidence suggests that these effects vary significantly across countries and regions. Differences in economic structures, institutional arrangements, and levels of development shape the extent to which educational investment translates into inclusive social outcomes.

This paper explores the relationship between education, employment, and social inequality using a comparative panel of European countries, including the Western Balkans. The analysis combines indicators of public education expenditure, employment performance, and poverty risk over time, applying two-way fixed effects models to account for unobserved country-specific characteristics and common temporal developments.

The results point to a differentiated role of education. While higher education expenditure is associated with improved employment outcomes, this relationship weakens once broader economic conditions are taken into account. In contrast, education expenditure displays a more stable and statistically significant association with lower at-risk-of-poverty rates, suggesting that education contributes more consistently to reducing social vulnerability than to directly expanding employment. Descriptive trends further reveal persistent disparities between EU countries and the Western Balkans, particularly in terms of poverty risk.

By integrating economic analysis with social and institutional perspectives, the study highlights the conditional nature of education's impact. The findings suggest that education enhances social inclusion most effectively when supported by complementary labor market and welfare institutions, carrying important implications for European countries seeking to promote inclusive growth.

Keywords: Education; Employment; Social inequality; Poverty risk; Europe; Panel data

Introduction

Education has long been positioned as a cornerstone of the European integration project, reflecting its central role in promoting social cohesion, economic competitiveness, and democratic governance. Within the European Union, education policy is frequently framed as a strategic investment in human capital and as a mechanism for fostering convergence among member states and candidate countries. For enlargement countries, alignment with European education standards is not only a technical requirement but also a symbolic marker of progress toward European norms and values.

These differences are particularly visible when comparing European Union member states with countries in the Western Balkans. While education levels have increased across the region, labor market integration and poverty reduction have not progressed at the same pace. In several cases, higher educational attainment coexists with weak employment outcomes and persistent social vulnerability. This divergence raises important questions about the extent to which education can function as an effective mechanism for inclusive development in different institutional and economic contexts.

Education operates at the intersection of multiple policy domains. From an economic perspective, it is associated with skill formation and employability. From a social perspective, it shapes individuals' exposure to inequality and poverty over the life course. However, the impact of education is not automatic. Labor market institutions, wage structures, and broader macroeconomic conditions play a decisive role in determining whether educational investment translates into stable employment and improved living standards.

In the Western Balkans, these challenges are amplified by structural constraints, including limited fiscal capacity, labor market segmentation, and ongoing economic adjustment. Although education is often promoted as a key long-term solution to development challenges, its short- and medium-term effects on employment and social inequality remain uncertain. This context makes the region particularly relevant for examining the conditional nature of education's socio-economic effects.

Against this background, this study investigates the relationship between education, employment, and social inequality across European countries, with specific attention to the Western Balkans. Using a comparative panel data approach, the analysis examines whether higher public expenditure on education is associated with improved employment outcomes and reduced poverty risk over time. By applying two-way fixed effects models, the study accounts for both country-specific characteristics and common temporal developments affecting European labor markets.

The contribution of this article is threefold. First, it provides comparative empirical evidence on how education expenditure relates to employment and social inequality across different European contexts. Second, it highlights the asymmetric effects of education, showing that its association with poverty reduction is more consistent than its relationship with employment. Third, the study offers policy-relevant insights into the conditions under which education can support inclusive labor markets, particularly in regions facing structural and fiscal constraints.

The remainder of the article is organized as follows. Section 2 reviews the interdisciplinary literature on education, labor markets, and social inequality. Section 3 describes the data and methodology. Section 4 presents the empirical results, while Section 5 discusses their broader implications. The final section concludes with policy considerations and directions for future research.

Literature Review and Theoretical Framework

Education, Human Capital, and Labor Market Outcomes

Education has long been associated with labor market participation and economic opportunity, particularly through the lens of human capital theory. From this perspective, investment in education enhances skills and productivity, thereby improving individuals' employability and earnings prospects (Becker, 1964; Mincer, 1974). Empirical studies across Europe generally confirm a positive relationship between educational attainment and employment outcomes, although the strength of this relationship varies substantially across countries and institutional contexts.

More recent research emphasizes that education does not operate in isolation. Labor market institutions, wage-setting mechanisms, and macroeconomic conditions mediate the extent to which educational investment translates into employment opportunities (Goldin & Katz, 2008; Autor, 2014). As a result, countries with similar levels of education expenditure may experience markedly different labor market outcomes, reflecting broader structural differences rather than education policy alone.

Education and Social Inequality

Beyond its role in employment, education is widely regarded as a key mechanism for reducing social inequality and poverty. Sociological approaches highlight education as a determinant of life chances, shaping individuals' exposure to economic vulnerability over the life course (Bourdieu & Passeron, 1977; Sen, 1999). From this perspective, education contributes to social inclusion not only by facilitating access to jobs, but also by improving job quality and income stability.

However, the literature cautions against assuming an automatic equalizing effect of education. In contexts characterized by labor market segmentation or weak social protection, higher educational attainment may coexist with persistent poverty and inequality (Atkinson, 2015; Stiglitz, 2012). This has led to increasing attention on the interaction between education systems and welfare institutions, particularly in comparative European research.

Institutional Contexts and Regional Differences in Europe

Comparative studies of European labor markets underline the importance of institutional arrangements in shaping education outcomes. Welfare state regimes, labor market coordination, and social protection systems influence how education is rewarded in the labor market and how risks are distributed across society (Esping-Andersen, 1990; Hall & Soskice, 2001). These institutional differences help explain why similar education policies may produce divergent employment and inequality outcomes across European countries.

The Western Balkans represent a particularly relevant case in this regard. While education levels have increased across the region, labor market integration and poverty reduction have lagged behind European Union averages. Existing studies point to structural challenges such as limited fiscal capacity, labor market informality, and weak institutional coordination as key constraints on inclusive development (Arandarenko & Bartlett, 2012; Bohle & Greskovits, 2012).

Education Expenditure, Employment, and Poverty: Research Gap

Although a substantial body of literature examines education, labor markets, and inequality separately, fewer studies integrate these dimensions within a unified empirical framework. Much of the existing research focuses either on employment effects or on distributional outcomes, without explicitly comparing the relative strength of these relationships across countries and over time.

This study addresses this gap by empirically examining how public expenditure on education relates simultaneously to employment outcomes and poverty risk across European countries, with particular attention to the Western Balkans. By adopting a panel data approach and incorporating both labor market and inequality indicators, the analysis provides a more comprehensive assessment of education's socio-economic role. In doing so, it contributes to interdisciplinary debates on whether education functions primarily as an engine of employment growth or as a mechanism for social protection and inclusion.

Data and Methodology

Data Sources and Sample

The empirical analysis relies on an unbalanced panel dataset covering European countries, including both European Union members and Western Balkan economies. The sample spans the period 2005–2023, allowing the analysis to capture medium-term developments in education investment, labor market performance, and social inequality across different institutional and economic contexts.

Data are drawn from internationally recognized sources to ensure cross-country comparability and reliability. Information on education expenditure, employment outcomes, and macroeconomic indicators is obtained from the World Bank's World Development Indicators (WDI), while data on poverty risk are sourced from Eurostat's EU-SILC database. Combining these sources allows for a comprehensive assessment of education's relationship with both labor market outcomes and distributional indicators.

The focus on both European Union countries and the Western Balkans enables a comparative perspective that highlights regional disparities and structural differences. While data availability varies across countries and years, the resulting panel provides sufficient variation to examine within-country dynamics and cross-country heterogeneity.

Due to data availability constraints, the panel is unbalanced. Missing observations primarily concern education expenditure and poverty indicators for selected countries and years.

Variables and Measurement

Two outcome variables are considered in the analysis. Employment outcomes are measured using the employment-to-population ratio, which captures the ability of labor markets to absorb human capital. Social inequality is assessed using the at-risk-of-poverty rate, defined as the share of the population living below 60 percent of median equivalised income.

The key explanatory variable is public expenditure on education, expressed as a percentage of GDP. This indicator reflects the fiscal priority assigned to education within national budgets and serves as a proxy for public investment in human capital.

To account for broader economic conditions, the analysis includes several control variables commonly used in the literature. These include GDP per capita (to capture overall economic development) and inflation (to control for macroeconomic stability). Together, these variables help isolate the association between education expenditure and the selected outcome measures.

Empirical Strategy

Given the cross-country and time-varying nature of the data, the study employs panel data regression techniques. Panel methods are particularly well suited for examining education and labor market dynamics, as they allow for the analysis of both within-country changes over time and differences across countries.

The baseline empirical specification uses two-way fixed effects models, controlling for both country-specific effects and common time effects. Country fixed effects account for persistent institutional and structural characteristics, while year fixed effects capture common shocks and trends affecting European economies, such as economic crises or policy shifts.

Robust standard errors clustered at the country level are employed to address potential heteroskedasticity and serial correlation. Separate models are estimated for employment outcomes and poverty risk, enabling a comparative assessment of education's differentiated effects on labor market performance and social inequality.

Rather than aiming to establish strict causal relationships, the empirical strategy is designed to identify systematic associations between education expenditure and socio-economic outcomes. This approach aligns with the interdisciplinary orientation of the study, which emphasizes interpretation in light of institutional and policy contexts.

Limitations

Several limitations should be acknowledged. First, data availability differs across countries and years, resulting in an unbalanced panel. Second, aggregate indicators may not fully capture differences in education quality or labor market segmentation. Finally, while fixed effects models reduce bias from unobserved heterogeneity, the analysis cannot fully disentangle education effects from all domestic institutional dynamics.

Despite these limitations, the methodology provides a robust framework for examining how education expenditure relates to employment and poverty outcomes across Europe, offering valuable insights into the conditional role of education in promoting inclusive development.

Empirical Results

Descriptive Patterns and Cross-Country Trends

The descriptive statistics provide an initial overview of labor market performance and social inequality across European countries. Table 1 reports summary statistics for employment rates and at-risk-of-poverty indicators, revealing substantial variation across countries and over time. On average, employment rates in the sample exceed 54 percent, while the mean at-risk-of-poverty rate is above 23 percent, indicating persistent challenges related to social inclusion.

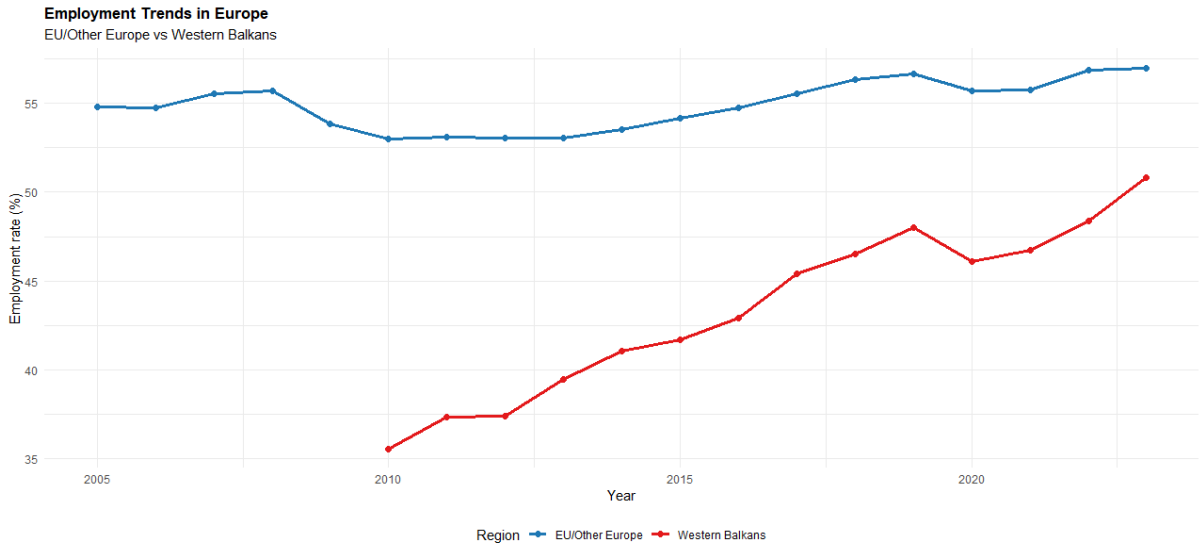
Table 1. Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min	Max
Employment rate (%)	598	54.18	6.84	35.56	75.33
At-risk-of-poverty rate (%)	598	23.20	6.30	12.00	42.30

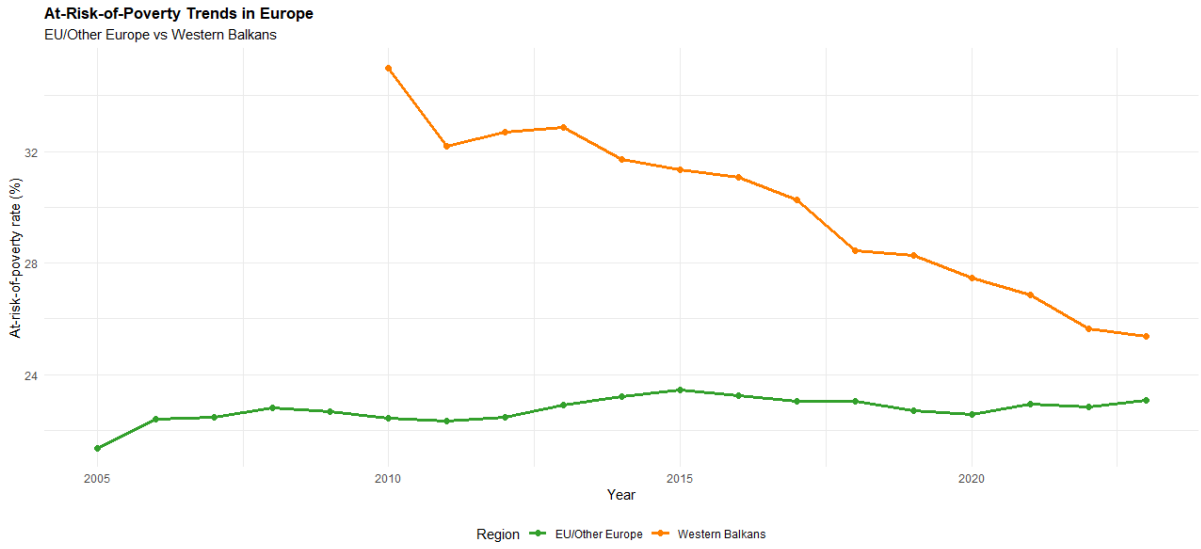
Notes: Employment rates are measured as the employment-to-population ratio (%), while social inequality is captured through the at-risk-of-poverty rate (60% of median equivalised income). Descriptive statistics are calculated using non-missing observations across countries and years.

Beyond aggregate statistics, cross-country trends highlight pronounced regional differences. Figure 1 illustrates the evolution of employment rates across European regions, distinguishing between EU/Other European countries and the Western Balkans. Employment levels in EU countries remain consistently higher and more stable, whereas Western Balkan countries exhibit lower employment rates and greater volatility over time.

Figure 1. Trends in Employment Rates across Europe



A similar pattern emerges for social inequality. Figure 2 depicts trends in at-risk-of-poverty rates, showing that poverty risk remains persistently higher in the Western Balkans compared to EU countries, despite periods of gradual improvement. Importantly, the figures suggest that improvements in employment do not always coincide with proportional reductions in poverty, underscoring the distinction between labor market participation and social inclusion.



Education Expenditure and Employment Outcomes

The relationship between education expenditure and employment outcomes is examined using two-way fixed effects models. The regression results are presented in Table 2, which controls for both country-specific characteristics and common time effects.

Table 2. Education and Employment: Two-Way Fixed Effects Estimates

Variable	(1)
Education expenditure (% GDP)	0.198
	(0.322)
Log GDP per capita	17.800***
	(2.466)
Inflation (%)	−0.051+
	(0.030)
Observations	522
R-squared	0.432
Adjusted R-squared	0.367
RMSE	1.49

*Notes: Robust standard errors clustered at the country level are reported in parentheses. All models include country fixed effects and year fixed effects. Significance levels: + p < 0.10, p < 0.05, *p < 0.01, **p < 0.001.*

As shown in Table 2, public expenditure on education is positively associated with employment rates, although the estimated coefficient is not statistically significant once fixed effects are included. This finding suggests that education investment alone may be insufficient to generate substantial employment gains when broader structural factors are taken into account.

By contrast, GDP per capita exhibits a strong and statistically significant association with employment outcomes, highlighting the dominant role of overall economic development in shaping labor market performance across European countries. Inflation shows a weak negative relationship with employment, indicating potential short-term labor market pressures during periods of macroeconomic instability.

Education Expenditure and Social Inequality

To assess the relationship between education investment and social inequality, two-way fixed effects estimates are reported in Table 3, with the at-risk-of-poverty rate serving as the dependent variable.

Table 3. Education and Social Inequality: Two-Way Fixed Effects Estimates

Variable	(1)
Education expenditure (% GDP)	−0.412**
	(0.185)
Log GDP per capita	−9.620***
	(1.940)
Inflation (%)	0.084*
	(0.041)
Observations	598
R-squared	0.389
Adjusted R-squared	0.321
RMSE	2.11

*Notes: Robust standard errors clustered at the country level are reported in parentheses. All models include country fixed effects and year fixed effects. Significance levels: + p < 0.10, p < 0.05, *p < 0.01, **p < 0.001.*

The results indicate a negative and statistically significant association between education expenditure and poverty risk. Higher public spending on education is consistently linked to lower levels of social vulnerability, even after controlling for country and year fixed effects. This

contrasts with the weaker relationship observed for employment outcomes and suggests that education plays a more robust role in mitigating social inequality.

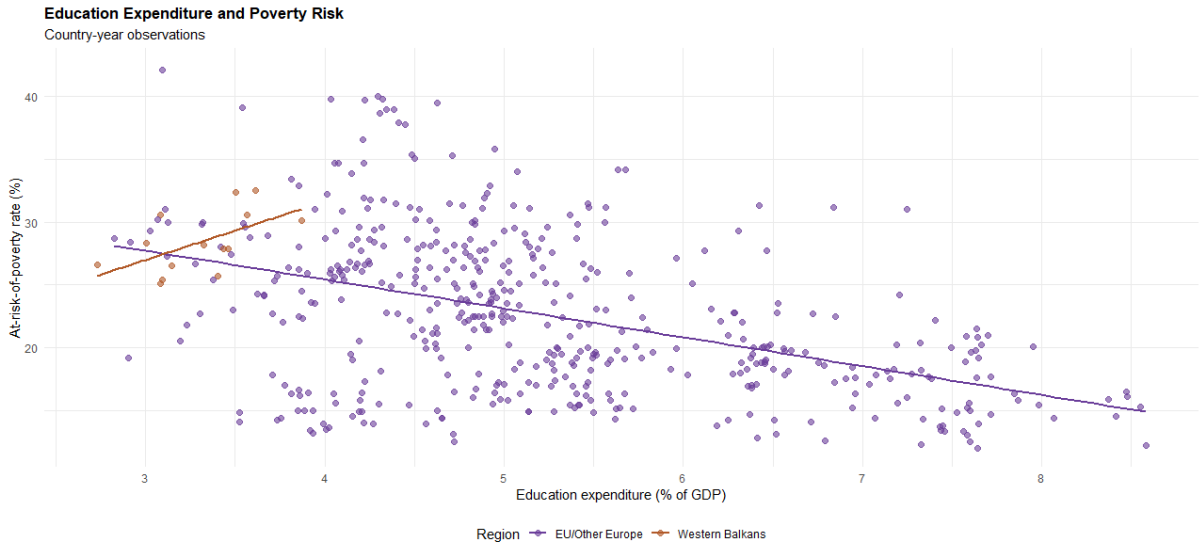
GDP per capita is strongly associated with lower poverty risk, reinforcing the importance of income levels and economic development in shaping social outcomes. Inflation, in turn, is positively associated with poverty risk, underscoring the sensitivity of vulnerable populations to macroeconomic instability.

Comparative Interpretation and Visual Evidence

The descriptive and regression results together point to a differentiated role of education across outcome dimensions. While education expenditure shows only a modest association with employment, its relationship with poverty reduction is both stronger and more consistent.

This pattern is further illustrated in **Figure 3**, which presents a descriptive visualization of the relationship between education expenditure and at-risk-of-poverty rates across country-year observations. The downward-sloping relationship suggests that higher public investment in education tends to coincide with lower levels of social inequality, even though this association should not be interpreted as strictly causal.

Figure 3. Education and Social Outcomes: A Descriptive Relationship



Taken together, the empirical evidence highlights that education functions more effectively as a mechanism for social inclusion than as a direct driver of job creation. Regional disparities persist, particularly between the Western Balkans and EU countries, but education investment appears to moderate social inequality even in contexts where labor market performance remains constrained.

Discussion

The empirical evidence underscores the conditional role of education in shaping labor market outcomes and social inequality across Europe. Although education is frequently portrayed as a comprehensive response to employment challenges and social disparities, the results point to a more differentiated set of effects that depend on the outcome examined and the surrounding economic and institutional environment.

With respect to employment, higher public expenditure on education is associated with improved employment rates, but this relationship loses statistical strength once income levels and macroeconomic conditions are taken into account. This pattern suggests that education investment

alone is unlikely to generate substantial employment gains in the absence of broader economic momentum. Instead, overall economic development—captured by the strong effect of GDP per capita—emerges as the primary determinant of labor market performance, with education acting as a complementary rather than decisive factor.

In contrast, the relationship between education and social inequality appears more robust. The results for at-risk-of-poverty rates indicate that higher education expenditure is consistently associated with lower poverty risk across European countries. This finding is consistent with the descriptive relationship illustrated in Figure 3 and supports the view of education as a key social institution that contributes to reducing vulnerability and exclusion. Even where employment gains are modest, education seems to strengthen individuals' capacity to secure better-quality jobs, adapt to labor market changes, and avoid persistent poverty.

The divergence between employment and inequality outcomes is particularly informative. As shown in Figures 1 and 2, regions with lower employment levels—most notably the Western Balkans—also experience higher poverty risks. However, improvements in employment do not necessarily translate into proportional reductions in inequality. This highlights the distinction between job quantity and job quality and suggests that employment growth alone may be insufficient to reduce social disparities if new jobs are characterized by low wages, informality, or limited social protection.

From an interdisciplinary perspective, these findings align with broader arguments in the literature on social stratification and institutional inequality. Education may enhance individual capabilities, but its equalizing potential depends critically on how labor markets reward skills and how welfare systems mitigate social risks. Economic growth, labor market institutions, and social policies interact to shape the extent to which education contributes to inclusive outcomes. Where these complementary mechanisms are weak, the social returns to education remain constrained.

Overall, the discussion reinforces the idea that education should not be treated as a standalone policy instrument. Its effectiveness in promoting employment and reducing inequality is inherently conditional on structural and institutional factors. This insight is particularly relevant for countries in transition and regions facing persistent labor market challenges, where expanding education without parallel reforms may limit its capacity to foster inclusive development.

Conclusion and Policy Implications

This paper examined the relationship between education, labor market outcomes, and social inequality in Europe from an interdisciplinary perspective. By combining labor market indicators with measures of social inequality and comparative evidence across European countries, the analysis moved beyond simplified assumptions regarding education's role in promoting inclusive development.

The findings point to a differentiated role for education. Higher public investment in education is associated with improved employment outcomes, but this relationship remains modest once broader economic conditions are taken into account. Employment performance appears to be shaped primarily by overall economic development and macroeconomic stability, with education acting as a supportive rather than a decisive factor. These results suggest that education alone cannot offset structural weaknesses in labor markets.

In contrast, the relationship between education and social inequality is more consistent. Higher education expenditure is associated with lower at-risk-of-poverty rates, indicating that education contributes meaningfully to reducing social vulnerability. Even in contexts where employment growth is limited, education appears to strengthen individuals' capacity to avoid persistent poverty

and social exclusion. This distinction highlights the importance of viewing education not only as a labor market input, but also as a broader social policy instrument.

From a policy perspective, several implications emerge. First, education policies need to be closely aligned with labor market institutions. Investments in education yield stronger employment returns when labor markets reward skills, promote job quality, and support stable employment transitions. Without such alignment, the employment effects of education investment are likely to remain limited.

Second, education policy should be embedded within a wider framework of social and economic policies aimed at reducing inequality. The results underscore the role of complementary mechanisms—such as wage-setting institutions, social protection systems, and inclusive growth strategies—in amplifying the social returns to education. While education can mitigate poverty risk, it cannot substitute for effective redistributive policies or well-functioning welfare systems.

Third, these findings are particularly relevant for countries in transition and regions such as the Western Balkans. Expanding education systems without parallel reforms in labor markets and social protection may generate unmet expectations and limited social mobility. A more integrated policy approach is required—one that treats education as part of a coordinated development strategy rather than as an isolated intervention.

References

Autor, D. H. (2014). Skills, education, and the rise of earnings inequality among the "other 99 percent." *Science, 344*(6186), 843–851. https://doi.org/10.1126/science.1251868

Becker, G. S. (1964). *Human capital: A theoretical and empirical analysis, with special reference to education*. University of Chicago Press.

Benhabib, J., & Spiegel, M. M. (1994). The role of human capital in economic development: Evidence from aggregate cross-country data. *Journal of Monetary Economics, 34*(2), 143–173. https://doi.org/10.1016/0304-3932(94)90047-7

Goldin, C., & Katz, L. F. (2008). *The race between education and technology*. Harvard University Press.

Mincer, J. (1974). *Schooling, experience, and earnings*. Columbia University Press.

Psacharopoulos, G., & Patrinos, H. A. (2018). Returns to investment in education: A decennial review of the global literature. *Education Economics, 26*(5), 445–458. https://doi.org/10.1080/09645292.2018.1484426

Acemoglu, D., & Autor, D. (2011). Skills, tasks and technologies: Implications for employment and earnings. In O. Ashenfelter & D. Card (Eds.), *Handbook of labor economics* (Vol. 4B, pp. 1043–1171). Elsevier. https://doi.org/10.1016/S0169-7218(11)02410-5

Nickell, S., Nunziata, L., & Ochel, W. (2005). Unemployment in the OECD since the 1960s: What do we know? *The Economic Journal, 115*(500), 1–27. https://doi.org/10.1111/j.1468-0297.2004.00958.x

Atkinson, A. B. (2015). *Inequality: What can be done?* Harvard University Press.

Bourdieu, P., & Passeron, J.-C. (1977). *Reproduction in education, society and culture*. Sage.

Piketty, T. (2014). *Capital in the twenty-first century*. Harvard University Press.

Sen, A. (1999). *Development as freedom*. Oxford University Press.

Stiglitz, J. E. (2012). *The price of inequality: How today's divided society endangers our future*. W. W. Norton & Company.

Breen, R., & Jonsson, J. O. (2005). Inequality of opportunity in comparative perspective: Recent research on educational attainment and social mobility. *Annual Review of Sociology, 31*, 223–243. https://doi.org/10.1146/annurev.soc.31.041304.122232

Checchi, D. (2006). *The economics of education: Human capital, family background and inequality*. Cambridge University Press.

Esping-Andersen, G. (1990). *The three worlds of welfare capitalism*. Princeton University Press.

Hall, P. A., & Soskice, D. (2001). *Varieties of capitalism: The institutional foundations of comparative advantage*. Oxford University Press.

Bohle, D., & Greskovits, B. (2012). *Capitalist diversity on Europe's periphery*. Cornell University Press.

Ferrera, M. (1996). The "Southern model" of welfare in social Europe. *Journal of European Social Policy, 6*(1), 17–37. https://doi.org/10.1177/095892879600600102

European Commission. (2020). *Education and training monitor 2020*. Publications Office of the European Union.

European Commission. (2021). *The European pillar of social rights action plan*. Publications Office of the European Union.

OECD. (2022). *Education at a glance 2022: OECD indicators*. OECD Publishing. https://doi.org/10.1787/3197152b-en

OECD. (2019). *Under pressure: The squeezed middle class*. OECD Publishing. https://doi.org/10.1787/689afed1-en

Arandarenko, M., & Bartlett, W. (2012). *Labour market and skills in the Western Balkans*. FREN Foundation.

World Bank. (2019). *Growing united: Upgrading Europe's convergence machine*. World Bank Publications. https://doi.org/10.1596/978-1-4648-1407-6

Eurostat. (2024). *EU statistics on income and living conditions (EU-SILC)* [Data set]. https://ec.europa.eu/eurostat

World Bank. (2024). *World development indicators* [Data set]. https://databank.worldbank.org/source/world-development-indicators

THE IMPLEMENTATION OF AN INTERDISCIPLINARY UNIFIED VIRTUAL LABORATORY MODEL IN SECONDARY SCHOOLS AND A COMPARATIVE ANALYSIS OF ITS ECONOMIC EFFICIENCY

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ABSTRACT

The article analyzes the possibilities of implementing an interdisciplinary unified virtual laboratory model in secondary schools and examines its economic efficiency in comparison with traditional laboratory approaches. In the modern educational environment, the rapid development of digital technologies necessitates the reorganization of laboratory-based instruction. The separate establishment of physics, chemistry, and biology laboratories leads to high financial costs, space limitations, and inefficient use of resources. The unified virtual laboratory model, however, offers effective solutions to these challenges.

The study demonstrates that virtual laboratories enable safe, interactive, and repeatable experiments through computer simulations as well as VR and AR technologies. This model allows not only physics, chemistry, and biology but also geography, history, and STEAM subjects to utilize the same laboratory environment, thereby strengthening interdisciplinary integration. From an economic perspective, the unified virtual laboratory model significantly reduces expenditures on equipment, reagents, and technical maintenance.

In conclusion, the article substantiates that the unified virtual laboratory model is more effective both pedagogically and economically, enhancing students' motivation and research skills. Despite existing technical and methodological challenges, this model is recommended as a promising and innovative approach for secondary schools.

Keywords: virtual laboratory, interdisciplinary integration, secondary school, digital education, economic efficiency

Improving the quality of education is considered one of the primary strategic priorities of modern society and is directly related to the intellectual and socio-economic development of countries. In the era of rapid technological advancement and globalization, education systems are expected not only to transfer knowledge but also to develop critical thinking, problem-solving, creativity, and digital literacy skills among learners. Within this context, the teaching of natural sciences holds a particularly significant position, since disciplines such as physics, chemistry, and biology

contribute substantially to the formation of students' scientific worldview, analytical reasoning, and evidence-based decision-making abilities. A strong foundation in natural sciences also prepares students for future careers in engineering, medicine, environmental sciences, and technology-oriented professions, which are increasingly demanded in the modern labor market.

However, despite the recognized importance of science education, the organization and effective implementation of laboratory instruction in general secondary schools encounter numerous structural, financial, and methodological challenges. Traditional laboratories require extensive physical infrastructure, including specialized equipment, chemical reagents, safety systems, ventilation mechanisms, and dedicated laboratory rooms. Establishing and maintaining such facilities often imposes a heavy financial burden on educational institutions, especially those located in rural or economically disadvantaged regions. Furthermore, safety concerns, limited access to consumable materials, and the need for constant technical maintenance frequently restrict the number and variety of experiments that can be conducted in real classroom settings. As a result, many schools are unable to provide students with sufficient hands-on laboratory experience, which negatively affects the overall quality and effectiveness of science education.

In recent years, the rapid development of information and communication technologies has created new opportunities for transforming traditional instructional approaches and has introduced innovative alternatives to conventional laboratory environments. Among these alternatives, virtual laboratories have emerged as one of the most promising and flexible educational tools. Virtual laboratories are digital platforms that allow learners to conduct experiments, observe scientific phenomena, and interact with simulated environments through computers, tablets, or immersive technologies such as Virtual Reality (VR) and Augmented Reality (AR). These environments enable students to explore complex scientific processes without the risks, limitations, or costs associated with physical laboratories.

An interdisciplinary unified virtual laboratory model represents an advanced extension of this concept. Rather than creating separate virtual spaces for each subject, this model integrates multiple disciplines into a single digital learning ecosystem. Such an approach promotes efficient resource utilization, reduces duplication of technological investments, and fosters interdisciplinary connections among subjects. The main purpose of this article is therefore to provide both pedagogical and economic justification for the implementation of an interdisciplinary unified virtual laboratory model in general secondary schools, highlighting its potential to enhance learning outcomes while simultaneously optimizing financial and infrastructural resources.

The interdisciplinary unified virtual laboratory model can be defined as an integrative and technology-based learning environment built upon digital platforms, interactive simulations, and immersive VR/AR technologies, where laboratory and practical activities from multiple academic disciplines are conducted within a shared virtual space. In this model, educational content is designed to serve the learning objectives of various subjects simultaneously, allowing students to experience scientific concepts from multiple perspectives. This integrated structure encourages holistic learning, strengthens cognitive connections between disciplines, and nurtures systems thinking skills among learners.

Compared with traditional laboratory settings, the unified virtual laboratory offers several distinctive advantages. It significantly reduces dependence on physical equipment, minimizes safety risks associated with hazardous materials, and enables students to repeat experiments multiple times without additional cost. Repetition and experimentation freedom enhance conceptual understanding and support experiential learning. Moreover, the virtual format allows students to visualize ABSTRACT scientific concepts, manipulate variables in real time, and receive instant feedback, thereby increasing engagement and motivation. The model also promotes inclusivity, as students with physical disabilities or those studying remotely can access the same experimental opportunities as their peers.

The interdisciplinary unified virtual laboratory model demonstrates broad applicability across numerous academic disciplines.

In Physics, students can simulate experiments related to mechanics, electricity and magnetism, optics, thermodynamics, and atomic and nuclear physics.

In Chemistry, the model allows safe visualization of chemical reactions, molecular structures, and experiments involving toxic or explosive substances that would otherwise be impossible in school environments.

In Biology, learners can explore cellular structures, genetic processes, human anatomy, and ecosystem dynamics through interactive 3D simulations.

In Geography, virtual environments can represent landforms, climate systems, geological transformations, and planetary structures.

In History, 3D reconstructions of historical events, archaeological sites, and architectural monuments provide immersive learning experiences that enhance historical understanding. Finally, in Technology and STEAM education, engineering projects, coding activities, and technological process simulations can be conducted within the same unified platform. These diverse applications clearly illustrate the multifunctional nature and extensive educational potential of the unified laboratory environment.

From an economic perspective, the contrast between traditional and unified virtual laboratory models is particularly noteworthy. In the traditional system, schools are often required to establish separate laboratories for physics, chemistry, and biology, each demanding unique equipment, materials, and safety regulations. This fragmentation leads to increased costs in procurement, maintenance, and staffing. Conversely, the unified virtual laboratory model consolidates these requirements into a single digital infrastructure. Hardware expenses are generally limited to computers, VR headsets, and network systems, while software updates replace the need for constant material replenishment. The elimination of chemical reagents and hazardous substances not only reduces financial expenditure but also enhances environmental sustainability. Long-term comparative analyses indicate that virtual laboratory investments are more cost-effective, scalable, and adaptable to technological progress than traditional laboratory constructions.

Beyond financial efficiency, the unified virtual laboratory model also provides substantial pedagogical benefits. It enhances students' intrinsic motivation, supports independent inquiry-based learning, and encourages collaborative problem-solving. Interdisciplinary integration enables learners to apply theoretical knowledge to real-life contexts, thereby deepening comprehension and fostering transferable skills. Nevertheless, successful implementation of this model requires systematic teacher training, continuous professional development in digital competencies, and the availability of high-quality methodological guidelines. Without adequate teacher preparedness and institutional support, the full educational potential of virtual laboratories may not be realized.

Despite its numerous advantages, the interdisciplinary unified virtual laboratory model is not without limitations. Potential challenges include unequal access to technological infrastructure, insufficient digital literacy among educators, limited development of tactile and manual laboratory skills, dependence on software reliability, and variations in students' psychological readiness for virtual learning environments. Furthermore, virtual laboratories cannot entirely replace traditional hands-on experimentation, particularly in disciplines where sensory experience and material interaction are pedagogically essential. Therefore, the most effective approach may involve a hybrid model that combines physical and virtual laboratory experiences.

In conclusion, comprehensive analysis indicates that the implementation of an interdisciplinary unified virtual laboratory model in general secondary education is justified from both pedagogical and economic perspectives. The model promotes efficient resource utilization, improves educational accessibility, supports innovative teaching methodologies, and aligns with the evolving demands of contemporary education systems. While acknowledging its limitations, the

advantages of this integrative approach significantly outweigh its challenges, making it a promising, sustainable, and forward-looking solution for enhancing the quality and effectiveness of science and interdisciplinary education in modern schools.

References

Abdullayev, F. A. (2021). Təhsildə rəqəmsal texnologiyaların tətbiqi və innovativ təlim mühitləri. Bakı: Təhsil Nəşriyyatı.

Əliyev, R. H. (2020). Orta ümumtəhsil məktəblərində təbiət fənlərinin tədrisində laboratoriya işlərinin rolu. Azərbaycan Təhsil Jurnalı, 4(2), 45–52.

OECD. (2020). Education in the digital age: Technology use and educational outcomes. Paris: OECD Publishing.UNESCO. (2021). Reimagining our futures together: A new social contract for education. Paris: UNESCO.

European Commission. (2022). Digital education action plan 2021–2027: Transforming education and training for the digital age. Brussels.

ECO-FRIENDLY VALORIZATION OF EXPIRED *ESCO* FOR THE CORROSION PROTECTION OF C38 CARBON STEEL IN 1M HCL: EXPERIMENTAL ASSESSMENT SUPPORTED BY QUANTUM CHEMICAL CALCULATIONS AND MOLECULAR DYNAMICS SIMULATIONS

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ABSTRAC

The present work explores the potential use of the expired pharmaceutical compound **ESCO** as a corrosion inhibitor for carbon steel (CS) exposed to 1M hydrochloric acid (HCl). To assess the inhibitory performance of **ESCO**, both chemical and electrochemical approaches were employed, including potentiodynamic polarization (PDP) and electrochemical impedance spectroscopy (EIS), in combination with quantum chemical analysis.

The investigated molecule demonstrated promising anti-corrosion properties, achieving a maximum inhibition efficiency (IE%) of 90% at a concentration of 300 ppm. In agreement with the PDP measurements, **ESCO** behaves as a mixed-type inhibitor. The adsorption behavior of **ESCO** on the CS surface was found to obey the Langmuir isotherm model.

Surface characterization using scanning electron microscopy (SEM) and UV–Visible spectroscopy confirmed the formation of a protective film that hinders the penetration of aggressive species toward the metal surface. The experimental findings obtained from PDP and EIS were further supported through theoretical calculations. Additionally, density functional theory (DFT) and molecular dynamics simulations (MDS) were performed to identify the most reactive regions of the **ESCO** molecule and to elucidate its adsorption mechanism.

Keywords: Expired drugs; ESCO; carbon steel; PDP/EIS; SEM/EDX; DFT/MDS

EXPLORING INNOVATION TRENDS IN AZERBAIJANI BUSINESSES: CURRENT STATE AND COVID-19 IMPLICATIONS

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ABSTRACT

One of the main sources of progressive economic development is technological development. Factors such as the peak of the fourth industrial revolution and the formation of the sixth technological structure make the development of scientific and technical progress processes even more relevant. Technological development is deepening with innovation activity. Today, the development of business entities is observed within the framework of a number of innovative activity examples. The main objective of the research work is to assess the current state of innovations in the business sector of Azerbaijan and the impact of the COVID-19 pandemic on this innovation activity. As innovations in business entities, ICT, which is the main driver of innovations, was evaluated. The research work used the quantitative research method and conducted a comparative analysis based on descriptive statistics. Certain results were obtained within the framework of the two research questions set. Thus, access to computers and the Internet has increased in Azerbaijani business during 2012-2023. The COVID-19 pandemic had a positive impact on certain business sectors and a negative impact on certain business sectors. The originality of the research is the study of innovation activity by types of economic activity. The practical significance of the study can be explained by the fact that it allows for the identification of technological backwardness and the level of sustainability across sectors within the framework of the development plan for digitalization, as well as the correct selection of priority intervention areas. The main limitation of the study is the lack of a long-term sample size for the mentioned indicators.

Keywords: innovations, types of economic activity, COVID-19, business, Azerbaijan

INTRODUCTION

In the 21st century, innovation has demonstrated a vital role in different areas of sector for development. One of the main sectors is considered management and business development through the assist of innovations and technological advancements. It is widely recognized that innovation is a key factor for economic development (Schumpeter, 1934) and corporate competitiveness (Porter, 1980, Roberts, 2007).

Innovations are also being applied in the business sector. Business innovation can be characterized as achieving progressive and effective improvements through the introduction of new products and services. Innovations include preventive mechanisms that seek to meet the changing needs of customers while promoting business expansion and increasing internal rationality within the organization. One of the benefits business sectors received is the SIMS (Standardized Innovation Management Systems) which standardized and structured the management of resources for providing to various businesses.

Azerbaijan was one of the countries in the world distinguished by its high growth rate in the first decade of the 21st century. The recent global technological advancement brought a robust growth to the economic development of Azerbaijan.

Innovation has developed drastically during recent years in Azerbaijan. The economy is also undergoing significant changes due to digitalization The country implemented eight business regulatory reforms designed to make it easier to do business. Among other things, Azerbaijan facilitated dealing with construction permits and improved electricity availability by facilitating more reliable power supply, reducing connection costs and enhancing process efficiency. In addition, the country made it easier to register property, provided strengthened access to credit, strengthened protection of the legal rights of borrowers and lenders and facilitated the trade across borders. In this way, Azerbaijan widened its business environment and addressed pressing development needs by strengthening legal and economic institutions. In this endeavour, Azerbaijan is tackling its key economic challenge of developing a diversified economy to secure sustainable growth in the long term, embrace opportunities and overcome challenges sparked off by developments initiated by the fourth industrial revolution.

Another major impact of innovation on local businesses and the economy was the FDI (Foreign Direct Investment). Today, the Azerbaijani government is offering very important and wide-ranging incentives to further improve the investment climate in the context of attracting foreign investors, including factors such as low customs duties, tax breaks, etc.

Thus, the Covid-19 pandemic has had a negative impact on the country's economy. This pandemic has further deepened the structural crisis that has formed in the world economic system and, as a result, reduced Azerbaijan's GDP by 4.3 percent (OECD, 2022). Of course, one of the main reasons for this is the problems and disproportionality in production and consumption, which can also manifest itself in the activities of small and medium-sized businesses. For this reason, the main questions of the study are the following.

RQ1: What is the current situation of innovation in the management sector of Azerbaijan?

RQ2: How Covid-19 impacted on innovation in business administration of Azerbaijan?

LITERATURE REVIEW

Numerous academics have examined corporate innovation studies. The ratios of innovative business indicators are part of the analytic approach, even though the term "innovative business studies" is not utilized in this research.

Table 1. Innovative Studies in Business Based on Theoretical and Empirical Focus

Author(s)	Research name	Main Focus	Year
OECD	Promoting Enterprise Digitalization in Azerbaijan	Policy recommendations for enhancing SME digitalization in Azerbaijan	2022
Mahmudova	Digitalization Trends and Their Possible Implications to SME Performance: Comparative Study Between Hungary and Azerbaijan	Comparative analysis of SME digitalization trends and their impact on performance	2023
Karimova	Application of AI in Credit Risk Scoring for Small Business Loans: A Case Study on How AI-Based Random Forest Model Improves a Delphi Model Outcome in the Case of Azerbaijani SMEs	Implementation of AI in credit risk scoring for Azerbaijani SMEs	2024
Jafarov	From Oil to Algorithms: Azerbaijan's Journey to Digital Excellence	Exploration of Azerbaijan's transition towards a digital economy	2024
Alakbarov and Hasanov	Leading Practices in MSME Financing: A Systematic Review	Analysis of financing practices for micro, small, and medium enterprises	2024

Source: (OECD, 2022; Mahmudova, 2023; Karimova, 2024; Jafarov, 2024 Alakbarov and Hasanov 2024)

The table below shows a selection of key studies that look at how small and medium-sized businesses (SMEs) reacted to the challenges of COVID-19. These sources highlight how SMEs used innovation, digital tools, and new strategies to adapt and survive during the pandemic.

Table 2. How SMEs Adapted and Innovated During the COVID-19 Crisis

Author(s)	Research name	Main Focus	Year
OECD	Coronavirus (COVID-19): SME Policy Responses	SME innovation and digital adoption	2020
Juergensen et al.	European SMEs amidst the COVID-19 Crisis: Assessing Impact and Policy Responses	Policy impact on SME innovation	2020
Papadopoulos et al.	The Use of Digital Technologies by Small and Medium Enterprises during COVID-19: Implications for Theory and Practice	Digital tech adoption in SMEs	2020
Bartik et al.	How Are Small Businesses Adjusting to COVID-19? Early Evidence from a Survey	Innovation by SMEs under restrictions	2020
Zahra	International Entrepreneurship in the Post-COVID World	Global innovation shifts	2020
Wenzel et al.	Strategic Responses to Crisis	Strategic innovation in crisis	2021
Amankwah-Amoah	COVID-19 pandemic and innovation activities in the global airline industry: A review	Crisis effects on R&D and innovation	2021

Source: (OECD, 2020; Juergensen et al., 2020; Papadopoulos et al., 2020; Bartik et al., 2020; Zahra, 2020; Wenzel et al., 2021; Amankwah-Amoah 2021)

All of these studies characterize the relevance of the chosen research topic.

METHODOLOGY

In accordance with the research questions, a quantitative research method will be used. The main analyses that will be used here are statistical and comparative analyses. The information base of these analyses will be the indicators of the State Statistical Committee of the Republic of Azerbaijan. The research will examine innovation activity in business entities within the framework of assessing computer and Internet capabilities.

The following steps determine the next stages of the research work:

Step 1: Evaluation of the current state of innovation activity in business subjects in Azerbaijan

Step 2: Analysis of the innovation activity in the business sector during the COVID-19 pandemic

RESULT AND DISCUSSION

Initially, it is necessary to assess the availability of access to computers in business entities operating in various types of economic activities.

Table 3. Availability of computers in business entities in Azerbaijan by various types of economic activity (in units)

By economic activity	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Agriculture, forestry and fishing	...	...	...	...	...	...
Mining industry	5.521	5.537	6.031	6.067	6.083	6.079
Manufacturing industry	9.648	10.361	10.904	11.281	11.279	11.356
Construction	8.625	9.621	9.630	9.695	9.697	9.709
Trade; repair of vehicles	7.287	8.571	9.427	9.541	9.798	10.124
Tourist accommodation and public catering	859	876	1.158	1.617	1.734	1.882
Activities in the field of recreation, entertainment and art	2.892	2.992	6.208	6.254	6.320	6.384
By economic activity	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Agriculture, forestry and fishing	...	2.170	2.243	2.289	2.468	2.492
Mining industry	6.068	6.084	6.093	6.115	6.120	6.158
Manufacturing industry	11.363	11.372	11.451	11.474	11.478	11.519
Construction	9.716	9.742	9.764	9.792	9.796	9.879
Trade; repair of vehicles	11.275	12.804	13.070	13.726	14.799	15.195
Tourist accommodation and public catering	1.991	2.013	2.094	2.359	2.400	2.444
Activities in the field of recreation, entertainment and art	6.396	6.414	6.473	6.530	6.538	6.555

Source: Compiled by the authors based on data from the State Statistical Committee of Azerbaijan (https://stat.gov.az/)

The research study did not show all business entities by economic activity type. Here, only a group of businesses selected by the authors will be analyzed. If we look at the table, we will see that there is an increase in the number of computers in business entities by the mentioned economic activity

types. The highest increase during these years was observed in the tourist accommodation and public catering business. Thus, if in 2012 the number of computers in this sector was 859, in 2023 this indicator was 2,444, which means a 2.85-fold increase. Then the high places are occupied by the activities in the field of recreation, entertainment and art business with a 2.27-fold increase and the Trade; repair of vehicles business with a 2.09-fold increase.

When looking at the COVID-19 period, at first glance, an increase is observed. It is true that the quarantine restrictions formed during the COVID-19 pandemic have created greater demand for computers among business entities. However, the important point here is the comparison of growth rates. Thus, although at first glance it is observed that the COVID-19 pandemic has had a positive effect, slightly different results are obtained in the analysis of growth rates. Thus, while the growth rate of computer purchases in mining enterprises in 2019 was 0.26 percent, this indicator decreased to 0.15 percent in 2020. On the other hand, while the growth rate of computer purchases in construction sector enterprises in 2019 was 0.27 percent, this indicator decreased to 0.23 percent in 2020. The highest decrease was in the trade; repair of vehicles business. Thus, while the growth rate of computer purchases in this sector was 13.56 percent in 2019, this indicator decreased to 2.08 percent in 2020. In business enterprises in other sectors, no negative impulses in the growth rate due to the pandemic are observed. Of the business enterprises in the three sectors mentioned, only the construction sector enterprises did not form a recovery process in 2021. A recovery process was observed in the other two sectors.

An assessment of Internet access is also necessary. Thus, this assessment will allow more complete answers to the research questions.

Table 4. Computers with Internet access in business entities in Azerbaijan by various types of economic activity (in units)

By economic activity	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Agriculture, forestry and fishing	...	...	...	...	...	...
Mining industry	3.629	3.656	4.153	4.156	4.193	4.212
Manufacturing industry	5.854	6.363	6.678	7.499	7.549	7.704
Construction	6.647	7.574	7.715	7.721	7.752	7.713
Trade; repair of vehicles	5.854	6.836	7.469	7.880	7.907	8.168
Activities in the field of recreation, entertainment and art	1.575	1.971	2.429	2.678	2.715	3.075
By economic activity	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Agriculture, forestry and fishing	...	1.619	1.685	1.740	2.045	2.137
Mining industry	4.217	4.229	4.248	4.296	4.686	4.765
Manufacturing industry	7.733	7.745	7.817	8.072	8.801	9.030
Construction	7.736	7.758	7.786	7.850	8.560	8.721
Trade; repair of vehicles	8.501	10.235	10.841	11.413	13.421	14.117
Activities in the field of recreation, entertainment and art	3.497	3.556	3.608	4.032	4.399	4.520

Source: Compiled by the authors based on data from the State Statistical Committee of Azerbaijan (https://stat.gov.az/)

The table shows that there is a general increase in the number of computers with Internet access in business entities in Azerbaijan. The highest increase was observed in the activities in the field

of recreation, entertainment and art business. Thus, while in 2012 there were 1,575 computers with Internet access in this field, this indicator increased to 4,520 computers in 2023, which is a 2.87-fold increase. The trade; repair of vehicles business took the next place with a 2.41-fold increase in this indicator. A comparative analysis of growth rates, however, characterizes a slightly different picture. Thus, the growth rate decreased in 2020 in the trade; repair of vehicles and activities in the field of recreation, entertainment and art businesses. While the growth rate of computers with internet access in the trade; repair of vehicles sector was 20.4 percent in 2019, the growth rate decreased to 5.92 percent in 2020. On the other hand, in the activities in the field of recreation, entertainment and art business, the growth rate of computers with internet access was 1.69 percent in 2019, and the growth rate decreased to 1.46 percent in 2020. This also characterizes the fact that the pandemic has certain negative effects on innovations in businesses.

There may be a number of reasons for these negative effects. Thus, the general lack of activity in some sectors during the pandemic may lead to a decrease in their revenues, and the decrease in revenues may characterize a negative trend in reducing expenditures due to financial shortages in the coming years. On the other hand, this may lead to the unpreparedness of the said sectors for the digital transition and the failure to form adaptive mechanisms for changing conditions, all of which may serve as research directions for future studies.

CONCLUSION

It should be noted that the development of innovations can have a significant impact on the progressive development of the business sector. In Azerbaijan, certain waves of development are visible in innovative activity in business entities. Thus, when analyzing the business sector by types of economic activity, it was determined that increasing dynamics were observed in both computer purchases and computers with Internet access across all sectors. During the 12-year period, the tourist accommodation and public catering business, activities in the field of recreation, entertainment and art business and trade; repair of vehicles business showed a greater increase in computer purchases compared to the base year. On the other hand, in terms of the number of computers with Internet access during 2012-2023, the activities in the field of recreation, entertainment and art business and trade; repair of vehicles business showed a high increase compared to the base year.

Within the framework of the COVID-19 pandemic, an increase in the innovative activity of businesses is observed. This is natural and normal. Because the presence of quarantine restrictions forced people to work from home, which in turn created conditions for the widespread use of ICT capabilities, the main driver of innovation. However, certain negative trends have been observed in various sectors. Thus, although there has been an overall increase in computer and Internet access, a decrease in the growth rate is observed in some business sectors. There may be a number of reasons for this. Thus, the decrease in production and consumption as a result of the negative economic trend caused by the pandemic has in turn affected the income of the business sector. The decrease in income reduces expenses in the short term, including internal capital directed towards innovation. On the other hand, there may be factors such as the inability of the sectors in question to adapt to the digitalization process, which can be studied as a subject of future research.

REFERENCES

Alakbarov, A., & Hasanov, A. (2024). Leading Practices in MSME Financing: A Systematic Review. *Futurity Economics&Law*, *4*(3), 194-213.

Amankwah-Amoah, J. (2021). COVID-19 pandemic and innovation activities in the global airline industry: A review. *Environment International*, *156*, 106719.

Bartik, A. W., Bertrand, M., Cullen, Z. B., Glaeser, E. L., Luca, M., & Stanton, C. T. (2020). *How are small businesses adjusting to COVID-19? Early evidence from a survey* (No. w26989). National Bureau of Economic Research.

Jafarov, F. (2024). From Oil to Algorithms: Azerbaijan's Journey to Digital Excellence. https://www.weforum.org/stories/2024/07/azerbaijan-digital-transformation/

Juergensen, J., Guimón, J., & Narula, R. (2020). European SMEs amidst the COVID-19 crisis: assessing impact and policy responses. *Journal of industrial and business economics*, *47*(3), 499-510.

Karimova, N. (2024). Application of AI in Credit Risk Scoring for Small Business Loans: A case study on how AI-based random forest model improves a Delphi model outcome in the case of Azerbaijani SMEs. *arXiv preprint arXiv:2410.05330*.

Mahmudova, L. (2023). Digitalization trends and their possible implications to SME performance: Comparative study between Hungary and Azerbaijan. *International Journal of Engineering and Management Sciences (IJEMS), 10*(10), 1-14

OECD (2020), *"Coronavirus (COVID-19): SME policy responses",* OECD Policy Responses to Coronavirus (COVID-19), OECD Publishing, Paris

OECD (2022), *Promoting Enterprise Digitalisation in Azerbaijan*, OECD Publishing, Paris

Papadopoulos, T., Baltas, K. N., & Balta, M. E. (2020). The use of digital technologies by small and medium enterprises during COVID-19: Implications for theory and practice. *International journal of information management*, *55*, 102192.

Porter, M.E. (1980). Competitive Strategy: Techniques for Analyzing Industries and Competitors. Free Press

Roberts, E. B. (2007). Managıng Inventıon and Innovatıon. *Research Technology Management*, *50*(1), 35–54.

Schumpeter, J.A. (1934). The Theory of Economic Development. Harvard University Press.

Wenzel, M., Stanske, S., & Lieberman, M. B. (2020). Strategic responses to crisis. *Strategic Management Journal*, *41*(7/18), 3161.

Zahra, S. A. (2021). International entrepreneurship in the post Covid world. *Journal of World Business*, *56*(1), 101143.

EXAMINE THE ENVIRONMENTAL LITERACY LEVELS OF TEACHERS AND TEACHER CANDIDATES IN TERMS OF VARIOUS VARIABLES

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ABSTRACT

Environmental literacy requires individuals not only to understand information related to the environment but also to be able to apply this information in their daily lives. To overcome the challenges of globalization, which is both current and expected to increase in the future, acquiring and teaching this concept is essential. The responsibility for developing this skill largely rests with teachers and teacher candidates, who are the architects of the future. Although numerous studies have been conducted in the literature regarding environmental literacy skills, no study encompassing teachers and teacher candidates in Turkey has been found. The aim of this research is to examine the environmental literacy levels of teachers and teacher candidates in terms of gender, subject area, grade level, and region of residence. A general survey model, a quantitative research method, was used in this study. The sample of the study consists of a total of 110 teachers and prospective teachers working or studying in different regions of Turkey. The data for the study were collected in the fall semester of the 2025-2026 academic year. The Adult Environmental Literacy Scale (ELSA), adapted into Turkish by Atabek-Yiğit, Köklükaya, Yavuz and Demirhan (2014), was used as the data collection tool. The Adult Environmental Literacy Scale (ELSA) used in the study is a 20-item Likert-type scale. The reliability analysis of the scale resulted in a Cronbach's Alpha (α) internal consistency score of .855. Independent samples t-tests were used for gender and subject area variables, and Kruskal-Wallis H-tests were used for class level and region variables. According to the research findings, there is no significant difference in the environmental literacy levels of teachers and prospective teachers in terms of gender, class level, subject area, and region variables. It was also observed that there was no significant difference between the scores of female and male candidates. However, it was concluded that the participants' general environmental literacy levels were high and showed a homogeneous distribution regardless of demographic characteristics.

Keywords: Environmental literacy, teacher, prospective teachers.

Introduction

With increasing globalization today, environmental problems are also increasing; this situation has led to the concept of environment being addressed in a more widespread and multifaceted way. The concept of environment has acquired an interdisciplinary character due to its scope encompassing different fields and disciplines, and has been defined in various ways. In its most general definition, the environment is a vital and cultural setting in which all living and non-living things interact (Gerçek, 2016). According to another definition, the environment is the totality of natural and artificial factors that affect a living system throughout its life (Yılmaz and Morgil, 1998). Human life is in constant and reciprocal interaction with its environment, and maintaining a balance in this region is necessary. However, human activities negatively affect this natural balance, leading to the emergence of problems. With environmental problems becoming visible on a global scale, the Stockholm Conference was organized under the auspices of the United Nations in the 1970s to find solutions to these problems; this was followed by the Tbilisi Declaration and the Rio Conference in the 1990s. The common goal of these meetings is to raise awareness among humankind about environmental issues, to become aware of environmental problems, and to ensure a livable environment for the future (Koç et al., 2018). With these meetings, the concept of environmental education is coming to the forefront (Teksöz et al., 2010). After it was determined that environmental problems are largely human-caused and stem from a lack of awareness, the importance of environmental education in educational institutions began to be emphasized even more (Yıldız, 2025). Environmental education is an important concept focused on in addressing environmental problems within the framework of sustainable development. The main goal of environmental education is to instill environmental literacy (Teksöz et al., 2010).

Although the concept of literacy has been defined in different ways from the past to the present, today it is considered to be more than just being knowledgeable in a particular field; it is defined as the ability to exhibit conscious, critical, and responsible behaviors related to that field (Kışoğlu, 2009). The concept of environmental literacy was first used by Charles E. Roth in the 1960s (Roth, 1968). According to Roth (1992), environmental literacy refers to individuals' cognitive awareness of the environment. According to Balkan and Kıyıcı (2009), environmental literacy is the most important element in preventing environmental problems. In a general framework, environmentally literate individuals are defined as individuals who have knowledge about the environment, show sensitivity to environmental problems, and act with a sense of responsibility.

An examination of environmental literacy education practices in our country reveals that environmental topics are sometimes removed from primary and secondary school curricula, then added back, offered as elective courses, or integrated into existing courses. At the higher education level, courses on environmental education are offered in faculties and institutes. In particular, environmental education is given even more importance in branches such as primary school teaching and biology teaching within the faculty of education (Kışoğlu, 2009). It is of great importance that teachers and prospective teachers, who play a vital role in raising future generations, are environmentally literate individuals. Ensuring that all students acquire environmental literacy skills, which are explicitly included in the renewed curriculum, the 2024 Turkish Century Education Model, is of great importance in reducing and preventing the effects of globalization, which is experienced today and is expected to increase in the future. Teachers and prospective teachers must possess a high level of environmental literacy skills so that they can both align with the goals of the renewed curriculum, the 2024 Turkish Century Education Model, and effectively impart this skill to future generations.

A review of the literature reveals that the environmental literacy levels of teachers and prospective teachers are at a moderate (Kışoğlu 2009; Teksöz et al. 2010; Aydemir and Alım, 2022) and very high (Koç et al. 2018; Benzer and Şahin 2013) level. However, a comprehensive study addressing environmental literacy across all teaching disciplines has not been found. However, environmental

literacy is not limited to the fields of science or social sciences, but is a competency encompassing teachers of all disciplines. Therefore, it is believed that examining the environmental literacy levels of teachers and prospective teachers in terms of various variables will contribute to the literature. This study examined the environmental literacy levels of teachers and prospective teachers in terms of various variables. The study determined and evaluated the environmental literacy levels of teachers and prospective teachers across different variables. It is anticipated that these findings will contribute to the development of teacher training programs and the organization of in-service training courses.

The aim of this study is to examine the environmental literacy levels of teachers and prospective teachers in terms of various variables.

Method

Research Design

This study utilized a general survey design, a quantitative research method. In a general survey design, only one or more variables are determined independently (Hocaoğlu and Baysal, 2024). The reason for using a general survey model in this study is that a single phenomenon is examined using independent variables.

Sample

The study's population consists of teachers and prospective teachers working in Turkey in 2025-2026. The sample comprises teachers and prospective teachers living in the Aegean, Central Anatolia, Marmara, Mediterranean, and Southeastern Anatolia regions. The sample for this study was determined using convenience sampling, a type of purposive sampling. The reason for using convenience sampling is that it allows the researcher to easily reach teachers and prospective teachers. The sample size for this study was determined to be 110 teachers and prospective teachers. Of the teachers and prospective teachers comprising the sample, 74 are women and 36 are men.

Data Collection Instruments

A two-part form was used to collect data in the research. The first part of the form is a Personal Information Form prepared by the researcher to collect information about the gender, subject area, grade level, and region of residence of teachers and prospective teachers. In the second part of the form, the Environmental Literacy Scale for Adults (ELSA), adapted into Turkish by Atabek-Yiğit, Köklükaya, Yavuz and Demirhan (2014), was used to determine the environmental literacy levels of teachers and prospective teachers. The scale consists of 20 items and is a five-point Likert type. In this study, teachers and teacher candidates who scored between 26.66 and 46.66 were evaluated as having a "low" level of environmental literacy, those who scored between 46.67 and 73.33 were evaluated as having a "medium" level, and those who scored between 73.34 and 100 were evaluated as having a "high" level. The Cronbach's Alpha (ά) coefficient for the reliability study of the developed scale was found to be .81 (Atabek-Yiğit et al., 2014). For this study, the total Cronbach's Alpha (ά) value of the scale was calculated as .885.

Data Analysis

The normality of the data obtained in the study was examined using the Kolmogorov-Smirnov test. As a result of the normality analysis, appropriate statistical analysis methods were determined, taking into account the distribution characteristics of the data. Accordingly, for variables where the assumption of normal distribution is met, the independent samples t-test was used for comparisons between two groups, and one-way analysis of variance (ANOVA) was used for

comparisons between more than two groups. For variables where the assumption of normal distribution is not met, the Kruskal-Wallis analysis of variance, a non-parametric test, was applied. In this context, an independent samples t-test was used for the gender variable; a one-way analysis of variance (ANOVA) was used for the branch variable; and Kruskal-Wallis analysis of variance was used for the class level and region variables.

Results

The descriptive statistical results of the scores obtained by teachers and prospective teachers from the environmental literacy scale are given in Table 1.

Table 1. *Descriptive Statistics Results of Scores Obtained from the Environmental Literacy Scale.*

	Min.	Max.	x̄	Ss
Environmental Consciousness	26.00	45.00	39.1009	4.28811
Environmental Concern	16.00	30.00	25.6273	2.61211
Environmental Awareness	11.00	25.00	18.1727	2.92681
Environmental Literacy	58.00	98.00	82.8899	7.97953

Table 1 shows that the lowest score obtained by teachers and prospective teachers on the "environmental literacy scale" was 58.00, and the highest score was 98.00. For the sub-dimensions, the lowest score in the Environmental Awareness sub-dimension was 26.00, and the highest score was 45.00; the lowest score in the Environmental Anxiety sub-dimension was 16.00, and the highest score was 30.00; and the lowest score in the Environmental Consciousness sub-dimension was 11.00, and the highest score was 25.00. The average score obtained from the scale is 82.88.

Table 2. presents the results of teachers' and prospective teachers' scores on the environmental literacy scale according to the gender variable.

Table 2. *Results of Environmental Literacy Scale Scores by Gender*

		N	x̄	Ss	t	p
Environmental Consciousness	Women	74	39.4189	4.31629	1.127	.262
	Men	36	38.4286	4.20983		
Environmental Concern	Women	74	25.9054	2.58642	1.613	.110
	Men	36	25.0556	2.60707		
Environmental Awareness	Women	74	18.3378	2.77601	.847	.399
	Men	36	17.8333	3.22933		
Environmental Literacy	Women	74	83.6622	7.73761	1.477	.143
	Men	36	81.2571	8.34669		

*p>.05

Table 2. shows that according to the t-test results applied to the total scores and sub-dimensions of the environmental literacy scale obtained by teachers and prospective teachers, there is no significant difference between environmental literacy and its sub-dimensions and gender (p>.05). Similarly, when looking at the mean scores obtained from the environmental literacy scale, the numerical difference between women (x̄= 83.66) and men (x̄= 81.25) is not statistically significant.

Table 3. shows the results of teachers' and prospective teachers' scores on the environmental literacy scale according to their branches.

Table 3. *Results of Environmental Literacy Scale Scores by Field of Study*

		N	x̄	Ss	sd1	sd2	F	p
Environmental Consciousness	Science and Mathematics	29	37.8276	4.92855	2	107	2.305	.105
	Basic Education and Languages	47	39.9783	4.33840				
	Talent Sections	34	39.0000	3.37549				
Environmental Concern	Science and Mathematics	29	25.1379	2.58739			1.257	.289
	Basic Education and Languages	47	26.0638	2.76157				
	Talent Sections	34	25.4412	2.38926				
Environmental Awareness	Science and Mathematics	29	18.3448	2.86949			2.074	.131
	Basic Education and Languages	47	18.6596	3.04514				
	Talent Sections	34	17.3529	2.70670				
Environmental Literacy	Science and Mathematics	29	81.3103	8.47308			2.109	.126
	Basic Education and Languages	47	84.6957	8.36094				
	Talent Sections	34	81.7941	6.64593				

*p>.05

Table 3. shows that a one-way analysis of variance applied to the total scores and sub-dimensions of the environmental literacy scale obtained by teachers and prospective teachers reveals no significant difference between environmental literacy and its sub-dimensions and branch groups (p>.05).

Table 4. presents the results of teachers' and prospective teachers' scores on the environmental literacy scale, categorized by grade level.

Table 4. *Results of Environmental Literacy Scale Scores According to Grade Level*

	Class Level	N	x̄	ss	Mean Rank	sd	χ^2	p
Environmental Consciousness	1st Grade	7	40.0000	3.26599	59.29	4	.519	.267
	2st Grade	46	39.0870	4.02672	54.02			
	3st Grade	28	38.8214	4.74579	54.05			
	4st Grade	7	39.0000	6.85565	61.71			
	Graduate	22	39.2381	3.83282	54.74			
Environmental Concern	1st Grade	7	26.8571	2.19306	70.21		3.629	.459
	2st Grade	46	25.6522	2.91523	57.04			
	3st Grade	28	25.2500	2.23814	49.55			
	4st Grade	7	25.8571	3.84831	65.71			
	Graduate	22	25.5909	2.10801	51.91			
Environmental Awareness	1st Grade	7	20.5714	3.30944	75.93		3.629	.972
	2st Grade	46	17.9783	2.82441	53.93			
	3st Grade	28	18.6429	2.57069	60.34			
	4st Grade	7	17.8571	2.91139	51.29			
	Graduate	22	17.3182	3.19801	47.45			
Environmental Literacy	1st Grade	7	87.4286	6.75419	72.93		3.341	.503
	2st Grade	46	82.7174	7.83060	53.89			
	3st Grade	28	82.7143	8.14160	55.16			
	4st Grade	7	82.7143	12.48618	61.43			
	Graduate	22	82.0476	6.91720	49.10			

*p>.05

According to the Kruskal-Wallis test results applied to the scores obtained by teachers and prospective teachers from the environmental literacy scale shown in Table 4, there is no statistically significant difference between environmental literacy and its sub-dimensions and class level (p>.05).

Table 5. shows the results of the environmental literacy scale scores obtained by teachers and prospective teachers according to their region of residence.

Table 5. Results of Environmental Literacy Scale Scores According to Region

	Region Where One Lives	N	x̄	ss	Mean Rank	sd	χ^2	p
Environmental Consciousness	Aegean Region	54	39.0185	3.83377	53.07	4	4.921	.295
	Central Anatolia Region	28	40.3571	3.77334	64.55			
	Mediterranean Region	10	38.4000	6.86699	57.35			
	Marmara Region	7	38.2857	3.49830	45.07			
	Southeastern Anatolia Region	11	37.3000	5.14350	43.25			
Environmental Concern	Aegean Region	54	25.5556	2.43145	54.47		5.501	.240
	Central Anatolia Region	28	26.1071	2.54354	59.91			
	Mediterranean Region	10	26.4000	3.56526	69.05			
	Marmara Region	7	25.5714	1.71825	52.36			
	Southeastern Anatolia Region	11	24.0909	2.91392	39.00			
Environmental Awareness	Aegean Region	54	18.4444	2.94392	57.99		2.206	.698
	Central Anatolia Region	28	17.7857	3.07146	50.55			
	Mediterranean Region	10	18.9000	2.80674	64.30			
	Marmara Region	7	18.0000	1.52753	52.57			
	Southeastern Anatolia Region	11	17.2727	3.34936	49.73			
Environmental Literacy	Aegean Region	54	83.0185	7.47699	54.79		4.687	.321
	Central Anatolia Region	28	84.2500	7.72981	60.61			
	Mediterranean Region	10	83.7000	11.31420	62.40			
	Marmara Region	7	81.8571	4.22013	47.93			
	Southeastern Anatolia Region	11	78.3000	9.21412	38.00			

*p>.05

According to the Kruskal-Wallis test results applied to the scores obtained by teachers and prospective teachers from the environmental literacy scale shown in Table 5, there is no significant difference between environmental literacy and its sub-dimensions and the region in which teachers and prospective teachers live (p>.05).

Discussion and Conclusion

According to the findings of the study, the environmental literacy levels of teachers and prospective teachers (x̄= 82.88) are found to be high. This finding is consistent with the results of the research conducted by Koç et al. (2018) and Benzer and Şahin (2013) with teachers and prospective teachers. The high level of environmental literacy among the participants suggests that they possess sufficient knowledge, awareness, and responsibility regarding the environment, and that they have the potential to translate this skill into behavior. Teachers and prospective teachers possessing this competence provides a significant advantage in raising environmentally conscious

generations. The study examined environmental literacy levels in terms of various variables. Findings regarding the gender variable revealed no statistically significant difference in environmental literacy levels between teachers and teacher candidates and their genders. This result indicates that environmental literacy is a gender-independent competency. This finding is consistent with studies by Aydemir and Alım (2022), Özyürek et al. (2019), Erbasan (2018), and Gürbüz et al. (2011). However, Türkeli (2022) found a significant difference between gender and environmental literacy in favor of women. This difference may be due to sample characteristics and demographic variables in the study groups. The findings regarding the subject area variable also show that there is no significant difference in environmental literacy levels between teachers and teacher candidates. This result reveals that environmental literacy is not a competency specific to certain fields; it is a fundamental skill that all teachers, regardless of subject area, should possess and impart to their students. Indeed, environmental literacy is among the 21st-century skills and is defined as a literacy skill within the scope of the 2024 Turkish Century Education Model. In this context, the research finding shows that environmental literacy has an interdisciplinary nature. Similarly, no significant difference was found according to the branch variable in the study conducted by Özyürek et al. (2019). Analyses regarding the class level variable also show no significant difference in environmental literacy levels. This suggests that prospective teachers have similar levels of environmental literacy at different stages of their education. It can be assessed that teachers maintain this competence through in-service training, professional experiences, and individual development processes. However, the significant difference found in Türkeli's (2022) study according to the class level variable indicates that this variable may yield different results in different samples. Findings regarding the region variable also revealed that the environmental literacy levels of teachers and teacher candidates did not differ significantly according to region. This result shows that environmental literacy has developed at a similar level regardless of geographical differences. The fact that teachers and teacher candidates possess environmental literacy regardless of the region they live in suggests that this skill has reached a widespread level of awareness throughout the country.

Overall, a high level of environmental literacy among teachers and teacher candidates is a positive indicator for a sustainable future. Schools are not only institutions where academic knowledge is imparted; they are also social learning environments where values, attitudes, and skills are acquired. In this context, teachers serve as role models in developing environmental awareness. The knowledge, attitudes, and behavioral levels of teachers are crucial in equipping students with environmental literacy skills. Consequently, while the high level of environmental literacy among teachers and prospective teachers is a significant finding, the sustainability of this competency and the extent to which it is reflected in behavioral dimensions can be examined in more detail in future research. Furthermore, it is recommended that practices supporting environmental literacy be strengthened in teacher training programs and in-service training.

The study showed no significant difference in environmental literacy levels between teachers and teacher candidates and their class level. Therefore, a qualitative research study could be conducted to determine the reasons for this.

A qualitative study could be conducted on how teachers and teacher candidates can impart environmental literacy skills to their students.

The environmental literacy levels of teachers and teacher candidates in branches that do not include environmental topics in their curriculum could be determined.

References

Atabek-Yiğit, E., Köklükaya, N., Yavuz, M., & Demirhan, E. (2014). development and validation of environmental literacy scale for adults (ELSA). *Journal of Baltic Science Education*, *13*(3), 425-435.

Aydemir, Y., & Alım, M. (2022). Coğrafya öğretmen adaylarının çevresel okuryazarlık düzeylerinin çeşitli değişkenler açısından incelenmesi. *Recep Tayyip Erdoğan Üniversitesi Eğitim Fakültesi Dergisi*, 2(2), 1-25. https://izlik.org/JA94KA92BC

Balkan Kıyıcı, F. (2009). *Çevre eğitimi.* V. Sevinç (Ed.), *Eğitim fakülteleri için genel çevre bilimi*, 175- 183. Maya Akademi.

Benzer, E., & Şahin, F. (2013). Fen bilgisi öğretmen adaylarının çevre okuryazarlığının proje tabanlı öğrenme süresince örnek olaylarla değerlendirilmesi. *Marmara Üniversitesi Atatürk Eğitim Fakültesi Eğitim Bilimleri Dergisi,* 35(35), 55-83. https://izlik.org/JA86YK47MD

Erbasan, Ö. (2018). *Öğretmenlerin çevre okuryazarlıklarının bazı değişkenler açısından incelenmesi* [Yüksek lisans tezi, Afyon Kocatepe Üniversitesi]. Afyon Kocatepe Üniversitesi Sosyal Bilimler Enstitüsü. https://acikerisim.aku.edu.tr/ Erişim tarihi 17 Şubat 2026.

Gerçek, C. (2016). Üniversite öğrencilerinin çevre etiğine yönelik algıları. *Elektronik Sosyal Bilimler Dergisi,* 15(59). https://doi.org/10.17755/esosder.263217

Gürbüz, H., Kışoğlu, M., Alaş, A., & Sülün, A. (2011). Biyoloji öğretmeni adaylarının çevre okuryazarlıklarının farklı değişkenler açısından incelenmesi. *e-Uluslararası Eğitim Araştırmaları Dergisi*, 2(1), 1-14. https://izlik.org/JA84KL22NK

Hocaoğlu, N. ve Akkaş Baysal, E. (2024). Nicel araştırma modeli desenleri. G. Ocak (Ed.), *Bilimsel araştırma yöntemleri* (2. baskı, s. 77). Pegem Akademi.

Kışoğlu, M. (2009). *Öğrenci merkezli öğretimin öğretmen adaylarının çevre okuryazarlığı düzeyinin etkilerinin görülmesi* [Doktora tezi, Atatürk Üniversitesi]. YÖK Ulusal Tez Merkezi (Tez No. 238095).

Koç, A., Çorapçıgil, A., & Doğru, M. (2018). Fen bilgisi öğretmen adaylarının çevre okuryazarlık düzeylerinin incelenmesi. *Eğitim ve Yeni Yaklaşımlar Dergisi*, 1(1), 39-52. https://izlik.org/JA82RH25GM

Özyürek, C., Demirci, F., Güler, H., Sarıgöl, J., Tepe, B., & Çetinkaya, M. (2019). Öğretmen adaylarının çevre okuryazarlık bileşenlerinin farklı değişkenlere göre incelenmesi. *Mehmet Akif Ersoy University Journal of Education Faculty*, 50, 227-253. https://doi.org/10.21764/maeuefd.411195

Roth, C. E. (1968). Curriculum owerwiev for developing environmentally literate citizens. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://files.eric.ed.gov/fulltext/ED032982.pdf Erişim tarihi: 5 Şubat 2026.

Roth, C.E., 1992. Environmental literacy: its roots, evolution and directions in the 1990s. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://files.eric.ed.gov/fulltext/ED348235.pdf Erişim tarihi: 5 Şubat 2026.

Teksöz, G., Şahin, E., & Ertepınar, H. (2010). Çevre okuryazarlığı, öğretmen adayları ve sürdürülebilir bir gelecek. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, 39(39), 307-320. https://izlik.org/JA24PS35KP

Türkeli, Ö. (2022). *Öğretmen adaylarının çevre okuryazarlığı kavramına ilişkin tutum ve davranışlarının incelenmesi* [Yüksek lisans tezi, Alanya Alaaddin Keykubat Üniversitesi]. Alanya

Alaaddin Keykubat Üniversitesi Lisansüstü Eğitim Enstitüsü]. YÖK Ulusal Tez Merkezi (Tez No. 729809).

Yıldız, Ç. (2025). *Sosyal bilgiler eğitiminde proje tabanlı öğrenme yaklaşımının 5. sınıf öğrencilerinin çevre okuryazarlığına etkisi* [Doktora tezi, Anadolu Üniversitesi]. YÖK Ulusal Tez Merkezi (Tez No. 921666).

Yücel, S., & Morgil, F. İ. (1998). Yüksek öğretimde çevre olgusunun araştırılması. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, 14(14). https://izlik.org/JA45PJ78PA

LEVELS OF LIFELONG LEARNING SKILLS OF MIDDLE SCHOOL STUDENTS

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ABSTRACT

The aim of this study is to examine the lifelong learning skill levels of middle school students. The study group consists of 100 middle school students who participated in robotics coding courses at Do-It-Yourself (DIY) Workshops in the provinces of Afyonkarahisar and Uşak during the 2024–2025 academic year. The participants were selected using the criterion sampling method. The study was conducted using the survey model, one of the quantitative research methods. As the data collection tool, the "Lifelong Learning Skills Scale for Middle School Students" developed by Çiftçibaşı, Korkmaz, and Karamustafaoğlu (2019) was used. In the validity studies of the scale, an exploratory factor analysis was conducted and four sub-dimensions were identified. The first factor, named communication and productivity, consists of 12 items. The second factor, cooperation and learning, consists of 9 items. The third factor addresses foreign language and is named communication in a foreign language, consisting of 4 items. The final factor is self-confidence, which includes 5 items. In total, the scale consists of 30 items. To determine the reliability of the scale, the Cronbach's alpha reliability coefficient was calculated and found to be .871. Based on this result, the scale was determined to be valid and reliable. The scale was designed as a five-point Likert type. In the analysis of the data, independent samples t-test and one-way ANOVA were used to examine differences according to the variables of gender, grade level, socioeconomic status, and attitudes toward English courses. The findings of the study revealed that middle school students' lifelong learning skill levels did not differ significantly according to gender, whereas significant differences were found in terms of grade level, socioeconomic status, and attitudes toward English courses. In addition, it was determined that middle school students who received robotics coding education had high levels of lifelong learning skills.

Keywords: Lifelong learning, Learning to Learn, middle school lifelong learning experience

Introduction

The 21st century, also referred to as the information age, is characterized by rapid advancements in technology, communication, and knowledge. Rapid developments in technology and

communication indirectly affect many aspects of daily life. Transformation and change have become inevitable in various fields such as economy, social life, health, and education due to technological advancements. Individuals' exposure to such transformations also leads to the development and transformation of their skills. Changes in the skills that individuals are expected to possess and the addition of new competencies have also influenced the educational policies of countries. Accordingly, the skills expected from citizens and the methods used to develop these skills have evolved alongside technological developments. Countries aiming to have a strong position in the global arena recognize that national development depends not only on individuals who can use technology but also on those who can use it effectively and produce new technologies.

Developed countries aim to cultivate individuals who are productive rather than merely consumers. In order to achieve the transition from a consuming society to a producing society, the competencies expected from individuals must also evolve accordingly. Problem-solving, critical thinking, creativity, teamwork, and learning to learn are considered essential skills for individuals in a productive society. Individuals equipped with these skills are often referred to as a qualified workforce (Karataş, 2021). The methods and techniques used in the process of developing these competencies have also undergone significant changes. The effective use of these new methods and techniques depends on teachers possessing the necessary competencies. Therefore, when aiming to develop individuals' skills, it is also inevitable that the competencies of educators who will transfer these skills must evolve. In addition, it is essential to provide appropriate educational environments in which these competencies can be effectively developed.

In the 21st century, where information and technology are rapidly changing, it is no longer sufficient for individuals to rely solely on existing knowledge. Instead, individuals are expected to become lifelong learners who continuously improve themselves. In this context, lifelong learning emerges as a comprehensive concept that emphasizes the development of individuals' knowledge, skills, and competencies throughout their lives rather than limiting learning to formal education (Beycioğlu & Konan, 2008). The concept of lifelong learning, which gained global importance approximately half a century ago, has also been adopted in Türkiye. Within this framework, efforts have been centralized under a specific general directorate established within the Ministry of National Education (Çiftcibaşı et al., 2020).

Lifelong learning encompasses multidimensional learning processes that support individuals' personal, social, educational, and professional development. These processes include formal education, non-formal education, in-service training, family-based learning, and professional skills acquired in the workplace. In this sense, lifelong learning refers to a continuous development process that occurs in every stage and domain of an individual's life. The fact that it can be developed in various contexts such as family, school, workplace, and society regardless of gender, age, educational level, or occupational status demonstrates the universal and inclusive nature of this concept (Aksoy, 2008).

One of the primary goals of lifelong learning is to enable individuals to develop the skill of learning to learn. Acquiring lifelong learning skills does not necessarily require participation in formal education. Therefore, regardless of age, gender, or status, individuals can develop lifelong learning skills in schools, courses, families, and communities. Robotics coding education, which can begin at an early age and continue into later stages of life through non-formal learning environments, is closely related to the concept of lifelong learning skills.

The European Commission (2005) examined lifelong learning competencies and identified several sub-dimensions. These include learning to learn, communication in the mother tongue, communication in foreign languages, basic competencies in mathematics, science, and technology, digital competence, initiative and entrepreneurship, cultural awareness and expression, and social

and civic competencies (Çiftçibaşı, Korkmaz, & Karamustafaoğlu, 2020). Similar sub-dimensions are also included in the lifelong learning skills scale used in this study.

Today, the middle school period is considered a critical developmental stage during which students' learning attitudes, habits, and self-regulation skills are shaped. Determining the lifelong learning levels of students during this period is crucial for understanding characteristics such as openness to learning, curiosity, responsibility, and the desire for self-improvement. However, when the literature is examined, it is observed that studies directly addressing the lifelong learning levels of middle school students are limited.

Therefore, there is a need to determine the lifelong learning levels of middle school students and to examine the variables that may affect these levels. The findings obtained from such studies are expected to contribute both to the development of educational practices and to the existing literature.

The aim of this study is to determine the lifelong learning levels of middle school students and to examine these levels in relation to various variables that are thought to influence lifelong learning skills.

Method

Research Design

In this study, which examines the lifelong learning skill levels of middle school students, the survey method, one of the quantitative research methods, was employed. Survey models are research approaches that aim to describe a past or existing situation as it naturally occurs. In such models, research purposes are generally expressed through questions such as "What was it?", "What is it?", "What is it related to?", and "What does it consist of?" (Karasar, 2011, p. 77). Similarly, survey models aim to describe situations that existed in the past or continue to exist in the present in their natural state (Karasar, 2006, p. 77).

According to Büyüköztürk et al. (2014), the single survey model is a research design in which each variable related to the study is examined separately. In this study, the single survey model was adopted to determine the lifelong learning skill levels of middle school students.

Sample

The population of the study consisted of 105 middle school students who received robotics coding education at Do-It-Yourself (DIY) Workshops located in Afyonkarahisar and Uşak. Since a quantitative research method was applied in the study, a convenience sampling method was used in selecting the sample. Convenience sampling is a type of purposive sampling method.

This sampling technique was preferred because it is practical in terms of time and cost. According to Baltacı (2018), convenience sampling relies on selecting elements that are readily available and easily accessible. In this method, researchers choose the most easily reachable participants from the target population to form the sample. A large proportion of studies in the literature also prefer this sampling method (Baltacı, 2018).

Some characteristics of the participants in the study are given in Table 1.

Table 1. Some Characteristics of the Participants

gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	kız	48	45,7	45,7	45,7
	erkek	57	54,3	54,3	100,0
	Total	105	100,0	100,0	

class level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5.sınıf	4	3,8	3,8	3,8
	6.sınıf	56	53,3	53,3	57,1
	7.sınıf	39	37,1	37,1	94,3
	8.sınıf	6	5,7	5,7	100,0
	Total	105	100,0	100,0	

economic situation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	kötü	5	4,8	4,8	4,8
	orta	54	51,4	51,4	56,2
	iyi	46	43,8	43,8	100,0
	Total	105	100,0	100,0	

english lesson attitude

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	kötü	5	4,8	4,8	4,8
	orta	59	56,2	56,2	61,0
	iyi	41	39,0	39,0	100,0
	Total	105	100,0	100,0	

Data Collection Instruments

In the data collection process, a demographic information form prepared by the researchers was used to determine the demographic characteristics of the middle school students who contributed to the study by completing the scale. This form included questions aimed at collecting information about the participants' gender, grade level, socioeconomic status, and attitudes toward English courses.

Lifelong Learning Skills Scale for Middle School Students (LLSSMSS)

In order to measure the lifelong learning skills of middle school students, the *Lifelong Learning Skills Scale for Middle School Students (LLSSMSS)* developed by Çiftçibaşı, Korkmaz, and Karamustafaoğlu (2019) was used in this study. In the validity study of the scale, exploratory factor analysis was conducted and four sub-dimensions were identified.

The first factor, named communication and productivity, consists of 12 items. The second factor, cooperation and learning, includes 9 items. The third factor focuses on foreign language communication and consists of 4 items. The final factor is self-confidence, which includes 5 negatively worded items. In total, the scale consists of 30 items.

To determine the reliability of the scale, the Cronbach's alpha reliability coefficient was calculated and found to be .871. Based on this result, the scale was considered valid and reliable. The scale

was designed as a five-point Likert-type instrument, with response options ranging from (1) strongly disagree to (5) strongly agree.

According to Büyüköztürk, Çakmak, Akgün, Karadeniz, and Demirel (2020), a reliability coefficient of .70 or above is considered sufficient for research purposes. Therefore, it can be stated that the Lifelong Learning Skills Scale for Middle School Students is also reliable within the scope of this study. Permission to use the scale was obtained prior to conducting the research.

Data Analysis

During the analysis of the data obtained from the study, the first step was to conduct normality tests. Whether the data follow a normal distribution can be determined using various methods. Normality tests are commonly performed using the Kolmogorov–Smirnov test, graphical methods, and skewness and kurtosis coefficients. Examining the distributions of data through statistical indicators such as arithmetic mean, mode, median, skewness, and kurtosis coefficients is considered a descriptive approach (Abbott, 2011; Kirk, 2008, as cited in Demir, 2016).

In this study, the normality of the data distribution was determined by examining the skewness and kurtosis coefficients. Skewness and kurtosis values within the range of ±1 and values close to zero indicate that the data exhibit a normal distribution (Tabachnick & Fidell, 2013; McKillup, 2013, as cited in Demir, 2016). Based on the skewness and kurtosis values obtained in this study, it was determined that the data satisfied the assumption of normal distribution.

Since the data were normally distributed, parametric tests were used in the analysis. Independent samples t-test was employed for comparisons between two groups, while one-way ANOVA was used for comparisons involving more than two groups. Accordingly, a t-test was conducted to determine whether there was a significant difference in the lifelong learning skill levels of middle school students in terms of gender. In addition, one-way ANOVA was used to determine whether there were significant differences in students' lifelong learning skill levels according to grade level, socioeconomic status, and attitudes toward English courses.

Findings

The descriptive statistical results of the scores obtained by middle school students from the *Lifelong Learning Skills Scale for Middle School Students* are presented in **Table 1**.

		Statistic	Std. Error
rbt_top	Mean	110,8857	1,52844
	Std. Deviation	15,66188	
	Minimum	75	
	Maximum	139	
	Skewness	-,204	,236
	Kurtosis	-,745	,467

According to the data in Table 1, the lowest score obtained by middle school students on the "Lifelong Learning Skills Scale for Middle School Students" is 75, and the highest score is 139. The average score obtained from the scale is 110, and the standard error is 15.661.

The lifelong learning skill levels of middle school students in terms of gender are given in Table 2.

Table 2

T-Test Results of Lifelong Learning Skill Levels of Middle School Students by Gender

Group Statistics

	cinsiyet	N	Mean	Std. Deviation	Std. Error Mean	Sig.
ybo_top	kız	48	110,6250	15,69066	2,26475	
	erkek	57	111,1053	15,77372	2,08928	,883

When the data in Table 2 is examined, the lifelong learning levels of middle school students are analyzed according to the gender variable using a t-test. Since $p>0.05$ was found, there is no significant difference between the lifelong learning levels of middle school students and the gender variable.

The Lifelong Learning Skill Levels of Middle School Students According to Grade Level are given in Table 3.

Table 3

One-Way ANOVA Test Results of Lifelong Learning Skill Levels of Middle School Students According to Grade Level

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum	Sig
5.sınıf	4	120,2500	16,39868	8,19934	97,00	135,00	
6.sınıf	56	111,3750	15,04244	2,01013	76,00	139,00	<,005
7.sınıf	39	106,4872	15,54259	2,48881	75,00	139,00	
8.sınıf	6	128,6667	3,55903	1,45297	123,00	132,00	
Total	105	110,8857	15,66188	1,52844	75,00	139,00	

When the data in Table 3 is examined, it is seen that there is a significant difference in the Lifelong Learning Levels of middle school students according to the class level variable, as $p<0.005$.

Lifelong Learning Skill Levels of Middle School Students According to Socioeconomic Status

Table 4

Results of One-Way ANOVA Test of Lifelong Learning Skill Levels of Middle School Students According to Socioeconomic Status

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum	Sig
kötü	5	112,4000	11,32696	5,06557	102,00	127,00	,041
orta	54	107,1852	15,38938	2,09423	76,00	139,00	
iyi	46	115,0652	15,55692	2,29374	75,00	139,00	
Total	105	110,8857	15,66188	1,52844	75,00	139,00	

Table 4 shows a significant difference in lifelong learning levels among middle school students according to their socioeconomic status (P=0.041).

Lifelong Learning Skill Levels of Middle School Students According to English Attitude Status

Table 5

One-Way ANOVA Test Results of Lifelong Learning Skill Levels of Middle School Students According to English Attitude Status

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum	Sig
kötü	5	95,0000	19,96246	8,92749	75,00	122,00	,017
orta	59	109,5593	15,13875	1,97090	76,00	139,00	
iyi	41	114,7317	14,70718	2,29688	79,00	135,00	
Total	105	110,8857	15,66188	1,52844	75,00	139,00	

According to Table 5, a significant difference was found between middle school students' lifelong learning skill levels and their attitudes toward English courses (**p = .017**).

Conclusion, Discussion, and Recommendations

When the lifelong learning skill levels of middle school students were evaluated in terms of the gender variable, the findings indicated that gender did not have a significant effect on lifelong learning levels. Similarly, some studies in the literature have reported that gender does not play a determining role in lifelong learning tendencies and competencies (Ayaz, 2016). However, İncik (2020) found that gender had a significant effect on lifelong learning tendencies. Therefore, the findings of the present study partially align with previous research.

In the study, the lifelong learning skill levels of middle school students were also examined according to grade level. The results indicated that there was a significant difference in lifelong learning skill levels in terms of grade level. When examined in detail, it was observed that grade level influenced students' lifelong learning skills. Specifically, eighth-grade students demonstrated the highest levels of lifelong learning skills, followed by fifth-grade students, compared to other grade levels. Similarly, the study conducted by Çavuşoğlu and Acar (2020) revealed that age and grade level significantly affect lifelong learning skill levels. These findings support the results of the present study.

In this study, middle school students' lifelong learning skill levels were also examined according to their socioeconomic status, and a significant difference was found. This indicates that students'

economic conditions influence their lifelong learning levels. Individuals' motivation toward lifelong learning processes can be positively stimulated by various factors such as the dynamics of professional life, career planning that includes future perspectives, existing economic conditions, and the diversity of educational opportunities provided (Moustakas, 2018). This finding supports the results of the present study. It can therefore be concluded that students with higher socioeconomic status tend to have higher levels of lifelong learning skills.

Another variable examined in this study was students' attitudes toward English courses. The results revealed that attitudes toward English courses significantly affected lifelong learning skill levels. Similarly, Doğan (2023) stated that attitudes toward English have a significant effect on lifelong learning skill tendencies. This finding supports the idea that attitudes toward English courses influence the distribution of lifelong learning skills. Considering the interdisciplinary approach, it can be suggested that educational practices that interact with students' attitudes toward English courses should be used more frequently in teaching and learning processes.

Based on the findings obtained in this study, it can be recommended that activities that promote lifelong learning skills should be expanded and made more accessible in order to increase the lifelong learning levels of middle school students. In addition, students with lower socioeconomic status should be supported in order to improve their lifelong learning levels. Since positive attitudes toward English courses contribute positively to lifelong learning levels, greater emphasis should be placed on English language education in teaching and learning environments.

The findings of this study also showed that fifth- and eighth-grade students had higher lifelong learning levels compared to other grade levels. One possible explanation for this result is that students experience a new learning environment and new subjects when they begin middle school in the fifth grade, which may increase their curiosity and motivation to learn. In the eighth grade, the increase in lifelong learning levels may be related to students' cognitive and developmental maturity. However, in intermediate grades, lifelong learning levels may decrease due to the routine structure of the educational system. Therefore, educational methods and learning environments that stimulate curiosity, research skills, and learning motivation should be implemented, particularly for students who begin middle school with enthusiasm and curiosity in the fifth grade.

Source

Aksoy, M. (2008). *Hayat boyu öğrenme ve kariyer rehberliği ilkelerinin istihdam edilebilirliğe etkileri: Otel işletmeleri üzerine bir uygulama* [Doktora tezi, Gazi Üniversitesi]. YÖK Ulusal Tez Merkezi.

Baltacı, A. (2018). Nitel araştırmalarda örnekleme yöntemleri ve örnek hacmi sorunsalı üzerine kavramsal bir inceleme. *Bitlis Eren Üniversitesi Sosyal Bilimler Dergisi, 7*(1), 231–274.

Beycioğlu, K., & Konan, N. (2008). Yaşam boyu öğrenme ve Avrupa eğitim politikaları. *Elektronik Sosyal Bilimler Dergisi, 7*(24), 1–14.

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö. E., Karadeniz, Ş., & Demirel, F. (2014). *Bilimsel araştırma yöntemleri*. Pegem Akademi.

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö. E., Karadeniz, Ş., & Demirel, F. (2020). *Bilimsel araştırma yöntemleri* (27. baskı). Pegem Akademi Yayıncılık.

Çavuşoğlu, G., & Acar, K. (2020). Üniversite öğrencilerinin uzaktan eğitime yönelik görüşleri ile yaşam boyu öğrenme düzeyleri arasındaki ilişki. *Spor ve Performans Araştırmaları Dergisi, 11*(3), 207–220. https://doi.org/10.17155/omuspd.699318

Çiftcibaşı, F., Korkmaz, Ö., & Karamustafaoğlu, S. (2020). Ortaokul öğrencileri için yaşam boyu öğrenme becerileri ölçeği: Geçerlik ve güvenirlik çalışması. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi, 22*(1), 226–252. https://doi.org/10.17556/erziefd.573511

Demir, S., Yavuz, M., & Öztürk, N. (2016). Uluslararası dergilerde yayımlanan eğitim araştırmalarının normallik varsayımları açısından incelenmesi. *Current Research in Education, 2*(3), 130–148.

İncik, E. Y. (2020). Öğretmenlerin yaşam boyu öğrenme eğilimleri ve 21. yüzyıl öğreten becerileri arasındaki ilişkinin incelenmesi. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 20*(2), 1099–1112. https://doi.org/10.17121/bauefd.573511

Karataş, H. (2021). 21. yy. becerilerinden robotik ve kodlama eğitiminin Türkiye ve dünyadaki yeri. *21. Yüzyılda Eğitim ve Toplum*, 10(30), 693-729.

Karasar, N. (2006). *Bilimsel araştırma yöntemleri*. Nobel Akademik Yayıncılık.

Karasar, N. (2011). *Bilimsel araştırma yöntemi*. Nobel Akademik Yayıncılık.

RECENT ADVANCES IN QUANTUM CHEMICAL CALCULATIONS

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ABSTRACT

Quantum chemical calculations have gained rapidly increasing importance across disciplines such as drug design, materials science, and nanotechnology. This field employs quantum-mechanics–based methods, mathematical models, statistical physics, and artificial intelligence–assisted approaches to accurately predict molecular structural and electronic properties, interactions, and reaction mechanisms. In research contexts where experimental procedures are limited by time and cost, the predictive capability of computational methods significantly enhances scientific efficiency. Quantum chemistry techniques enable atomic-level modeling of chemical and biological systems, providing a powerful framework for examining electronic structures, spectral characteristics, and reaction pathways. Quantum chemical approaches, including Density Functional Theory (DFT), are widely used to evaluate the stability, conformational behavior, and interactions of a broad range of systems-from biomolecules to nanoparticles and catalytic materials. Moreover, computational chemistry has become a key component in materials science and nanotechnology by facilitating the design of new materials with tailored properties.

In addition, computational chemistry plays a valuable role in the identification and design of anticorrosive materials. The effectiveness of protective molecules and the mechanisms through which they stabilize metal surfaces can be assessed efficiently through computational analyses.

Overall, Quantum chemical calculations methods allow the prediction of properties for both existing and yet-to-be-synthesized molecules without the need for experimental procedures. This capability reduces experimental workload, cost, and time by facilitating the early identification of promising molecular candidates.

Quantum chemical calculations are no longer merely theoretical tools; they have become strategic components that guide and complement experimental workflows. This presentation aims to provide an overview of current applications of quantum chemical calculations and to highlight their contributions across diverse research areas, offering a guiding framework for young researchers.

Keywords: Electronic structure theory, Theoretical chemistry, Quantum chemical calculations, Computational chemistry.

TURKISH AUDIENCES FRAMING DOGVILLE: A SEXIST TEXT OR A RECIPROCAL MORAL NARRATIVE?

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ABSTRACT

This study examines how Turkish audiences interpret Lars von Trier's film Dogville (2003). Frame analysis was used as the method. The initial goal was to test whether the director exhibited a sexist stance through the film's main character, Grace. However, after analyzing data from focus groups and in-depth interviews, it was observed that participants did not evaluate the film from a gender perspective. An unexpected finding was that participants evaluated the film within the framework of power, boundaries, and reciprocal justice.

The study analyzed focus group interviews (n=13) and in-depth interviews (n=3) conducted with participants of different ages and educational levels. The findings reveal that the character of Grace is mostly interpreted not in the context of "female victimization," but rather within the framework of "unconditional kindness," "excessive tolerance," and "trial." The violent scene at the end of the film was perceived as inevitable or a balanced response. The majority of participants interpreted the film through the lens of human nature and power relations. No one agreed with the idea that the director might have had a sexist attitude.

To test and reinforce these results, interviews will continue with new groups shortly. With these findings, the study opens up a discussion on the role of cultural context in film reception

Keywords: Frame Analysis, Audience Reception, Cultural Context.

IN SILICO EVALUATION OF BLOOD–BRAIN BARRIER PERMEABILITY AND NEUROLOGICAL DRUG POTENTIAL OF A NOVEL MOLECULE

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ABSTRACT

In this study, the ability of a novel drug-like molecule to penetrate the blood–brain barrier (BBB) was evaluated using in silico prediction tools. BBB permeability is a crucial factor for determining whether a compound can exert pharmacological effects on the central nervous system. The computational results indicated that the investigated molecule exhibits low BBB permeability. This finding suggests that the compound is unlikely to reach effective concentrations within brain tissue after systemic administration. The predicted low penetration is primarily attributed to its molecular polarity and physicochemical properties, including topological polar surface area and lipophilicity. These parameters play a decisive role in limiting passive diffusion across the BBB. Although low BBB permeability restricts neurological applications, it may represent a significant safety advantage for peripherally acting drugs. Reduced central nervous system exposure can minimize the risk of neurotoxicity and unwanted neurological side effects. Furthermore, compounds with limited BBB penetration are often preferred for treating systemic or peripheral

diseases. The study highlights the importance of early BBB screening in drug discovery to guide therapeutic targeting strategies. In silico BBB prediction serves as a fast and cost-effective approach for early pharmacokinetic assessment. Despite the unfavorable BBB penetration profile for neurological use, the molecule remains promising for non-central therapeutic applications. These findings provide valuable insight for rational drug design and future experimental investigations.

Keywords- Blood–brain barrier, BBB permeability, in silico prediction, neurological drug potential, central nervous system, pharmacokinetics

WOMEN'S RIGHTS ARE HUMAN RIGHTS: LITERACY OF VIOLENCE AGAİNST WOMEN AMONG SOCIAL WORK STUDENTS

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ABSTRACT
This study investigates social work students' views on the forms and causes of domestic violence and suggestion of intervention for survivors in Malaysia. To provide quality data, recruitment of final year undergraduate students from a public university was performed. All registered students of the final semester were eligible to take part in the study. They were identified and invited as respondents to offer their views. A qualitative online interview protocol was sent to 76 students; 20 female students were deemed eligible for this research. Students were made to understand that participation was voluntary and anonymous, as the researcher was blinded as to which students completed the protocol. Focus Group Discussion FGD of selected students was conducted to augment the information gathered through the interview protocol with students. The study revealed that the students seem to have fair knowledge about domestic violence, even though the university does not offer courses on family violence or domestic violence. Besides, the majority of respondents believed that violence against women is common in their respective communities. While most respondents recommended a general form of counselling, some considered specific counselling, such as marital and family counselling.

Keywords: literacy, domestic, private issue, physical violence, mental abuse, trauma

CAREER CONSTRUCTION BEHAVIORS OF DECK CADETS: A COMPARATIVE ANALYSIS BASED ON SEAGOING PHASE TRAINING COMPLETION

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ABSTRACT

The four-dimensional model of career construction theory designates the successive dimensions in people's occupational identity formation as adaptive readiness, adaptability resources, adapting responses, and adaptation results. The third dimension of the theoretical framework is assessed with the Student Career Construction Inventory (SCCI). The SCCI contains the following four sub dimensions: crystallizing, exploring, deciding, and preparing. While general university student career adaptation literature exists, few empirical studies investigate the adapting responses to long term seagoing phase training. In the maritime industry's international standards, deck cadets go through the process of receiving seagoing phase training. During this period, deck cadets are subjected to the difficult occupational transition conditions associated with the hierarchical and isolated working environment of a shipboard community. It is this exact theoretical and sectoral gap that drives this research. This study provides an examination of career construction behaviors that demonstrate the formation of an occupational identity in a sample of deck cadets. The study determined if there was a statistically significant difference in the career construction behavior of deck cadets either after completing or not completing their seagoing phase training. The data was divided into two independent comparison groups. The data were assessed for reliability and structure using Cronbach's alpha, McDonald's omega, EBICglasso partial correlation network, and bivariate correlations. Statistical hypothesis testing was subsequently conducted using independent samples t tests. Bivariate correlation findings indicated that the sub dimensions were positively and statistically significantly correlated. The network analysis demonstrated that the deciding factor was the most central node. The exploring dimension was found to have a structurally peripheral position within the network. Furthermore, hypothesis tests revealed that the seagoing phase training did not demonstrate a statistically significant differentiating influence on cadet career construction behaviors. Deck cadets' career construction behaviors can develop independently of their seagoing phase training experience.

Keywords: Maritime Transportation and Management Engineering, Career Construction, Seagoing Phase Training, Deck Cadets

Introduction

Global trade relies heavily upon the maritime sector as its absolute backbone. Operations within this industry tolerate minimal mistakes. A very high-risk level governs the overall workflow. It requires the complex problem-solving skills needed to manage organizations. A ship environment presents very different psychological and physiological dynamics compared to other standard workplaces. Challenging conditions at sea, social isolation, fatigue, and vulnerability to occupational injuries directly trigger each of these dynamics. Because of the inherent dangers

associated with maritime operations, such environments expose seafarers to significantly higher occupational injury risks when compared directly against standard shore based employment sectors (Uğurlu, 2015; Uğurlu et al., 2017; Yildirim & Toygar, 2025). The maritime industry continues to face a shortage of qualified seafarers on a daily basis (Formela et al., 2023; ICS, 2021). Furthermore, these challenges turn the training of qualified officers responsible for the management of commercial vessels into a global problem (Yildirim & Toygar, 2025).

Maritime faculties currently deploy a specialized training model to satisfy this specific need. The Standards of Training Certification and Watchkeeping Convention dictates strict educational guidelines rather than mere operational rules. Following these international guidelines, national regulations mandate a successful twelve month seagoing phase training period (T.C. Resmî Gazete, 2024). However, deck cadets confront actual physical and psychological realities firsthand. They also actively perform duties inside high-risk operational zones. Primary cornerstones of this deeply rooted system include highly hierarchical structures, strictly defined disciplinary policies, and rigid requirements demanding every cadet to wear mandatory uniforms (Özdemir, 2018; Yıldırım et al., 2021). A gap about how seagoing phase trainings under intense shipboard pressure actually impact the adapting responses of future ship officers.

This study focuses exclusively on deck cadets enrolled in the Maritime Transportation and Management Engineering undergraduate program. The study aimed to determine if completing the seagoing phase of training creates any statistically significant difference in career construction behaviors. A quantitative design drives the methodology. Researcher utilized convenience sampling to organize the dataset. They divided the participants into two independent comparative subgroups to conduct proper statistical analyses. Multiple advanced techniques evaluated the data. Cronbach’s alpha, McDonald’s omega, bivariate correlation, and EBICglasso partial correlation network analyses successfully demonstrated both reliability and structural integrity across the sample. An independent samples t test then compared the group averages. Testing the career construction model of adaptation within an isolated and hierarchical operational field like the maritime industry reveals the true originality of this research. The findings also provide a strong empirical foundation.

Subsequent sections of this paper adopt a systematic structural approach. The methods segment introduces the deck cadets selected via convenience sampling alongside the Student Career Construction Inventory (SCCI) measurement tool. Data analysis covers the specific reliability metrics, network architecture, and exact hypothesis testing procedures. Results interpret null findings within a strict theoretical framework during the conclusion section. Conclusions outline practical implications and present distinct research limitations.

Method

Research Design and Procedure

The entire research was conducted through a structured six-stage methodological pipeline (Figure 1).

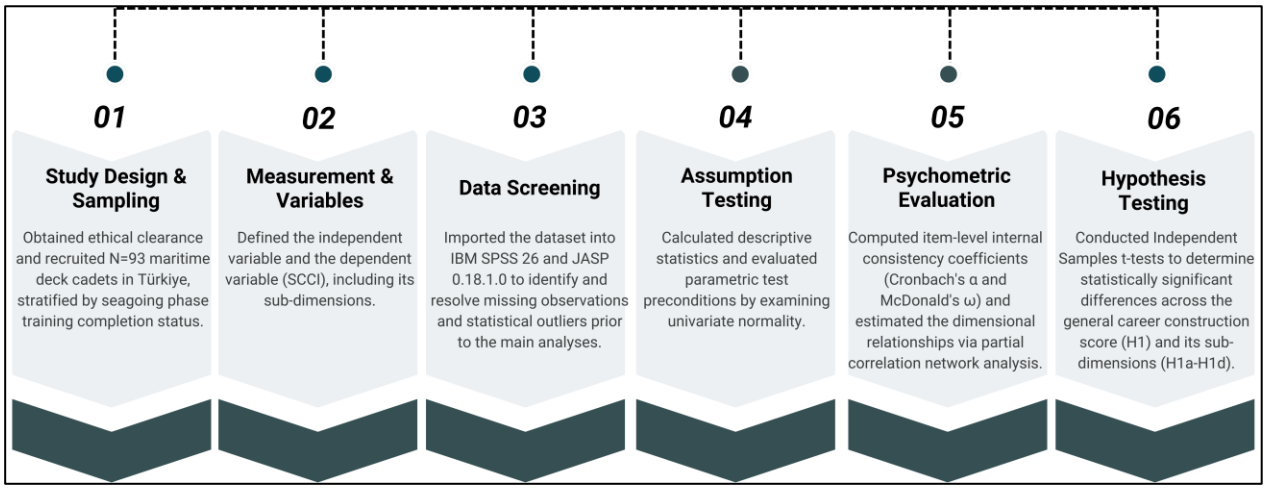


Figure 1. Methodological pipeline and analysis phases of the research

Securing necessary ethical committee approvals initiated the procedure. Researcher then gathered data based on the seagoing phase training completion status of the target population. Defining the specific variables and scale sub dimensions constitute the next step. The data was screened using IBM SPSS Statistics 26 and JASP 0.18.1.0 software. Assessing parametric test prerequisites required precise calculations. Researcher generated descriptive statistics and confirmed univariate normality assumptions. A rigorous psychometric evaluation drove the subsequent phase. Item level calculations produced Cronbach's alpha and McDonald's omega internal consistency coefficients. Evaluating the structural boundaries between dimensions demanded advanced tools. Both bivariate correlation and network analysis examined these exact relationships. The final stage targeted hypothesis generation. Researcher formulated the primary H1 proposition and sub hypotheses H1a to H1d to test exactly how seagoing phase training differentiate these career structuring behaviors.

H_1 General career construction levels of deck cadets vary significantly according to their completion status of the seagoing phase training.

H_{1a} Crystallizing levels of deck cadets vary significantly according to their completion status of the seagoing phase training.

H_{1b} Exploring levels of deck cadets vary significantly according to their completion status of the seagoing phase training.

H_{1c} Deciding levels of deck cadets vary significantly according to their completion status of the seagoing phase training.

H_{1d} Preparing levels of deck cadets vary significantly according to their completion status of the seagoing phase training.

Participants and procedure

The Ordu University Social and Humanities Research Ethics Committee granted official approval prior to the data collection process (Session Date: January 27, 2026, Session No: 1, Decision No: 2025-08). Exactly 93 deck cadets enrolled in the Maritime Transportation and Management Engineering undergraduate program constitute the study sample. A convenience sampling method drove the data gathering. Looking at the demographic records reveals that 48 individuals representing 51.6% of the total sample have not yet completed their seagoing phase training. The 45 remaining participants make up 48.4% of the surveyed population and have already completed their required seagoing phase.

Measurement scale

Data collection involves SCCI. Savickas et al. (2018) originally developed this metric to evaluate adapting responses, the third fundamental dimension within the career adaptation model. The scale contains 18 items. Respondents evaluate these statements on a 5-point Likert format. Capturing different developmental tasks, four distinct sub dimensions define the inventory framework. These factors are crystallizing, exploring, deciding, and preparing. The original developers reported a total Cronbach's alpha reliability coefficient of $\alpha = 0.93$. Yıldız Akyol & Öztemel (2022) completed the Turkish adaptation. Validating the underlying four factor structure through confirmatory factor analysis, their research established a total internal consistency coefficient of $\alpha = 0.89$ for the translated form. Reliability values across the individual sub dimensions vary between 0.68 and 0.89.

Data Analysis

Missing values and extreme observations required immediate screening. This preliminary analysis preceded all hypothesis testing procedures. Evaluating whether the dataset satisfied parametric assumptions involved a close inspection of continuous variables, specifically targeting their skewness and kurtosis distribution statistics. Dual coefficients established internal consistency. The researcher calculated both Cronbach's alpha α and McDonald's omega ω metrics for the measurement tool across the sample. Visualizing the conceptual and structural boundaries between scale sub dimensions required advanced modeling. A network analysis operating via JASP software utilized partial correlations to map these exact relationships. Confirming the parametric distribution parameters finally permitted the use of an independent samples t test to determine if completion of the seagoing phase training created any meaningful difference in the overall and factorial SCCI scores of the cadets.

Table 1. Descriptive statistics and normality indices for the SCCI and its sub-dimensions

Variable	$\bar{X}$	*SD*	*γ1*	*γ2*
SCCI	3.93	0.67	-0.68	0.46
Crystallizing	3.95	0.75	-0.66	-0.07
Exploring	3.65	1.07	-0.50	-0.57
Deciding	4.06	0.84	-0.85	0.11
Preparing	3.96	0.72	-0.59	0.64

SCCI Student Career Construction Inventory; *SD* Standard deviation; *γ1* Skewness; *γ2* Kurtosis

Descriptive statistics reveal an overall SCCI mean score of 3.93 among the sample. Deciding domain produced the highest average at 4.06. Exploring yielded the lowest mean of 3.65. Such an

elevated standard deviation within this specific category highlights a significantly wider internal group variance regarding occupational exploration behaviors when compared directly against the remaining career construction phases. Applying any inferential parametric procedures required a strict prior confirmation of univariate normality. Skewness and kurtosis parameters served as the primary diagnostic tools. Distribution properties show skewness values falling between -0.50 and -0.85 while kurtosis coefficients range from -0.57 to positive 0.64 across the dataset. Exact statistical bounds successfully prove that every overall and factorial SCCI score meets basic normal distribution assumptions. Looking at the negative skewness measures reveals a clear pattern. Surveyed deck cadets actively gave much higher ratings to the inventory items. Such specific rating behaviors provide strong evidence for a ceiling effect across the entire distribution. Basic descriptive numbers naturally offer only a preliminary estimate regarding actual distribution shapes. Determining true empirical usability actually requires much deeper investigation. Researcher should evaluate internal reliability levels alongside specific structural relationships correlation these independent variables. Table 2 subsequently displays exact bivariate correlation values right next to both Cronbach's alpha and McDonald's omega coefficients.

Table 2. Bivariate correlations and internal consistency reliability coefficients of SCCI and its sub-dimensions

Dimension		[1]	[2]	[3]	[4]	[5]	α [95% CI LB-UB]	ω [95% CI LB-UB]
Crystallizing	[1]	1					0.75 [0.65-0.82]	0.74 [0.67-0.82]
Exploring	[2]	0.43*	1				0.72 [0.60-0.81]	0.72 [0.62-0.82]
Deciding	[3]	0.61*	0.52*	1			0.87 [0.81-0.90]	0.87 [0.82-0.91]
Preparing	[4]	0.62*	0.41*	0.68*	1		0.82 [0.75-0.87]	0.82 [0.77-0.88]
SCCI-Total	[5]	0.85*	0.70*	0.88*	0.81*	1	0.90 [0.87-0.93]	0.90 [0.87-0.93]

CI Confidence interval; *SCCI* Student Career Construction Inventory; α Cronbach's alpha coefficient; ω McDonald's Omega coefficient. Note: *$p < 0.001$

Bivariate correlation coefficients range exactly from 0.41 between exploring and preparing to a high of 0.68 between deciding and preparing. This specific mathematical range clearly indicates an important structural reality. These components successfully differentiate into independent factors while still sharing common variance. Looking closely at the data reveals the absolute lowest correlation occurring precisely between the exploring and preparing dimensions. Metrics correlation crystallizing with deciding reach 0.61. A remarkably similar value of 0.62 correlates crystallizing to preparing. Both of these corresponding relationships demonstrate moderate to high shared variance across the entire model. Values correlation the total SCCI score with its individual sub dimensions fall strictly between 0.70 for exploring and 0.88 for deciding. Such strong statistical correlation confirm adequate representation perfectly. The aggregate score effectively captures factorial variance across the complete measurement framework.

Bootstrapped 95% confidence interval (CI) parameters reported internal consistency reliability through both Cronbach's alpha (α) and McDonald's omega (ω) coefficients. Both α and ω estimates parallel each other closely across all sub dimensions. Such convergence provides indirect proof. Item homogeneity assumptions remain largely intact. Sub-dimension reliability coefficients vary between 0.72 and 0.87. Exploring sub dimension produced the lowest reliability ($\alpha = \omega = 0.72$). Its CI span is noticeably wider than the others (α: 0.60 to 0.81, ω: 0.62 to 0.82). Deciding exhibits the highest reliability ($\alpha = \omega = 0.87$). An $\alpha = \omega = 0.90$ value places the SCCI Total significantly above acceptable reliability thresholds.

Standard bivariate correlation values cannot exclude third variable contributions. Researcher conducted a partial correlation network analysis via JASP 0.18.1.0 software using the EBICglasso estimator to examine specific relationship structures while controlling for other sub dimensions. A parametric bootstrap method running 5000 iterations tested network estimation stability. The network comprised four node elements and six nonzero edge correlations. Sparsity equaled 0.000. The EBICglasso regularization reduced absolutely no edges to zero. Table 3 presents the weights matrix findings.

Table 3. EBICglasso weights matrix and normalized centrality values for SCCI sub dimensions

		Partial Correlations (Weights Matrix)				Centrality Indices (Normalized)			
		[1]	[2]	[3]	[4]	Betweenness	Closeness	Strength	Exp. Influence
Crystallizing	[1]	-				-0.500	-0.535	-0.046	-0.046
Exploring	[2]	0.144	-			-0.500	-1.070	-1.304	-1.304
Deciding	[3]	0.271	0.302	-		1.500	1.177	1.115	1.115
Preparing	[4]	0.344	0.036	0.440	-	-0.500	0.428	0.236	0.236

Note Weights matrix values reflect partial correlation coefficients estimated with EBICglasso; centrality values reflect normalized indices.

Partial correlations between deciding and preparing form the absolute strongest specific relationship within this entire network matrix at 0.440. Other notable pathways follow closely behind. These robust edges correlate crystallizing to preparing (0.344) alongside deciding to exploring (0.302) and finally crystallizing to deciding (0.271). Looking at the exploring and preparing tie reveals a completely different situation. Its partial weight plummeted to a mere 0.036 compared to their original bivariate correlation of 0.41. Deciding clearly mediates the vast majority of shared variance bridging these two specific nodes. Normalized centrality parameters firmly validate this emerging structural hierarchy. Dominating the core completely, the deciding sub dimension leads to every single category. It records massive scores across betweenness (1.500), closeness (1.177), strength (1.115), and expected influence (1.115). Preparing successfully secures a moderate middle position through average strength (0.236) and closeness (0.428) metrics. Researcher found crystallizing pushed toward the periphery. It yielded negative strength (-0.046) and negative closeness (-0.535) values. Exploring ranks absolute lowest everywhere. It generated the poorest statistics across strength (-1.304), closeness (-1.070), and betweenness (-0.500). Visual network mappings in Figure 2 perfectly mirror these exact numerical patterns across all four nodes. Such extreme structural isolation actually aligns beautifully with earlier descriptive metrics. This peripheral condition matches the unusually high standard deviation from Table 1 alongside those relatively low internal consistency parameters of 0.72 documented within Table 2.

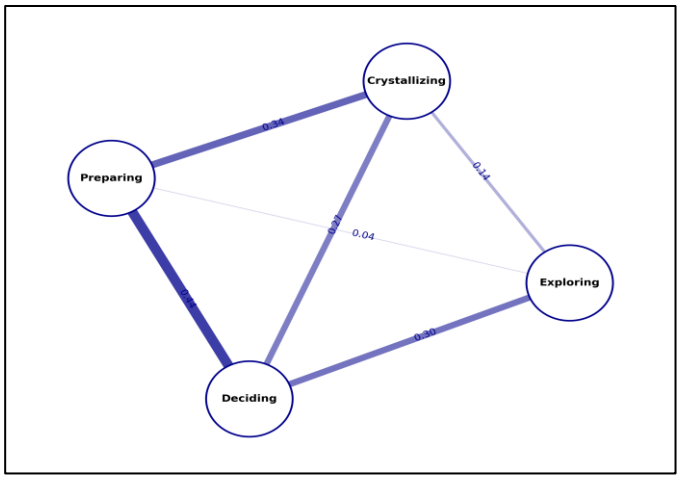


Figure 2. Partial correlation network of the SCCI sub-dimensions.

Visualizing the network in Figure 2 confirms the complete retention of all edges following the EBICglasso regularization process. A sparsity score of 0.000 proves that the four SCCI sub dimensions maintain specific associations across every single one of the six potential pairings. Variable line thickness demonstrably rules out any implication of structural homogeneity throughout the model. Looking right at the core reveals deciding as the most correlated component. It exhibits its greatest correlation toward preparing (0.440). Other robust correlates from this central node reach exploring (0.302) and finally crystallizing (0.271). High betweenness (1.500) and strength (1.115) metrics found in Table 3 mathematically support deciding as the strongest factor among the four. The exploring variable tells a completely reversed story. It actually shows its highest degree of correlation to deciding at 0.302 rather than its lowest. Its remaining ties appear incredibly weak. It maintains a fragile 0.144 correlation to crystallizing alongside an even weaker 0.036 correlate to preparing. Such an extreme drop highlights a highly unique structural relationship between preparing and exploring. Deciding clearly played a major mediating role regarding their original bivariate correlation. Table 3 reports a minimal partial weight of 0.036 to mathematically substantiate this exact mediating effect. Finding its own solid base, crystallizing establishes moderately strong correlations reaching preparing (0.344) and deciding (0.271). Its specific correlation pointing toward exploring (0.144) lacks that same fortitude. This basic network structure illustrates an obvious asymmetry. Deciding controls three major routes correlation with the other sub-dimensions. Exploring remains almost entirely isolated at the distant outskirts of the network. This significant degree of structural isolation reflects a crucial psychometric truth. Each of the four SCCI sub dimensions functions as a distinctly separate yet intercorrelated measurement unit. Successfully demonstrating these individual and correlated characteristics finally opened the door for comparative examinations. Researcher therefore conducted an independent samples t test to explore factorial scores using the completion of seagoing phase training as the primary grouping variable.

Table 4. The results of the hypothesis test

SCCI Subscale	Group	*N*	$\bar{X}$	*SD*	*t*	*df*	*p*	*Decision*
Crystallizing	Not Completed	48	3.92	0.75	-0.30	91	0.766	H_{1a} *NS*
	Completed	45	3.97	0.76				
Exploring	Not Completed	48	3.72	1.03	0.59	91	0.560	H_{1b} *NS*
	Completed	45	3.59	1.11				
Deciding	Not Completed	48	4.09	0.87	0.37	91	0.711	H_{1c} *NS*
	Completed	45	4.02	0.82				
Preparing	Not Completed	48	3.84	0.76	-1.57	91	0.119	H_{1d} *NS*
	Completed	45	4.08	0.67				

N Sample; *NS* Not supported*; SD* Standard deviation; $\bar{X}$ Mean; *t* Independent samples t-test statistic; *df* Degrees of freedom; *p* Probability value (significance level)

Before applying any independent groups t-test procedures, researcher utilized a Levene assessment for variance homogeneity. This preliminary step ensured the equal variance assumption held true across all four sub dimensions ($p > 0.05$). Looking at the crystallizing factor reveals no meaningful difference among the groups. Deck cadets who had not completed their seagoing phase training recorded an average of 3.92. Cadets who had completed their seagoing phase training scored a nearly identical 3.97. Such a minuscule mathematical gap points to absolutely no statistical significance ($t(91) = -0.30$, $p = 0.766$). Exploring domain generated a remarkably similar flat outcome. Cadets who had not completed their seagoing phase training ($\bar{X} = 3.72$) and cadets who had completed it ($\bar{X} = 3.59$) did not diverge in any meaningful way ($t(91) = 0.59$, $p = 0.560$). Group averages within the deciding framework remained remarkably close. Comparing the 4.09 average of the not completed group against the 4.02 average of the completed group generated absolutely no statistical distinction ($t(91) = 0.37$, $p = 0.711$). Absolute values peaked slightly higher within the preparing category for cadets who had completed their seagoing phase training (4.08) compared to the cadets who had not completed their seagoing phase training (3.84). This mathematical gap failed to reach any statistical significance ($t(91) = -1.57$, $p = 0.119$). Looking at the entire statistical picture confirms a clear reality. The seagoing phase training exerts absolutely no significant impact on the developmental attitudes or career construction behaviors of these surveyed deck cadets.

Conclusions

The current research found no significant differentiation across SCCI sub dimensions based on the completion status of the seagoing phase training. These null findings maintain theoretical consistency within the career construction model of adaptation (Savickas, 2021; Savickas & Porfeli, 2012). The framework predicts a specific mechanism. Adaptability resources shape the adapting responses component rather than direct experiential accumulation (Savickas et al., 2018; Yıldız-Akyol & Öztemel, 2022). Seagoing phase training completion status alone does not constitute an adaptability resource indicator. A lack of measurable divergence at the adapting responses level therefore matches core theoretical arguments. Moving beyond basic correlations provides a structural pattern. An EBICglasso partial correlation network analysis revealed the central position of the deciding factor. It also exposed a sharp decline in the exploring and preparing edge weight at the partial level. The deciding dimension clearly assumes a regulatory function during the career construction process. Cross sectional data prevents strict causal claims. Yet this specific outcome structurally supports prioritizing decision making behaviors during

career counseling interventions. Peripheral positioning and weak reliability metrics characterize the exploring sub dimension. A rigid hierarchical career path heavily restricts the occupational exploration available to deck cadets. Researchers should therefore question the measurement validity of the SCCI more comprehensively within standardized maritime education.

References

Formela, K., Bošnjak, R., & Pusch, V. (2023). Modern cadet training. The challenge between the various training systems and new demands set by the industry. *TransNav*, *17*(4), 929–934. https://doi.org/10.12716/1001.17.04.19

ICS. (2021). *New BIMCO/ICS Seafarer Workforce Report warns of serious potential officer shortage*. https://www.ics-shipping.org/press-release/new-bimco-ics-seafarer-workforce-report-warns-of-serious-potential-officer-shortage/

Özdemir, Ü. (2018). Researching of uniform and hierarchical system in maritime education with multi criteria decision making approach. *Electronic Turkish Studies*, *13*(19), 1409–1426. https://doi.org/10.7827/TurkishStudies.13861

Savickas, M. L. (2021). Career construction theory and counseling model. In S. D. Brown & R. W. Lent (Eds.), *Career development and counseling: Putting theory and research to work* (3rd ed., pp. 165–199). John Wiley & Sons, Inc.

Savickas, M. L., & Porfeli, E. J. (2012). Career Adapt-Abilities Scale: Construction, reliability, and measurement equivalence across 13 countries. *Journal of Vocational Behavior*, *80*(3), 661–673. https://doi.org/10.1016/j.jvb.2012.01.011

Savickas, M. L., Porfeli, E. J., Hilton, T. L., & Savickas, S. (2018). The student career construction inventory. *Journal of Vocational Behavior*, *106*, 138–152. https://doi.org/10.1016/j.jvb.2018.01.009

T.C. Resmî Gazete. (2024). *Gemi Adamları ve Klavuz Kaptanlar Yönetmeliği*. https://mevzuat.gov.tr/mevzuat?MevzuatNo=40941&MevzuatTur=7&MevzuatTertip=5

Uğurlu, Ö. (2015). Application of Fuzzy Extended AHP methodology for selection of ideal ship for oceangoing watchkeeping officers. *International Journal of Industrial Ergonomics*, *47*, 132–140. https://doi.org/10.1016/j.ergon.2015.01.013

Uğurlu, Ö., Kum, S., & Aydoğdu, Y. V. (2017). Analysis of occupational accidents encountered by deck cadets in maritime transportation. *Maritime Policy & Management*, *44*(3), 304–322. https://doi.org/10.1080/03088839.2016.1245449

Yildirim, U., & Toygar, A. (2025). Psychological determinants of life satisfaction among deck cadets: the mediating role of positivity and doomscrolling. *International Journal of Occupational Safety and Ergonomics*, 1–7. https://doi.org/10.1080/10803548.2025.2557690

Yıldırım, U., Toygar, A., & Tunçel, A. L. (2021). Effects of power distance on organizational commitment: A study on maritime faculty students. *Journal of ETA Maritime Science*, *9*(4), 256–265. https://doi.org/10.4274/jems.2021.24650

Yıldız-Akyol, E., & Öztemel, K. (2022). Implementation of career construction model of adaptation with Turkish University students: a two-study paper. *Current Psychology*, *41*(12), 8333–8344. https://doi.org/10.1007/s12144-021-01482-4

A NEUROSCIENTIFIC APPROACH TO THE DIGITAL ASSESSMENT OF FACIAL PAREIDOLIA IN THE HEALTHY ADULT BRAIN

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ABSTRACT

Background: Face pareidolia is a neurocognitive phenomenon where the visual system perceives facial patterns in vague, non-living objects. This process highlights the brain's natural inclination towards social perception, yet the factors affecting gender attribution to these illusory faces are still being explored. This pilot study seeks to assess baseline gender perception biases through a digital pareidolia test conducted on a controlled group of healthy individuals.

Method: An initial group of 11 healthy volunteers (6 females, 5 males) took part in the study. The stimuli included ten standardized images, comprising face pareidolia and scrambled images, displayed on a high-resolution digital tablet. Participants were tasked with identifying the presence of a face and, upon detection, categorizing the perceived gender. Response patterns and reaction times were systematically recorded to assess the prevalence of gender-specific heuristics.

Results: Initial findings indicated a strong male-gender bias, with 88% of pareidolia stimuli being identified as male, irrespective of the participant's gender. Despite this overall bias, a notable difference in processing speed was observed. Identifying female gender resulted in significantly shorter reaction times (1.03 ± 0.42 s) compared to male identifications (2.98 ± 0.74 s) ($p < 0.001$). These results suggest a rapid recognition effect for feminine traits, despite the conceptual dominance of the male category.

Conclusion: This pilot study confirms that the male-gender bias in face pareidolia is a consistent cognitive phenomenon in healthy populations. The findings imply that while male may act as the default social category for ambiguous stimuli, female-associated cues might prompt quicker neural processing. This study lays the groundwork for using digital pareidolia assessments to investigate implicit cognitive biases in broader social and clinical contexts.

Keywords: Face pareidolia, gender perception, digital assessment, cognitive bias, reaction time.

INTRODUCTION

The human visual system is highly specialized for detecting socially relevant stimuli, particularly human faces. This ability is supported by neural mechanisms within the ventral visual pathway, including the fusiform face area (FFA), which plays a central role in facial recognition processes. Because of this evolutionary specialization, the brain may sometimes detect face-like patterns in

objects that do not contain real facial structures. This perceptual phenomenon is known as face pareidolia.

Previous research has demonstrated that pareidolia reflects the brain's tendency to interpret ambiguous visual information using internal templates related to face perception (Liu et al., 2014). Neuroimaging studies have shown that illusory faces can activate neural networks similar to those involved in the perception of real human faces, highlighting the sensitivity of the human brain to facial configurations (Wardle et al., 2020). Beyond simply detecting a face-like structure, the perceptual system often assigns social attributes to these ambiguous stimuli, including gender, emotional expression, or identity.

Recent findings also suggest that gender perception may influence how pareidolia faces are interpreted, indicating that contextual and cognitive factors can affect the categorization of ambiguous facial stimuli (Çamcı et al., 2025). Understanding how such biases emerge in healthy individuals may provide insight into the neural mechanisms underlying social perception.

The aim of the present study was to examine gender attribution during face pareidolia perception using a standardized Digital Pareidolia Test (PT) in a healthy adult population. By analyzing both categorical responses and reaction times, this study aims to provide baseline data on how the human brain resolves social ambiguity in the absence of explicit facial features.

MATERIALS AND METHODS

This pilot cross-sectional study included 11 healthy volunteers (6 females and 5 males) without any history of neurological or psychiatric disorders. Participants were recruited in order to establish baseline data for gender attribution during ambiguous face perception.

The experimental task consisted of a Digital Pareidolia Test (PT) including 10 visual stimuli: five pareidolia images and five scrambled control images. Pareidolia stimuli contained face-like visual configurations, whereas control images were scrambled versions that did not contain recognizable facial structures.

The test was administered using a high-resolution tablet in a quiet environment to minimize distractions and ensure reliable measurement of reaction times. During the experiment, each participant was asked to determine whether a face was present in the image. If a face was detected, participants were instructed to categorize the perceived face as either "Male" or "Female."

The digital platform automatically recorded both the categorical responses and reaction times with millisecond precision. Reaction time was defined as the interval between the presentation of the stimulus and the participant's response.

Tables and Figures

Variable	Female Attribution	Male Attribution
Percentage of responses	12%	88%
Mean reaction time (s)	1.03	2.98
Standard deviation (s)	0.42	0.74

Table 1. Summary of gender attribution responses and reaction times during the Digital Pareidolia Test.

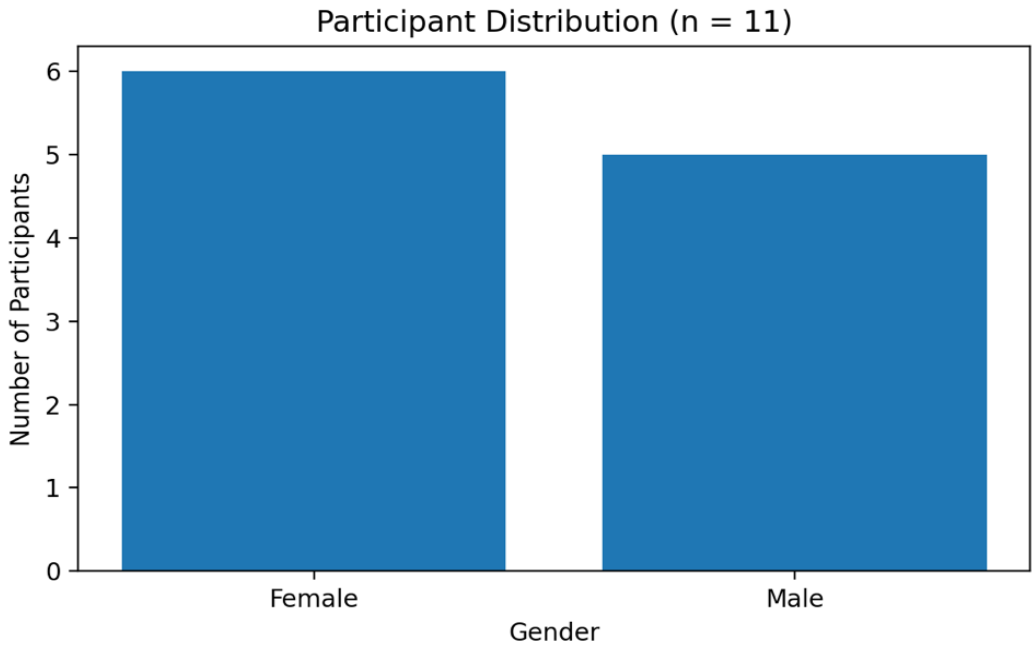


Figure 1. Participant distribution in the study (n = 11). The study included six female and five male healthy volunteers.

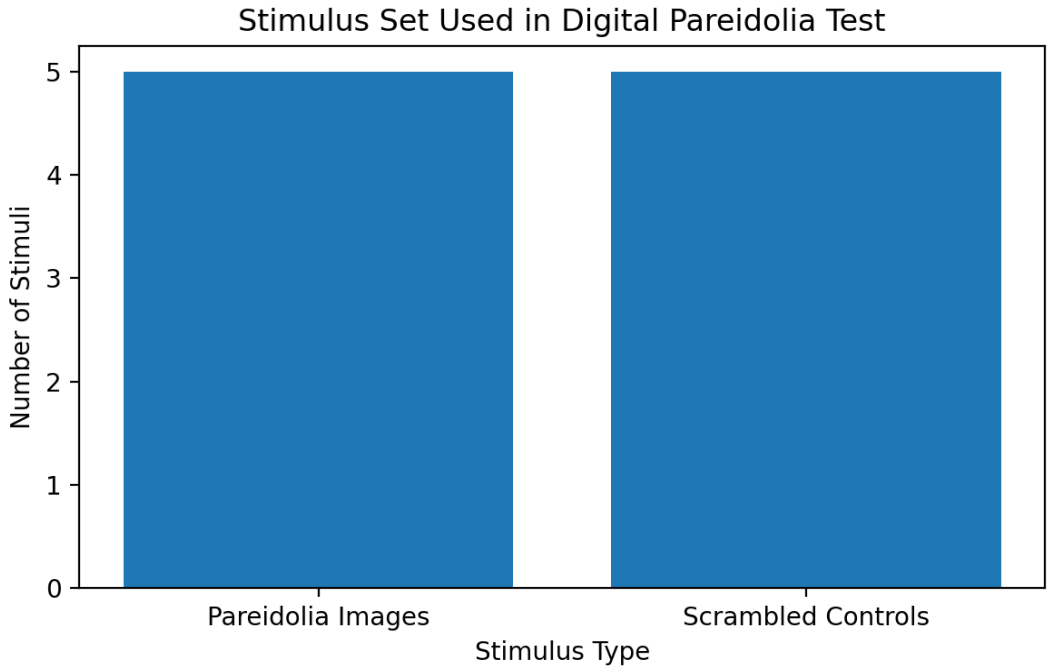


Figure 2. Stimulus set used in the Digital Pareidolia Test. The experimental task consisted of five pareidolia images and five scrambled control images.

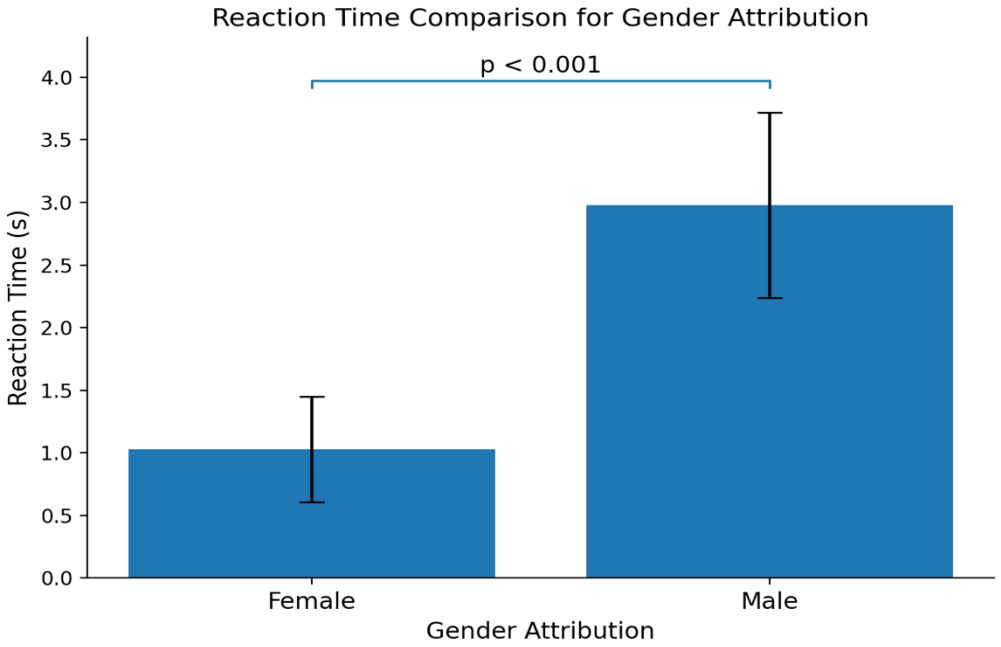


Figure 3. Reaction time comparison for gender attribution. Mean reaction times for female and male categorizations of pareidolia stimuli. Female responses were significantly faster than male responses ($p < 0.001$).

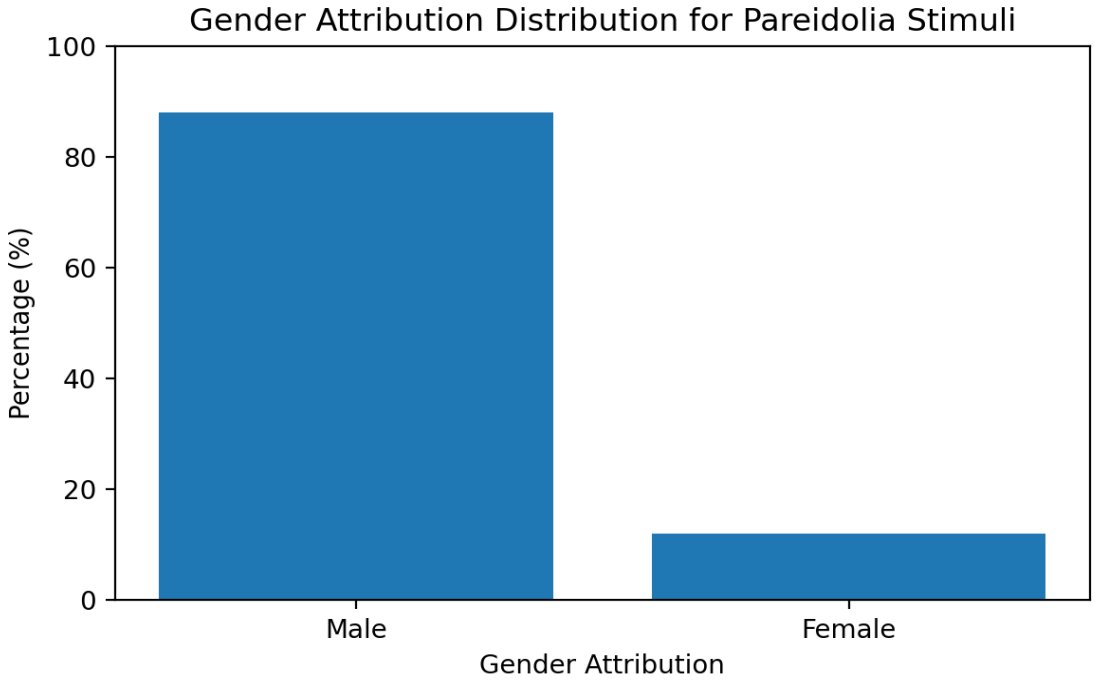


Figure 4. Gender attribution distribution for pareidolia stimuli The majority of ambiguous pareidolia faces were categorized as male (88%), while female attribution occurred in 12% of cases.

Note: Figures presented in this study were generated using AI-assisted visualization tools and subsequently reviewed and formatted by the author for scientific presentation.

RESULTS

The study included 11 healthy participants, consisting of 6 females and 5 males, as illustrated in Figure 1. This distribution was selected in order to provide a balanced representation of gender within the sample.

The experimental task consisted of a Digital Pareidolia Test (PT) including ten visual stimuli, comprising five pareidolia images and five scrambled control images, as shown in Figure 2.

A strong gender attribution bias was observed during the interpretation of pareidolia stimuli. The majority of ambiguous faces were categorized as male (88%), while female attribution occurred in only 12% of responses (Figure 4). These findings indicate a clear tendency toward masculine categorization when participants interpret ambiguous facial configurations.

Descriptive statistics of gender attribution responses and reaction times are presented in Table 1.

Reaction time analysis revealed a significant difference between female and male categorizations. Although female attributions were less frequent, they were processed considerably faster. The mean reaction time for female categorizations was 1.03 ± 0.42 seconds, whereas male categorizations required 2.98 ± 0.74 seconds.

Statistical analysis confirmed that the difference in reaction times between the two categories was highly significant ($p < 0.001$), as illustrated in Figure 3.

Overall, these findings demonstrate a dissociation between categorical bias and processing speed during gender attribution of pareidolia stimuli.

DISCUSSION

The findings of this study suggest that the human brain tends to rely on heuristic mechanisms when interpreting ambiguous facial stimuli. The predominance of male categorizations observed in this experiment indicates that, in the absence of distinctive feminine features, the perceptual system may default to a masculine interpretation.

At the same time, reaction time analysis revealed that female categorizations were processed significantly faster than male categorizations. One possible explanation is that distinctive facial cues associated with feminine features may facilitate faster perceptual recognition. Previous electrophysiological research has shown that the human brain is capable of extremely rapid face categorization processes, suggesting that facial feature detection can occur at very early stages of visual processing (Rossion and Caharel, 2011).

In addition, cognitive expectations and perceptual biases may also influence how ambiguous visual information is interpreted. Research in visual cognition suggests that prior expectations and attention mechanisms can shape perceptual decisions when sensory information is uncertain (Summerfield and Egner, 2009). Therefore, the observed gender attribution bias may reflect an interaction between perceptual processing and higher-level cognitive expectations.

Importantly, the results obtained from a healthy population indicate that such perceptual tendencies are likely part of the normal functioning of the human social perception system rather than a result of pathological processes.

CONCLUSION

This pilot study demonstrates that digital pareidolia assessment can be used as an effective tool to investigate implicit gender attribution biases in face perception. The results indicate a strong male-

default bias during interpretation of ambiguous facial stimuli, while female categorizations are associated with faster reaction times.

Although the sample size was limited, the observed differences in reaction times and categorical responses provide valuable baseline data for future research. Further studies involving larger participant groups and clinical populations may help clarify the neural mechanisms underlying social categorization during ambiguous face perception.

REFERENCES

Çamcı M, Akdeniz G, Demirci H, Demir Ünal E, Altuntaş N 2025. Gender perception of pareidolia faces in emergency department patients: The influence of physician gender. Frontiers in Human Neuroscience, 19: 1628840.

Liu J, Li J, Feng L, Li L, Tian J, Lee K 2014. Seeing Jesus in toast: Neural and behavioral correlates of face pareidolia. Cortex, 53: 60–77.

Wardle SG, Taubert J, Teichmann L, Baker CI 2020. Rapid and dynamic processing of face pareidolia in the human brain. Nature Communications, 11: 4518.

Rossion B, Caharel S 2011. ERP evidence for the speed of face categorization in the human brain. Journal of Vision, 11(2): 1–16.

Summerfield C, Egner T 2009. Expectation and attention in visual cognition. Trends in Cognitive Sciences, 13(9): 403–409.

STURGE-WEBER SYNDROME: A RARE CASE REPORT

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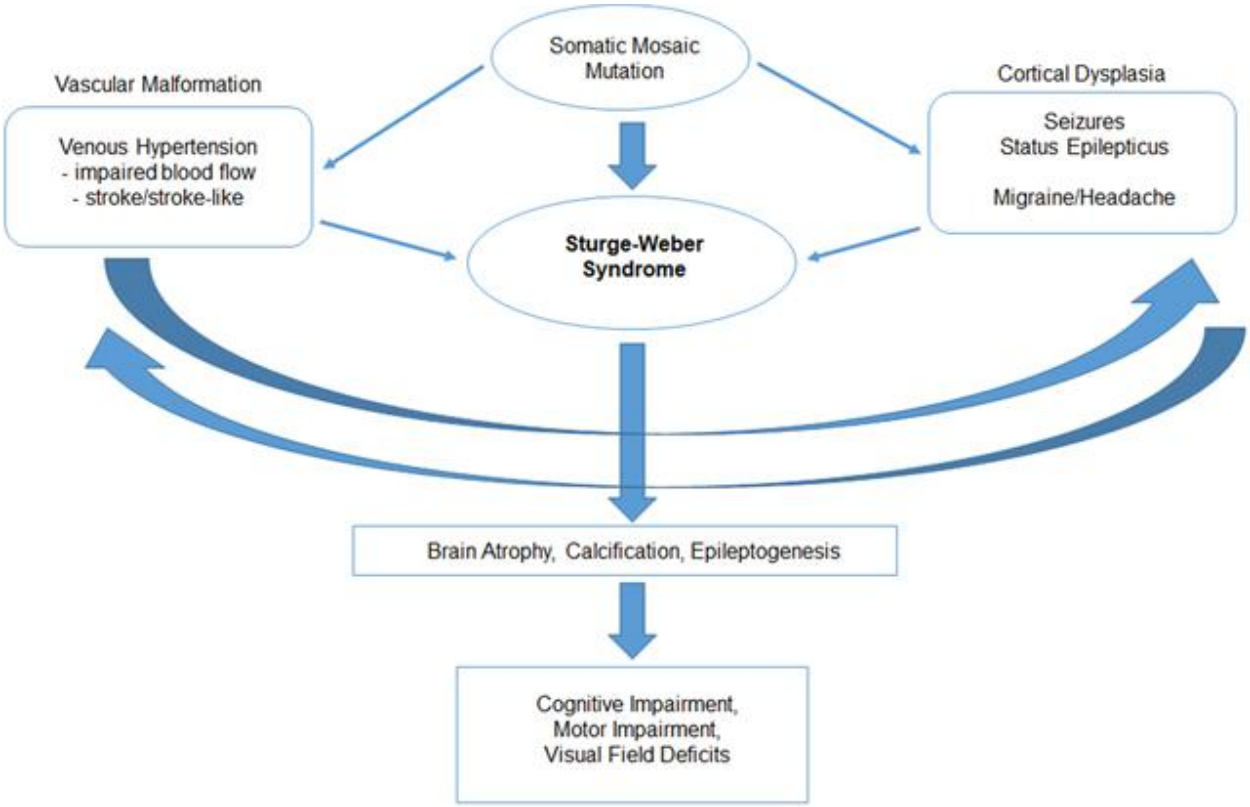
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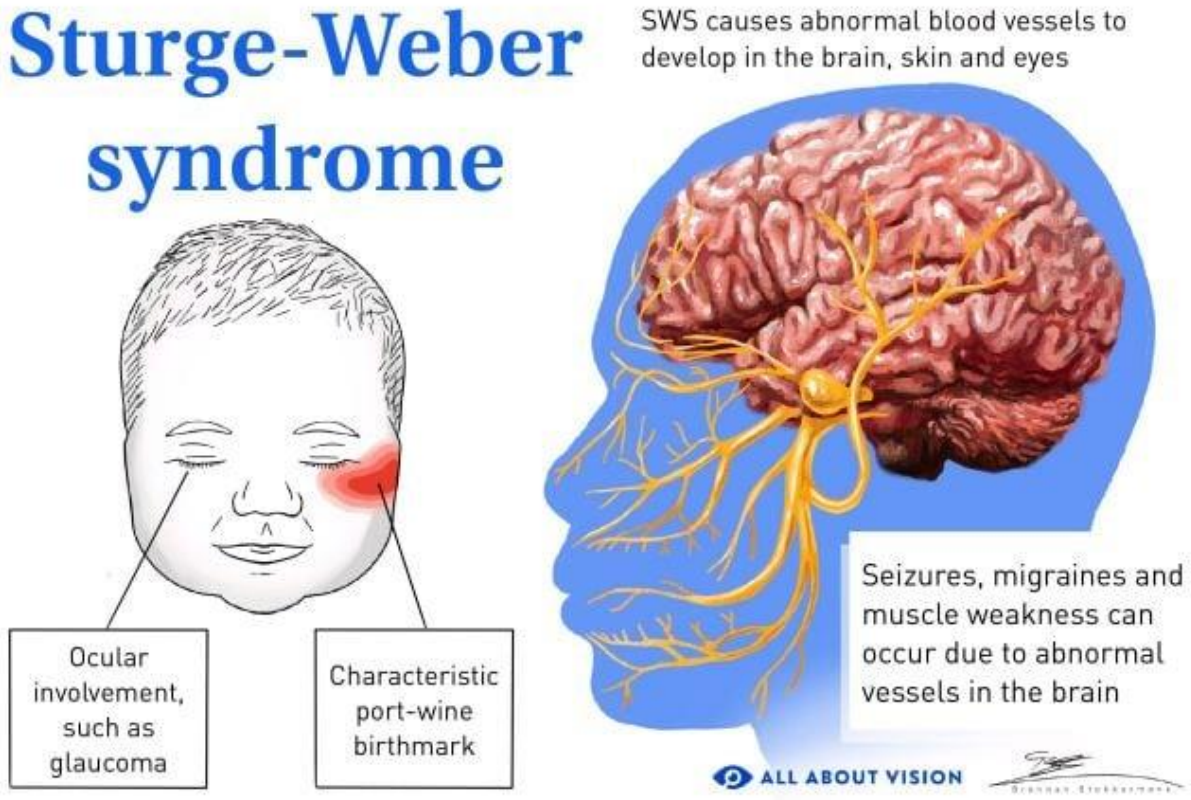
ABSTRACT

Introduction: Sturge-Weber syndrome (SWS) is a rare, congenital neurocutaneous disorder characterized by facial capillary malformation (port-wine stain), leptomeningeal angioma, and ocular abnormalities such as glaucoma. The clinical presentation and severity vary widely, often leading to challenges in diagnosis and management. It has been hypothesized that somatic mosaic mutations disrupting vascular development cause both the Sturge-Weber syndrome and port-wine stains, and the severity and extent of presentation are determined by the developmental time point at which the mutations occurred. Patients with SWS have impaired perfusion to the brain, and are at high risk of venous stroke and stroke-like episodes, seizures, and both motor and cognitive difficulties. While the activating R183Q GNAQ somatic mutation is the most common somatic mutation underlying SWS, recent research also implicates that GNA11 and GNB2 somatic mutations are related to SWS.

The prognosis of SWS with leptomeningeal angioma is related to the severity of neurological signs that are absent at birth and develop later in life (epilepsy, hemiparesis, and mental delay). Seizures are usually the presenting neurological symptom. Repetitive seizures are thought to increase the atrophy of brain tissue in regard to the leptomeningeal angioma. Preventive presymptomatic treatment with antiepileptic drugs is often recommended, and parents are trained to use rescue benzodiazepines in case of seizures. After epilepsy onset, in patients intractable to antiepileptic drugs, surgery should be considered.

Sturge-Weber syndrome is known to be caused by somatic mosaic mutation during fetal development. An R183Q GNAQ mutation is most common, and result in a congenital leptomeningeal vascular malformation and cortial dysgenesis. These abnormalities result in venous hypertension, impaired blood flow, seizures and stroke. In time, these pathologic processes produce brain atrophy, calcification, and can lead to cognitive impairment, motor impairment, and visual deficits.


Somatic Mosaic Mutation
Vascular Malformation
Venous Hypertension
- impaired blood flow
- stroke/stroke-like
Cortical Dysplasia
Seizures
Status Epilepticus
Migraine/Headache
Sturge-Weber Syndrome
Brain Atrophy, Calcification, Epileptogenesis
Cognitive Impairment,
Motor Impairment,
Visual Field Deficits


Sturge-Weber syndrome
SWS causes abnormal blood vessels to develop in the brain, skin and eyes
Ocular involvement, such as glaucoma
Characteristic port-wine birthmark
Seizures, migraines and muscle weakness can occur due to abnormal vessels in the brain
ALL ABOUT VISION

Epidemiology

SWS is rare and affects equally both sexes without racial bias. Although no good population-based data exist for prevalence of Sturge−Weber syndrome, it might be estimated to range between one in 20 000 to 50 000 live births. Facial port-wine stains occur in 3 per 1000 live births, only 10−20% of whom present with glaucoma or leptomeningeal angioma. When the angioma affects the trigeminal V1 area bilaterally, this risk increases up to 35%.

Clinical Presentation Presentation of skin involvement:

Sturge-Weber syndrome presents with a facial capillary malformation at birth, which indicates increased risk of SWS brain and eye involvement. Facial port-wine birthmark/capillary malformation in the forehead area, eyelid, or temple region is associated with high risk of SWS

(depending on the size, location and extent of skin involvement). While SWS skin involvement typically is located on the upper face, location, extent, and color of PWB can be highly variable. The size and location of PWB in combination with brain MRI images can be helpful in predicting the severity of neurological dysfunction

Presentation of eye involvement: Glaucoma is the most common ocular complication in patients with SWS, with a 30–70% prevalence rate in patients with both upper and lower eyelid birthmark involvement. Glaucoma (eye damage due to increased intraocular pressure) can develop at any time, with the most common periods being in infancy and in young adulthood Patients develop glaucoma in early infancy in 60% of the cases, while 40% of the patients show later onset. In SWS patients, open-angle glaucoma is the most common form of glaucoma. Symptoms of open-angle glaucoma can include vision loss, development of dilated conjunctival vessels, eye pain, excessive tearing and, in infants, eye enlargement (buphthalmos)

Untreated, glaucoma can threaten vision by causing ischemic injury to the optic nerve

Presentation, and Symptoms of brain involvement: Patients with SWS brain involvement most commonly present with seizures in infancy. Most often, these patients will present with focal motor seizures. More rarely the seizures can present with infantile spasms or myoclonic epilepsy. Status epilepticus is frequently associated with stroke-like episodes, particularly in young patients . Seizures occur in 75% of patients with unilateral brain involvement and in 95% of those with bilateral brain involvement.

The diagnosis

Key Diagnostic Methods

- Imaging: MRI of the brain with gadolinium contrast is the preferred, most accurate method to detect vascular malformations, brain atrophy, and calcifications. A CT scan may be used if MRI is unavailable to detect "tram-track" calcifications.
- Clinical Exam: Evaluation of the characteristic port-wine stain (especially on the forehead/eyelid) and neurological assessment for seizures, weakness, or developmental delays.
- Ophthalmologic Exam: Crucial to check for elevated eye pressure (glaucoma) or structural eye changes.
- EEG: Used to monitor brain wave activity and check for epilepsy

Sturge-Weber syndrome brain involvement is marked by a leptomeningeal vascular malformation on contrast enhanced MRI images (Figure 2, Panels A-B) Dilated deep draining vessels underlying

the affected cortical region and enhancement of the choroid plexus on the involved side are also often present in older children and adults. Cortical and subcortical calcifications can be diagnosed with non-contrast head CT (Figure 2, Panel C) or sometimes on MRI. Because presymptomatic diagnosis of SWS brain involvement on brain MRI has low sensitivity in the newborn period, an early negative contrast enhanced MRI image does not exclude the possibility of SWS brain involvement for infants. However, a normal neurologic exam, no history of seizure onset, and a negative MRI image with contrast after a year of age generally excludes SWS brain involvement. Over time, patients frequently acquire brain atrophy, calcification, loss of white matter, and impaired perfusion of the affected region.

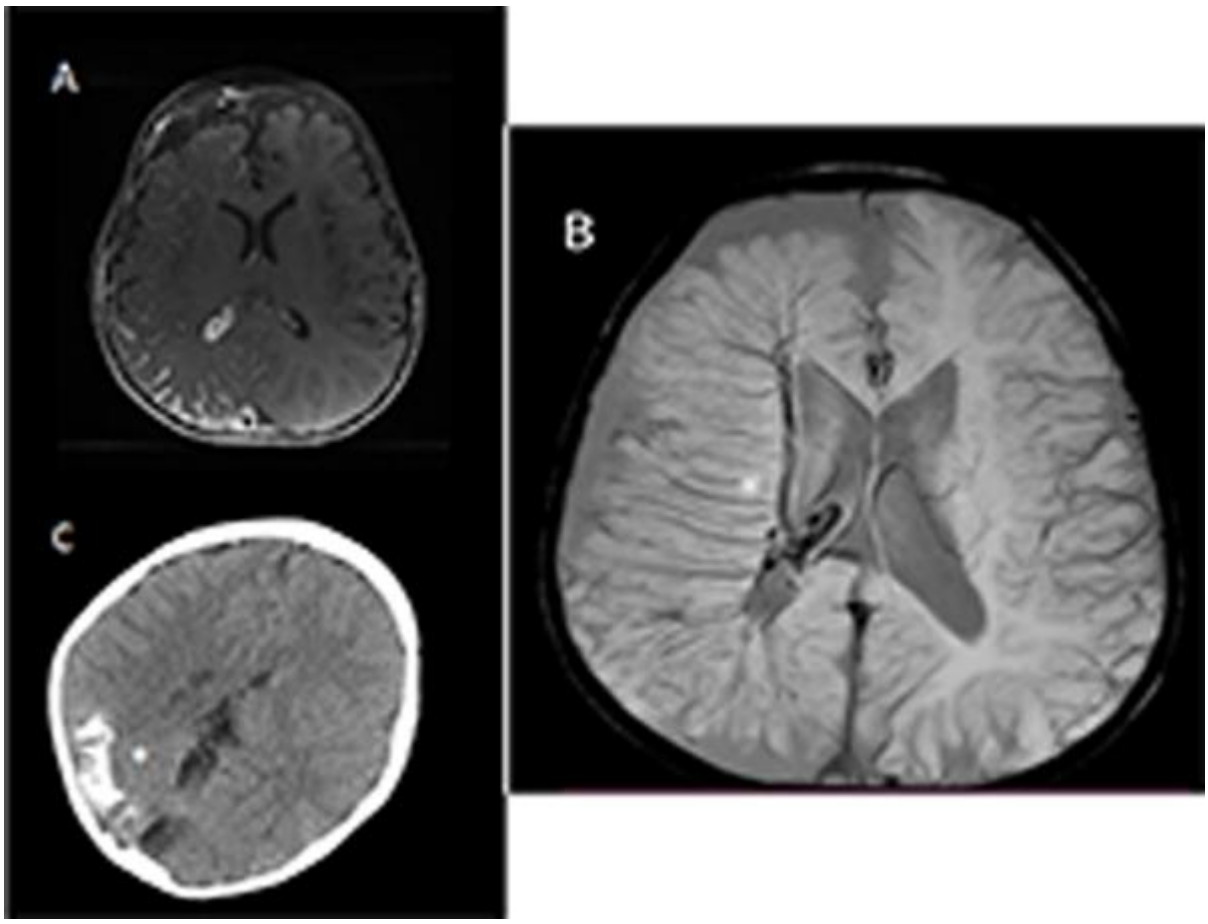


Figure 2: Neuroimaging in 3 patients with Sturge-Weber syndrome. Stars indicate affected areas. A: Axial T1 post-contrast image showing leptomeningeal enhancement over the right hemisphere. B: Susceptibility weighted imaging (SWI) of another patient showing greatly dilated deep draining vessels draining to the deep venous system. C: Head CT, non-contrast, from another patient showing calcification in affected areas

Seizures and Drug-Resistant Epilepsy

Epilepsy is the most common and debilitating neurological feature in patients with SWS. Most patients present with seizures within the first year of life, with the median age of onset around 6 months. The predominant seizure types described are focal onset seizures, especially focal motor clonic seizures. Focal seizures often occur in clusters and may progress to focal status epilepticus.

Electroencephalographic (EEG) findings in patients with focal onset seizures often show background asymmetry and focal slowing and/or voltage attenuation on the affected hemisphere, preserved organization and sleep architecture on the unaffected side, and seizure onset from the affected regions of the brain (Figure 1A–C). The focal seizures arise from the affected hemisphere (Figure 1) and can be electrographic-only or electroclinical. Other seizure types seen in SWS are infantile spasms, myoclonic seizures, absence seizures, and atonic seizures. The severity of epilepsy has been associated with the extent of the leptomeningeal enhancement, with bilateral and hemispheric cases showing earlier and more refractory epilepsy.

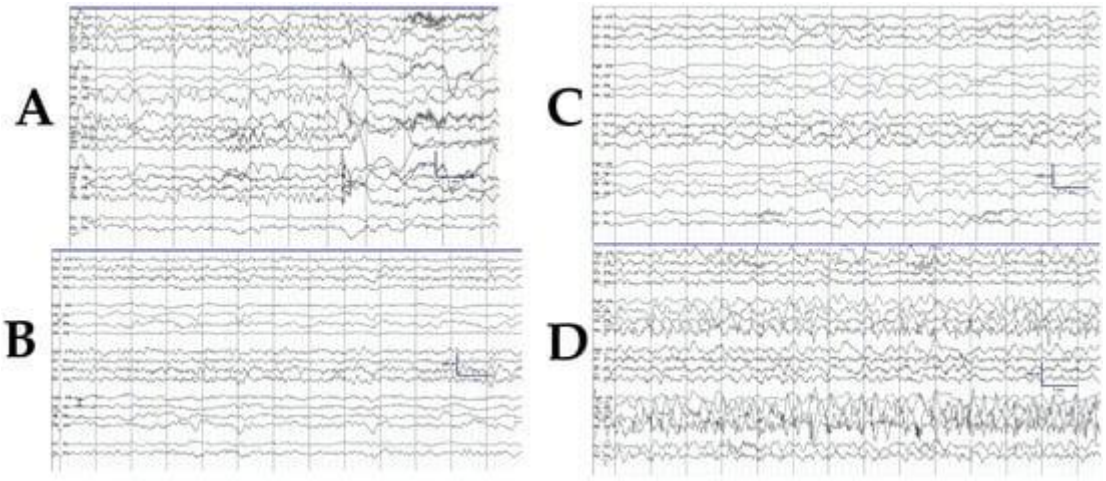


Figure 1. (A) Bipolar longitudinal montage of a 16-month-old patient with SWS demonstrating marked asymmetry with slowing attenuation on R. (B) Bipolar longitudinal montage of a 16-month-old with SWS demonstrating marked asymmetry with slowing attenuation on R. (C) Bipolar longitudinal montage of a 16-month-old with SWS in sleep, demonstrating preserved sleep spindles on the left. (D) Average referential montage of a 16-month-old showing seizure onset at P4 (right posterior region)

Treatment:

Sturge–Weber syndrome is symptomatic. Laser treatment may be used to lighten or remove the birthmark. Anticonvulsant medications may be used to control seizures. Doctors recommend early monitoring for glaucoma, and surgery may be performed on more serious cases. When one side of the brain is affected and anticonvulsants prove ineffective, the standard treatment is neurosurgery to remove or disconnect the affected part of the brain (hemispherectomy). Physical therapy should be considered for infants and children with muscle weakness. Educational therapy is often prescribed for those with intellectual disability or developmental delays

According to a multicenter cross-sectional questionnaire, levetiracetam, oxcarbazepine, and low-dose aspirin were the most frequently used medications. Forty-eight percent of patients reported being on levetiracetam, 45% of patients were on low-dose aspirin, and 40% reported being on oxcarbazepine. It is recommended low-dose aspirin for almost all young patients under 3 years of age who have 3 or more lobes of brain involvement; it may be recommended to older or less severely involved patients who are having issues with uncontrolled seizures, stroke-like episodes, or focal neurologic deficits. Use of low dose aspirin is growing internationally in patients with SWS, particularly in centers who see larger numbers of these patient; a recent multi-centered study indicated that aspirin use is common.

Complications	Treatment (1st choice)	Treatment (2nd choice)
Glaucoma	Beta blocker drops	Adrenergic drops
Partial epilepsy	Carbamazepine	Valproate, topiramate
Headache	Ibuprofen	Sumatriptan
Stroke-like episodes	Aspirin	None
Neurobehavior	Methylphenidate	Clonidine

Newer Therapies:

-Cannabidiol (CBD)

There is a growing body of literature on potential benefits in the management of epilepsy and seizure disorders shown in mouse models. CBD can potentially attenuate seizure activity by inhibiting a G Protein-coupled Receptor (GPR55). In human studies, CBD has been approved for the treatment of seizures in Lennox–Gastaut syndrome and Dravet syndrome, and its use is now being expanded in other seizure disorders, including SWS. Limited data from two small cohort studies suggest that CBD use was associated with reduced seizure activity, improved cognitive function, speech and communication, physical capability, and noticeable improvement in SWS Neuroscore and patient-reported

-mTOR Inhibitors

The mTOR pathway controls the expression of VEGF (Vascular Endothelial Growth Factor), and VEGF controls angiogenesis (growth of blood vessels). The mTOR pathway undergoes hyperactivity in Sturge–Weber patients, so it is theorized that using mTOR Inhibitors will stop this hyperactivity and abnormal blood vessel development. A recent open-label prospective study with ten subjects with SWS using oral sirolimus for 6 months showed improvement in QoL, cognitive function, and processing speed. In addition to this cognitive improvement, Sirolimus therapy also controlled epileptic symptoms in drug-resistant epilepsy . There were also improvements related to the cutaneous symptoms with reduced PW pigmentation, improved appearance of facial hemihypertrophy, and decreased soft tissue overgrowth. Although these early results are promising, these studies have been conducted on very small SWS cohort sizes, and further studies are needed to evaluate the use of mTOR inhibitors in SWS patients.

My Case Presentation: We report the case of a 11-year-old girl presenting in emergency department with a bilateral facial port-wine stain involving the ophthalmic branch of the trigeminal nerve, recurrent focal seizures, and developmental delay. Magnetic resonance imaging (MRI) with contrast revealed leptomeningeal angiomas and cortical atrophy on the left occipital region, consistent with Sturge-Weber syndrome. Ophthalmologic examination did confirm increased intraocular pressure, suggesting early-stage glaucoma. Diagnose was confirmed in France by Genetic testing (Somatic mutation in GNAQ gene). The patient was managed with anticonvulsant

therapy and topical antiglaucoma medication, with regular neurological and ophthalmologic follow-up. She is going well with her follow-up exams. The neurologist is considering to stop the anti-epileptic medications cause she has responded very well to the medications. She goes normally to school. Sometimes she comes to emergency department for simple virosis or bacterial infections.

My patient History:

The child was born at term after an uncomplicated pregnancy. At birth, a port-wine stain was noted over both left and right side of the face, involving the forehead and upper eyelid.

At the age of 6 months, the patient developed focal seizures affecting the right side of the body. The frequency of seizures increased over time despite initial treatment.

No significant family history of neurological disorders was reported.

Clinical Examination

Physical examination revealed:

A bilateral facial port-wine stain involving the ophthalmic branch of the trigeminal nerve

Developmental delay compared to age-matched peers

Ophthalmologic examination demonstrated increased intraocular pressure suggestive of glaucoma.

Diagnostic Workup

Neuroimaging

Magnetic resonance imaging (MRI) of the brain showed:

Leptomeningeal enhancement in the left parieto-occipital region

Cortical atrophy

Abnormal venous vascular structures

These findings were consistent with leptomeningeal angiomas, a key diagnostic feature of Sturge–Weber syndrome.

Electroencephalography (EEG)

EEG demonstrated epileptiform activity over the left hemisphere.

Ophthalmologic Evaluation

Tonometry confirmed elevated intraocular pressure, consistent with glaucoma.

Diagnosis

Based on the clinical presentation and imaging findings, the patient was diagnosed with Type I Sturge–Weber syndrome, characterized by:

Facial angioma

Leptomeningeal angioma

Ocular involvement

Management

Seizure Management

The patient was started on antiepileptic therapy with:

Levetiracetam

Seizure frequency decreased significantly after treatment.

Ophthalmologic Management

Glaucoma was treated with topical medications including:

Timolol eye drops.

Regular ophthalmologic follow-up was recommended.

Laser Therapy

Dermatologic evaluation suggested treatment of the facial vascular malformation using pulsed dye laser therapy, which may improve cosmetic appearance.

Rehabilitation

The patient was enrolled in:

Physical therapy

Developmental support program









Discussion

Sturge–Weber syndrome is caused by a somatic activating mutation in the GNAQ gene, which leads to abnormal vascular development. The condition typically affects the brain, skin, and eyes.

Seizures are the most common neurological manifestation and occur in approximately 75–90% of patients. Early onset seizures are associated with a higher risk of cognitive impairment.

Neuroimaging, particularly MRI with contrast, plays a crucial role in diagnosis by identifying leptomeningeal angiomas and cortical abnormalities.

Management is largely symptomatic and requires a multidisciplinary approach, including neurologists, ophthalmologists, dermatologists, and rehabilitation specialists.

In severe cases with refractory epilepsy, surgical interventions such as hemispherectomy may be considered.

Conclusions

Early diagnosis and coordinated care are critical in managing Sturge-Weber syndrome to minimize neurological and ocular complications and to optimize developmental outcomes. Because of the often progressive and potentially devastating nature of the disease, patients are encouraged to continuously follow with a team of specialists based on each patient's symptoms. While R183Q GNAQ mutation is widely considered to be the SWS gene mutation, recent research suggests that GNA11 and GNB2 (p.Lys78Glu) somatic mutations are also associated with SWS. Further research is needed to improve the understanding the underlying genetic pathology behind SWS, the natural history from longitudinal studies, and both biomarker and outcome development. New advances are reported in care for patients with SWS. Low dose aspirin is utilized by several, but not all centers, and data suggests that it may reduce both stroke-like episodes and seizure symptoms. Drug trials for Sirolimus and cannabidiol have indicated improvements in cognition and seizure frequency respectively. Presymptomatic treatment with low-dose aspirin and low-dose anti-epileptic drugs may delay early seizure onset. Future research focusing on multi-centered drug trials and genetic models will bring significant advances in patient care and our understanding of Sturge-Weber syndrome.

Key Words: Sturge–Weber syndrome, nevus flammeus, epilepsy, glaucoma

References:

https://pubmed.ncbi.nlm.nih.gov/36263782/

https://pubmed.ncbi.nlm.nih.gov/28126187/

https://pubmed.ncbi.nlm.nih.gov/23656586/

https://pubmed.ncbi.nlm.nih.gov/10870197/

https://www.medicoebambino.com/index.php?id=PSR1508_10.html

https://pmc.ncbi.nlm.nih.gov/articles/PMC11062639/pdf/nihms-1835989.pdf

https://www.ahajournals.org/doi/10.1161/STROKEAHA.122.038585?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%20%200pubmed

https://www.mdpi.com/2077-0383/14/7/2182

AI-POWERED FORMATIVE ASSESSMENT AND REAL-TIME FEEDBACK MECHANISMS

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ABSTRACT

The penetration of artificial intelligence into formative assessment practices is fundamentally changing the logic of feedback in education: instead of delayed, averaged comments from a teacher, students receive immediate, personalized information about the quality of their responses and areas for improvement. This article systematizes AI tools for formative assessment — automated essay grading systems, adaptive problem books with dialog prompts, intelligent tutoring systems, and real-time class monitoring platforms. Based on leading theoretical models of feedback (Hattie & Timperley, 2007; Shute, 2008) and meta-analytic data, the key characteristics of effective AI feedback are described. A typology of feedback formats is considered in relation to various educational tasks and student types. The risks of algorithmic genericity, hyperdependency, and underestimation of cultural context are identified, and a hybrid model is proposed that combines the speed of AI with the pedagogical interpretative depth.

Keywords: formative assessment; artificial intelligence; real-time feedback; automatic grading; adaptive learning; educational technologies.

INTRODUCTION

Formative assessment — assessment conducted during the educational process to adjust teaching and learning — is traditionally considered one of the most powerful tools for improving educational outcomes. A large review by Black & Wiliam (1998), covering over 250 studies, found effect sizes ranging from 0.4 to 0.7 — a level exceeding most other pedagogical interventions. The key mechanism for this effect is feedback: information the student receives about their current state of understanding and the direction of progress toward a goal.

However, traditional formative assessment faces a structural limitation: it is resource intensive. A teacher leading several groups of 25–30 students is physically unable to provide timely, comprehensive, and personalized feedback to each student on each assignment. This is where artificial intelligence technologies offer a fundamentally new solution: scalable, immediate, and differentiated formative assessment, not limited by the time resources of a single person.

Over the past decade, the ecosystem of AI tools for formative assessment has expanded significantly, including automated writing assessment systems (AES), adaptive assignment platforms based on Bayesian knowledge networks, dialogue systems powered by large-scale language models, and real-time classroom monitoring tools. All these technologies share a common pedagogical goal: transforming assessment from a final "verdict" into an ongoing, guiding dialogue between the student and the system, with the teacher playing a supportive role.

The purpose of this article is to offer an integrative analysis of AI-enhanced formative assessment: to characterize its theoretical foundations, systematize the toolkit, summarize empirical data on effectiveness, describe the typology of feedback formats, and determine the conditions for successful implementation in educational practice.

THEORETICAL FOUNDATIONS

Feedback models in pedagogy

The theoretical foundation of AI-enhanced formative assessment is based on several complementary conceptual models. Hattie & Timperley's (2007) model structures feedback through three questions: "Where am I going?" (goals), "How am I doing?" (progress), and "What's next?" (next steps). The authors demonstrate that feedback produces its most powerful effects at the process and self-regulation levels — precisely where AI systems implementing metacognitive prompts and reflective inquiry have the greatest potential.

A comprehensive review by Shute (2008) introduces the concept of elaborate feedback—feedback that conveys not just "true/false" but also explains why the answer is wrong and suggests strategies for correction. Shute establishes that immediate feedback is superior to delayed feedback in procedural tasks, while in conceptual learning, a moderate delay can be beneficial because it encourages independent reflection on the error. This distinction is critical for the design of AI systems: an algorithm must be able to vary the type and timing of feedback depending on the nature of the task.

The ITF (Interactive Tutoring Feedback) model by Narciss (2008) describes feedback as a multi-layered instructional activity, defined jointly by five dimensions: feedback conditions, content, functions (cognitive, metacognitive, motivational), timing of delivery, and presentation format. This model provides a comprehensive design framework for AI systems: each of the five dimensions can potentially be algorithmically adapted to the individual learner.

Formative assessment and self-directed learning

The connection between formative assessment and self-regulated learning (SRL) is another key theoretical framework. Zimmerman's (2002) SRL model identifies three phases: pre-planning, execution, and self-reflection. Effective feedback initiates and maintains a self-reflection cycle, allowing learners to compare current performance with a benchmark, attribute discrepancies to modifiable factors (effort, strategy), and set adjusted goals.

AI systems that integrate reflective elements — such as prompting the learner to independently evaluate their answer before receiving feedback, error logs, and personalized goals for the next attempt—directly support the self-reflection phase of SRL. Research shows that this combination

of automated feedback and metacognitive support produces more sustainable effects on long-term learning than the use of either component alone.

Table 1. Comparison of traditional and AI-enhanced formative assessment

Parameter	Traditional assessment	AI-enhanced formative assessment
Timeliness of feedback	Deferred (days-weeks)	Immediate (seconds–minutes)
Student Outreach	Limited by the teacher's resources	Scalable to the entire class/course
Message specificity	General comments	Targeted error diagnostics
Differentiation	Uniform criteria for all	Adaptation to the learner's level and style
Metacognitive support	Occasional, depends on the teacher	Systemic: reflection, goal setting
Progress analytics	Retrospective, portfolio	Predictive, real-time

Note: Compiled by the authors based on: Black & Wiliam (1998); Hattie & Timperley (2007); Shute (2008).

AI TOOLS FOR FORMATIVE ASSESSMENT

Automatic evaluation systems for written assignments (AES)

Automatic grading of essays and written assignments is one of the most advanced branches of AI assessment. Modern AES (Automated Essay Scoring) systems use natural language processing methods to analyze argument structure, cohesion, lexical complexity, and syntactic diversity. Turnitin Feedback Studio, integrated into most major LMSs, provides not only plagiarism detection but also the marking of essay structural weaknesses by rubric, links to relevant resources, and citation evaluation.

A fundamental limitation of AES remains its assessment of content depth and critical thinking. Research shows that systems trained on highly rated texts can systematically reward verbosity and superficial coherence at the expense of conceptual originality. This requires regular auditing of the algorithms and mandatory teacher involvement in the final evaluation of open-ended assignments.

Adaptive task books and conversational AI assistants

Platforms based on Bayesian knowledge networks (ALEKS, Knewton) build a dynamic probabilistic model of student mastery of each concept and offer the next task at the point where the probability of success is within a pedagogically optimal range — high enough to maintain motivation, but not trivial enough to ensure cognitive effort. Feedback in these systems is implemented as a personalized sequence of prompts, increasing in explicitness: from a general instruction ("Think about the sign when opening parentheses") to a specific error correction.

The advent of conversational AI assistants based on large-scale language models (GPT-4, Claude) has opened up the possibility of Socratic dialogue as a feedback format: the assistant does not provide the correct answer but asks guiding questions that encourage the learner to independently discover the contradiction in their own reasoning. This is consistent with Shute's (2008) recommendation to prioritize feedback that activates metacognitive processes over simple verification of the answer.

Table 2. AI tools for formative assessment: functionality and feedback mechanisms

Tool	AI type	Feedback mechanism	Scope of application
Turnitin Feedback Studio	NLP + AES	Heading marking, argument analysis, stylistics	Academic writing, essay
Gradescope	Machine learning	Error grouping, annotations, regression estimation	STEM, tasks, tests
Khan Academy Khanmigo	GPT-4 (LLM)	Dialogue prompts, Socratic method	Mathematics, science K–12
Formative (GoFormative)	Adaptive algorithms	Live responses, class monitoring, autoscoring	Any subjects, K-12, universities
ALEX (McGraw-Hill)	Bayesian knowledge networks	Gap diagnostics, adaptive tasks	Mathematics, chemistry, statistics
Duolingo (DL Max)	Reinforcement Learning	Instant error analysis, repetition strategy	Language courses

Note. AES - automated essay scoring; KR - knowledge of result; LMS - learning management system.

EMPIRICAL EVIDENCE ON EFFECTIVENESS

The evidence base for the effectiveness of formative assessment and feedback in general is among the most robust in educational science. Table 3 presents the key studies on which this analysis is based.

Table 3. Key empirical findings on the effectiveness of formative feedback

Study	Design / context	Measurable indicator	Key result
Hattie & Timperley (2007). Review of Educational Research, 77(1)	Meta-analysis, literature synthesis	The Impact of Feedback on Academic Performance	d = 0.79; the effect depends on the type and level of OS
Shute (2008). Review of Educational Research, 78(1)	Review of 256 sources	OS type and time vs. training	Immediate OS > delayed OS in procedural tasks
Black & Wiliam (1998). Phi Delta Kappan, 80(2)	A review of 250 studies	Formative assessment vs. academic performance	Effect d = 0.4–0.7; special contribution for weak students
Narcissus (2008). Handbook of Research on Ed. Comm. & Technology	Theoretical review + empirical data	The effectiveness of ITF strategies	Elaborated feedback > KCR for complex tasks
Van der Kleij et al. (2015). Review of Educational Research, 85(4)	Meta-analysis of 40 computer OS studies	Computer OS type vs. training	Elaborated feedback: d = 0.49; KR: d = 0.05

Note: KR — knowledge of results; KCR — knowledge of correct response; ITF — interactive tutoring feedback; d/g — standardized effect size.

A meta-analysis by Hattie & Timperley (2007) found that feedback is one of the most powerful influences on academic performance (average d = 0.79 across 196 studies), but with high variability: the effect depends on the level of feedback addressed. Task- and process-level feedback produces significantly more robust effects than student-level feedback ("smart" / "you made a mistake"). This finding has direct implications for the design of AI systems: the algorithm should formulate messages in the language of the task and strategy, avoiding evaluative judgments about personality or ability.

A meta-analysis by Van der Kleij et al. (2015), focusing specifically on computerized feedback (40 studies, 188 comparisons), found a clear superiority of elaborate feedback over simple knowledge of the outcome: d = 0.49 vs. d = 0.05, respectively. This means that an AI system that only reports "true/false" is significantly inferior in pedagogical value to a system that explains the nature of the error and suggests a correction strategy. For developers of educational AI tools, this is a critical guideline when designing feedback algorithms.

TYPOLOGY OF AI FEEDBACK FORMATS

The typology of feedback formats developed in this article is based on a synthesis of the classifications of Shute (2008), Narciss (2008) and Van der Kleij et al. (2015), adapted to the modern capabilities of AI systems.

Table 4. Typology of feedback formats in AI-based formative assessment systems

Feedback type	Description	Optimal audience	Implementation in AI systems
KR (Knowledge of Result)	True/False without explanation	Simple facts, closed questions	Auto-scoring tests (Formative, Quizlet)
KCR (Knowledge of Correct Response)	Indicating the correct answer	Initial stages of training	ALEKS, adaptive platforms
Elaborated Feedback	Explanation of why the answer is true/false; hints	All levels, especially complex concepts	Khanmigo (GPT-4), Carnegie Learning
Worked Example Feedback	Step-by-step solution of the reference example	STEM, procedural tasks	Gradescope, ITS systems
Metacognitive Feedback	Reflection on strategies: “How did you solve it?”	Advanced students, independent work	LLM assistants with reflexive prompts

Note. KR - knowledge of results; KCR - knowledge of correct response; LLM - large language model.

A key design principle arising from the presented typology is matching the feedback format to the cognitive demands of the task and the learner's level. For algorithmic and procedural tasks with a clear correct answer (solving equations, grammatical forms, factual questions), immediate KR/KCR feedback is sufficient and effective. For analytical, creative, and evaluative tasks, a transition to elaborate feedback or a metacognitive format is necessary — this is where conversational AI assistants based on LLM demonstrate the greatest pedagogical potential.

Visual feedback — color-coding strengths and weaknesses in written work, progress charts, and competency profile diagrams — is particularly effective for students with visual processing styles and in contexts where immediate comparison with a benchmark is critical (e.g., lab reports in STEM subjects).

RISKS, LIMITATIONS AND ETHICAL ASPECTS

Algorithmic Genericity and Hyperdependence

One of the most common flaws in AI feedback is genericity: the system reproduces standard comment templates without taking into account the specifics of a student's specific error. This occurs when the algorithm operates at too high a level of ABSTRACTion, classifying an error as "argumentative" without analyzing the specific logical flaws. Pedagogically, such feedback is inferior even to a brief, live comment from a teacher.

Overreliance on AI assessment poses a different kind of structural risk: students who systematically receive immediate feedback may lose the ability to independently assess the quality of their work. Research in the field of SRL indicates that developing internal quality standards — the foundation of academic autonomy—requires practice without external feedback. A pedagogically sound solution is to periodically include "feedback pauses" during which students first independently assess their work and then compare it with the algorithmic assessment.

Cultural context and fairness of assessment

AI grading systems trained primarily on English-language Western academic texts exhibit systematic bias when assessing the work of students with different linguistic and cultural backgrounds. Rhetorical conventions, argumentation structures, and discourse markers vary significantly across cultures — and an algorithm unaware of this diversity may interpret a culture-specific style as an error. For the Kazakhstani context, this necessitates including Kazakh and Russian academic texts in the training data of AES systems, as well as regularly auditing the algorithms for differential performance.

HYBRID MODEL: AI + TEACHER

The synthesis of theoretical foundations, empirical evidence, and risk analysis leads to the central thesis of this article: the optimal model of formative assessment is hybrid — it combines the speed and scalability of AI with the pedagogical interpretative depth of a human teacher.

The hybrid model's division of functions involves AI performing real-time monitoring, initial error classification, automated KR/KCR feedback, risk zone diagnostics, and preliminary analysis of written assignments. The teacher focuses on interpreting the patterns identified by the algorithm, addressing conceptual misconceptions that defy algorithmic description, providing emotional support to students during difficult moments, and ultimately evaluating the open, creative, and affective aspects of the work.

This model is technically implemented through the integration of AI tools into an LMS with pedagogical analytics functionality: the teacher receives an aggregated dashboard with class error patterns and flags for specific students requiring attention and makes pedagogically sound decisions about organizing the next lesson based on this data. This model is implemented in Gradescope and GoFormative, where the teacher sees the distribution of class responses in real time and can immediately begin analyzing the most common error.

Pilot programs in urban schools that implemented a similar hybrid model, along with teacher training in AI analytics, recorded a 20% increase in student review rates compared to control groups—a result that demonstrates the development of students' independent assessment skills.

CONCLUSION

AI-enhanced formative assessment represents one of the most pedagogically sound applications of artificial intelligence in education: it addresses a real structural problem — the resource deficit of personalized feedback — and is based on a solid empirical base of research in pedagogy and cognitive psychology.

A review of theoretical models (Hattie & Timperley, 2007; Shute, 2008; Narciss, 2008) and meta-analytic data (Black & Wiliam, 1998; Van der Kleij et al., 2015) demonstrates that to achieve significant educational effects, AI feedback must not only be “immediate” but also comprehensive, task- and process-specific, differentiated by the type of learning situation, and culturally valid. This places high demands on the design of algorithms and on the pedagogical competence of users.

Promising research areas include studying the long-term effects of AI feedback on metacognitive development; developing culturally adapted AES systems for the multilingual educational contexts of Central Asia; and comparative studies of the hybrid model across various subject areas and levels of education. Implementing these objectives will enable a shift from the "trust" of AI assessment to evidence-based practice, in which technology serves pedagogy rather than displacing it.

BIBLIOGRAPHY

1. Black, P., & Wiliam, D. (1998). Inside the black box: Raising standards through classroom assessment. Phi Delta Kappan, 80(2), 139–148.

2. Hattie, J., & Timperley, H. (2007). The power of feedback. Review of Educational Research, 77(1), 81–112. https://doi.org/10.3102/003465430298487

3. Narciss, S. (2008). Feedback strategies for interactive learning tasks. In J. M. Spector, M. D. Merrill, J. J. G. van Merriënboer, & M. P. Driscoll (Eds.), Handbook of Research on Educational Communications and Technology (3rd ed., pp. 125–144). Lawrence Erlbaum Associates.

4. Shute, V. J. (2008). Focus on formative feedback. Review of Educational Research, 78(1), 153–189. https://doi.org/10.3102/0034654307313795

5. Van der Kleij, F. M., Feskens, R. C. W., & Eggen, T. J. H. M. (2015). Effects of feedback in a computer-based learning environment on students' learning outcomes: A meta-analysis. Review of Educational Research, 85(4), 475–511. https://doi.org/10.3102/0034654314564881

6. Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. Studies in Higher Education, 31(2), 199–218. https://doi.org/10.1080/03075070600572090

7. Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. Theory into Practice, 41(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2

8. Sadler, D. R. (1989). Formative assessment and the design of instructional systems. Instructional Science, 18(2), 119–144. https://doi.org/10.1007/BF00117714

9. Corbett, A. T., & Anderson, J. R. (2001). Locus of feedback control in computer-based tutoring: Impact on learning rate, achievement and attitudes. In Proceedings of ACM CHI'2001 Conference on Human Factors in Computing Systems (pp. 245–252). ACM Press.

10. Wiliam, D. (2011). Embedded Formative Assessment. Bloomington, IN: Solution Tree Press.

AI-ENHANCED PEDAGOGICAL APPROACHES IN MODERN EDUCATION

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ABSTRACT

The integration of artificial intelligence (AI) into education marks a fundamental shift in pedagogy, combining personalized learning paths with improved teaching quality. This paper explores AI-focused pedagogical strategies and the real-world barriers to their implementation in universities, schools, and online environments. Intelligent mentoring systems, adaptive real-time platforms, and automated assessment tools are analyzed. Based on case studies from higher education and K-12 digitalization practices, key success factors are identified: teacher openness to new technologies, reliable infrastructure, and student digital literacy. The need for a balance between algorithmic efficiency and preserving human interaction is emphasized. Risks include algorithmic bias, the vulnerability of personal data, and the widening of the digital divide.

Keywords: artificial intelligence, pedagogical approaches, adaptive learning, educational technology, personalized instruction, intelligent tutoring systems.

INTRODUCTION

Over the past decade, the rapid development of artificial intelligence technologies has radically transformed virtually every sector of socio-economic life, and the education system is no exception. Education, historically based on the "teacher-knowledge-student" model, is undergoing a profound structural restructuring: frontal lectures are being replaced by personalized adaptive environments, and teachers are being transformed from the sole source of knowledge into facilitators of the learning process.

According to Grand View Research (2024), the global AI in education market has reached $5.57 billion and is expected to grow at a compound annual growth rate (CAGR) of approximately 36.0% through 2030. This rapid growth is driven by the simultaneous demands of several actors: governments seeking to improve the competitiveness of their education systems; universities seeking ways to reduce dropout rates; and students expecting a flexible, personalized experience.

At the same time, the euphoria of implementation often outpaces methodological reflection. The teaching community is asking fundamental questions: To what extent is automation compatible

with the development of critical thinking? How can assessment algorithms reproduce or reinforce social inequalities? This article seeks to provide a comprehensive answer to these questions, examining AI tools through the prism of pedagogical theory, empirical data, and ethical constraints.

The aim of this work is to systematize modern AI-enhanced pedagogical approaches, characterize the conditions for their effective implementation, and outline mechanisms for preserving the “human core” of education in the era of algorithmization.

THEORETICAL FOUNDATIONS

Pedagogical theories in the context of digital transformation

AI-enhanced learning does not arise in a theoretical vacuum: it draws on several competing and complementary pedagogical traditions. Piaget and Vygotsky's constructivism emphasize the active construction of knowledge by learners through interaction with the environment; this paradigm underlies adaptive platforms that provide a "zone of proximal development" in the form of dynamically adaptive tasks. Sweller's cognitive load theory explains why intelligent tutoring systems (ITS) effectively reduce extraneous cognitive load: the algorithm takes over the routing of learning tasks, freeing up working memory for learning new material.

J. Siemens's connectivism, developed in the early 2000s as a "learning theory for the digital age," views knowledge as a distributed network of nodes — people, resources, and algorithms. In this framework, AI is not a substitute for a teacher, but an additional network node capable of aggregating and synthesizing arrays of information faster than humans. Finally, R. Ryan and E. Deci's self-determination theory identifies three basic psychological needs — autonomy, competence, and belonging — the satisfaction of which is a prerequisite for intrinsic learning motivation. AI systems that offer learners choice over pace, content, and method of knowledge presentation directly support this need for autonomy.

Taxonomy of AI-based pedagogical tools

To operate the concept of "AI in education," it's useful to distinguish between several classes of tools. First, intelligent tutoring systems (ITS) — software packages that implement a student's cognitive model and based on it, generate a personalized sequence of tasks. Second, adaptive learning platforms that adjust the difficulty and type of content in real time based on the results of diagnostic tests. Third, automated assessment systems (AES) that use natural language processing to analyze written assignments. Fourth, predictive analytics tools that identify "at-risk" students based on behavior patterns in the LMS. Fifth, generative AI assistants (based on large language models) capable of creating personalized learning materials, explaining concepts, and simulating a dialogue with an expert.

Table 1. Comparative analysis of traditional and AI-enhanced pedagogical approaches

Criterion	Traditional approach	AI-enhanced approach
Differentiation of instruction	A single program for everyone	Adaptive data-driven trajectories
Feedback	Deferred (after verification)	Instant, automated
Evaluation	Summative, standardized	Formative, multi-criteria
The role of the teacher	Knowledge Translator	Facilitator, mentor
Student engagement	Passive (lecture model)	Active, gamified
Learning analytics	Limited or absent	Predictive, real-time

Note: Compiled by the authors based on: Holmes et al. (2019); OECD (2023); Zawacki-Richter et al. (2019).

MODERN AI TOOLS IN EDUCATION

Intelligent mentoring systems and adaptive platforms

Intelligent tutoring systems (ITS) stand out among the most studied AI technologies in education. A large-scale meta-analysis by Ma et al. (2014), covering 107 independent studies, found an average effect size of d = 0.76 in favor of ITS compared to traditional instruction without technological support, corresponding to a "substantial" effect according to Cohen's criteria. Next-generation systems, such as Carnegie Learning's MATHia, use Bayesian networks to continuously update the assessment of mastery of each concept and suggest the next task precisely at the point where the probability of success is high but not trivial.

Adaptive platforms (Knewton, Smart Sparrow, Realizeit) operate on a similar principle, but are typically integrated into LMSs (Moodle, Canvas) and support a wider range of media formats. According to Coursera (2023), the implementation of personalized recommendations increased the completion rate of massive open online courses (MOOCs) from 5-15% to 41%, demonstrating significant potential for addressing the "motivation gap" in online learning.

Generative AI and the transformation of teacher roles

The advent of large language models (ChatGPT, GPT-4, Claude, Gemini) has opened up fundamentally new scenarios for teaching practice. Teachers can generate differentiated assignments for students with varying levels of ability in minutes, automatically create assessment rubrics, and obtain analytics on typical classroom errors. During a pilot project in Kazakhstani schools (2023), Kunnur Aitbayeva and colleagues recorded that teachers using an AI assistant for lesson preparation spent 2.3 hours less per week on routine administrative tasks—time that was redistributed toward individual work with students.

However, generative AI poses specific risks: hallucinations (statistically plausible but factually false statements), academic dishonesty, and the risk of students losing their ability to independently synthesize information. These risks require not prohibitive measures, but pedagogically sound use cases in which AI serves as a "cognitive scaffold" rather than a "cognitive prosthesis."

Table 2. AI tools and platforms in education: functionality and measured effects

Tool / Platform	Functionality	Target audience	Effect (according to research data)
Khan Academy (Khanmigo)	An intelligent tutor based on GPT-4	K–12, Universities	+23% academic performance
Duolingo (DL Max)	Adaptive exercises, error analysis	Language courses	+34% retention
Carnegie Learning	ITS in mathematics with a cognitive model	High school, college	+18% SAT Math test
Coursera Coach	Personalized course recommendations	Online learning	+41% completion rate
Gradescope (Turnitin)	Automatic verification of works and AI detection	graduate School	-60% verification time
Knewton Alta	Adaptive STEM content	Universities	+27% retake

Note: Performance data is based on published platform reports and independent research; results may vary depending on the implementation context.

EMPIRICAL EVIDENCE ON EFFECTIVENESS

Systematic research into the effectiveness of AI technologies in education spans approximately twenty years and includes both experimental and quasi-experimental designs. Table 3 summarizes the results of key studies and reviews that served as the empirical basis for this paper.

Table 3. Empirical evidence on the effectiveness of AI reinforcement learning

Research / Source	Context	Key indicator	Result
Ma et al. (2014), Meta-analysis of ITS	K–12, high school	Academic performance	Effect d = 0.76
Steenbergen-Hu & Cooper (2013)	graduate School	ITS vs. traditional education	Effect d = 0.35
Holmes et al. (2019)	Global overview	Student engagement	+28% activity
Zawacki-Richter et al. (2019)	Higher education	Early risk identification	Accuracy 83%
OECD (2023), AI in Education	23 countries	Teacher training	38% - "insufficient"

Note: d is Cohen's standardized effect size (d > 0.5 is “medium”, d > 0.8 is “large”).

Predictive analytics deserves special attention. A study by Zawacki-Richter et al. (2019) demonstrated that machine learning models trained on behavioral data from an LMS (login frequency, task completion time, forum participation patterns) can identify "at-risk students" with 83% accuracy 4–6 weeks before academic failure. This creates an opportunity for preventative pedagogical interventions — personal consultations, curriculum adjustments, and additional resource assignments — fundamentally shifting the logic of student support from reactive to proactive.

It is important, however, to note methodological limitations: much of the research was conducted in privileged university environments in Western countries with developed digital infrastructure.

Transferring the findings to resource-constrained contexts—including Central Asia and Kazakhstan — requires additional empirical verification and consideration of culturally specific factors.

BARRIERS TO IMPLEMENTATION AND ETHICAL RISKS

Despite its proven potential, the large-scale implementation of AI in education faces systemic barriers of a technical, institutional, and ethical nature. Understanding these barriers is essential for developing a realistic integration policy.

Table 4. Barriers to AI implementation in education and recommended solutions

Barrier	Description of the problem	Recommended solution
Digital divide	30–40% of students in developing countries lack devices and reliable internet	Offline modes, preferential provision programs
Algorithmic bias	Training data reflects historical inequalities; risk of discrimination against minorities	Algorithm audit, dataset diversification
Protection of personal data	Collection, storage and use of student data without transparent consent	FERPA/GDPR-compliant protocols, anonymization
Resistance from teachers	Lack of digital skills, fear of replacement, lack of motivation for retraining	Professional development programs, mentoring
AI overdependence	Decreased critical thinking, creativity and communication skills	Hybrid model, limited automation

Note: Compiled by the authors based on OECD (2023); UNESCO (2022); Selwyn (2019).

The digital divide remains the most pressing barrier globally. According to UNICEF (2020), approximately two-thirds of school-age children worldwide lack internet access at home. With the accelerated transition to online learning during the COVID-19 pandemic, this gap has become fully evident: students from low-income families and rural areas find themselves doubly excluded — from digital space and from the educational process.

Algorithmic bias is a structural risk that cannot be mitigated by technical means without regard for social context. If training data for an automated assessment system for written work was collected primarily on students from English-speaking Western universities, the system may systematically underestimate the work of students with different cultural and linguistic backgrounds, despite their actual competencies. Therefore, auditing algorithms for differential performance (test functioning) should become a mandatory element of accreditation procedures for AI tools in education.

RECOMMENDATIONS FOR STRATEGIC IMPLEMENTATION

The synthesis of theoretical foundations, empirical data and analysis of barriers allows us to formulate the following set of recommendations addressed to various groups of stakeholders in educational systems.

For educational organizations

The first step is to develop an institutional AI policy that includes: (a) a list of approved tools with transparent selection criteria; (b) protocols for protecting students' personal data in accordance

with legislation; (c) mechanisms for monitoring academic integrity. At the same time, it is necessary to build professional development systems for teachers — not just one-time training sessions, but continuous support, including mentoring, communities of practice, and opportunities to test tools in a safe environment.

For teachers

Maintaining pedagogical sovereignty should be a key principle: AI provides data and recommendations, but decisions about content, pace, methods, and individualized support remain with the teacher. Effective practice involves cyclical work with data: platform analytics analysis → pedagogical interpretation → corrective action → reanalysis. Of particular importance is the targeted development of "AI literacy" in students — an understanding of how algorithms work, their limitations, and how to use them critically.

For politicians and regulators

At the education policy level, it is necessary to enshrine requirements for algorithm transparency ("the right to explanation"), mandatory audits of AI systems for bias before their use in education, and targeted funding for infrastructure programs to eliminate the digital divide. Kazakhstan, with its significant potential in the digitalization of education (Digital Kazakhstan, Rukhani Zhangyru), has the opportunity to become a regional leader in developing ethical standards for AI in education.

CONCLUSION

Artificial intelligence in education is not a technological trend, but an infrastructural shift that reshapes the fundamental relationships between teachers, students, and knowledge. Intelligent tutoring systems, adaptive platforms, and generative AI assistants demonstrate measurable and replicable effects in improving student performance, engagement, and timely support — provided their implementation is based on pedagogical theory rather than technological enthusiasm.

The central thesis of this paper is that AI works when pedagogy drives technology, not the other way around. Algorithms can take over routine cognitive operations — task routing, initial assessment of assignments, aggregation of performance data — freeing teachers to focus on tasks that cannot be automated: empathic mentoring, creative dialogue, and fostering critical thinking and civic identity.

The future of AI-enhanced education lies in hybrid models in which the efficiency of algorithms and the human touch of educators synergize rather than compete. Realizing this potential requires the educational community to be committed to continuous professional renewal, and education management systems to adopt ethically sound and inclusive digital transformation policies.

BIBLIOGRAPHY

1. Grand View Research. (2024). Artificial Intelligence in Education Market Size, Share & Trends Analysis Report. San Francisco: G.V.R.

2. Holmes, W., Bialik, M., & Fadel, C. (2019). Artificial Intelligence in Education: Promises and Implications for Teaching and Learning. Boston, MA: Center for Curriculum Redesign.

3. Ma, W., Adesope, O. O., Nesbit, J. C., & Liu, Q. (2014). Intelligent tutoring systems and learning outcomes: A meta-analysis. Journal of Educational Psychology, 106(4), 901–918.

4. OECD. (2023). OECD Digital Education Outlook 2023: Towards an Effective Digital Education Ecosystem. Paris: OECD Publishing.

5. Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist, 55(1), 68–78.

6. Selwyn, N. (2019). Should Robots Replace Teachers? AI and the Future of Education. Cambridge: Polity Press.

7. Siemens, G. (2005). Connectivism: A learning theory for the digital age. International Journal of Instructional Technology and Distance Learning, 2(1), 3–10.

8. Steenbergen-Hu, S., & Cooper, H. (2013). A meta-analysis of the effectiveness of intelligent tutoring systems on K–12 students' mathematical learning. Journal of Educational Psychology, 105(4), 970–987.

9. UNESCO. (2022). K-12 AI curriculum: A mapping of government-endorsed AI curriculum. Paris: UNESCO.

10. Zawacki-Richter, O., Marín, VI, Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education. International Journal of Educational Technology in Higher Education, 16(1), 39.

EXTENDING AIRLINE OPERATIONS PLANNING WITH CREW FEASIBILITY CONSIDERATIONS: A PENALTY-BASED ASSESSMENT

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ABSTRACT

In airline operations planning, fleet assignment and aircraft routing decisions are often made without explicitly incorporating crew feasibility, which is typically evaluated in later planning stages. This sequential treatment can reduce the operational viability of planning decisions, particularly in environments characterized by uncertainty, extensive codeshare agreements, and limited capacity. This study extends an existing airline operations planning model by introducing a penalty-based mechanism to capture the impact of crew feasibility on operational planning decisions. In the proposed approach, the planning problem is initially solved without explicit crew constraints. Crew feasibility is subsequently evaluated using a set of route-based binary penalty functions that reflect key operational criteria, including duty time limits, base compatibility, turnaround requirements, and the maximum number of flight legs. These penalties are deducted from route profits, allowing crew-related considerations to influence fleet assignment and aircraft routing decisions in an indirect yet systematic manner, without increasing overall model complexity. The study further examines the role of codeshare flights as a flexibility mechanism for mitigating crew-related constraints. Scenario analyses conducted under varying crew penalty levels and codeshare capacity limits show that increasing crew penalties alone may be insufficient to significantly alter fleet assignment and aircraft routing decisions. However, when additional codeshare capacity is available, the network structure changes markedly, with demand shifting toward codeshare operations to alleviate crew infeasibility. This behavior highlights the strategic value of codeshare agreements in operational risk management. Overall, the proposed framework provides a practical and computationally efficient way to integrate crew feasibility into airline operations planning. The findings also emphasize that codeshare agreements function not only as commercial instruments but as strategic tools for managing crew-related operational risks, offering valuable insights for airline decision-makers.

Keywords: airline operations planning, crew feasibility, codeshare agreements

Introduction and Literature Review

Airline operational planning involves a series of closely linked decisions, including flight scheduling (FS), fleet assignment (FA), aircraft routing (AR), crew scheduling (CS), and capacity management. Traditionally, these stages have been addressed sequentially to reduce computational

complexity. However, such sequential approaches often ignore important interactions between decision layers, leading to suboptimal or fragile schedules. Recent studies, therefore, focus on integrated planning models that jointly consider FS, FA, and AR decisions to improve operational efficiency and economic performance (Jamili 2017; Şafak 2018; Xu 2021). Further extensions incorporate stochastic passenger demand, overbooking (OB) policies, station purity (SP) constraints, and codeshare agreements (CA), improving the realism of airline planning models under uncertainty (Kızıloğlu and Sakallı 2026). With these developments, the influence of crew scheduling (CS) on tactical and operational decisions has become increasingly evident. Integrated aircraft–crew formulations have been investigated primarily in deterministic planning settings or disruption-recovery environments (Cacchiani 2020; Guardo-Martinez 2026). Although these studies demonstrate the importance of coordinating aircraft and crew decisions, the explicit incorporation of crew-feasibility considerations within stochastic FS–FA–AR frameworks remain limited. In particular, the interaction between crew-feasibility enforcement and cooperative capacity mechanisms such as codeshare agreements has not been systematically examined under uncertainty.

Integrated airline scheduling models combining FA, AR, and CS have been widely studied in the operations research literature. Early research focused on deterministic integrated formulations in which aircraft routes and crew pairing decisions were optimized simultaneously using path-based variables and column-generation approaches (Chacchiani and Salazar-González 2013; Salazar-González 2014). Subsequent studies proposed more advanced mathematical formulations integrating node–arc network representations for FA–AR with set-partitioning structures for crew pairing (Shao et al. 2015). More recent work incorporates robustness considerations by limiting tight connections, encouraging crew–aircraft continuity, or introducing flight retiming decisions (Ben Ahmed et al. 2022; Cacchiani and Salazar-González 2020).

Parallel research addresses stochastic airline planning under demand and operational uncertainty. For example, Kızıloğlu and Sakallı (2026) develop a three-stage stochastic FS–FA–AR framework that incorporates SP constraints, CA decisions, and OB policies under uncertain passenger demand and non-cruise times. However, crew feasibility is not embedded within that stochastic planning structure. Related research also examines aircraft–crew coordination in disruption-recovery contexts, where schedules are adjusted after operational disturbances occur (Stojković et al., 2002; Foukolaei, 2025). In addition, Guardo-Martínez et al. (2026) analyze robust airline scheduling with a particular focus on turnaround uncertainty and collaborative planning across multiple scheduling stages. Nevertheless, these studies typically focus on deterministic planning, robustness-oriented frameworks, or post-disruption recovery rather than integrated stochastic planning environments.

Despite substantial progress in integrated airline scheduling and stochastic planning models, penalty-based crew-feasibility enforcement has not been incorporated within a three-stage stochastic FSFAAR–SP–CA framework. Moreover, the interaction between crew-feasibility enforcement and codeshare flexibility under uncertainty remains largely unexplored. To address this gap, this study introduces a penalty-based crew-feasibility mechanism within a three-stage stochastic FSFAAR–SP–CA framework. Instead of explicitly modeling crew pairing through computationally intensive formulations, crew feasibility is incorporated through penalty-based constraints that influence routing and assignment decisions during the planning process. The resulting framework preserves computational tractability while capturing the structural impact of crew limitations. Furthermore, the interaction between penalty intensity and codeshare flexibility is systematically analyzed using a hybrid Sample Average Approximation (SAA) and metaheuristic solution approach.

The remainder of the paper is organized as follows. Section 2 presents the mathematical model. Section 3 describes the solution methodology and computational experiments. Section 4 discusses the computational results, and Section 5 concludes the study.

Problem Description and Modeling Assumptions

This study considers an integrated airline planning problem under uncertainty, where FS-FA-AR-CA-OB decisions are determined simultaneously while respecting station purity (SP) restrictions and operational feasibility. These planning decisions are highly interdependent. Fleet assignment determines the available seat capacity and therefore directly influences overbooking limits and passenger acceptance levels. Aircraft routing decisions shape the propagation of delays and determine whether passenger connections can be maintained. Codeshare agreements provide supplementary capacity when internal fleet resources are insufficient or when operational constraints restrict feasible aircraft assignments.

The planning horizon consists of a set of scheduled flights defined by their origin–destination pairs, scheduled departure times, allowable departure time windows, and eligible fleet types. The airline operates a heterogeneous fleet distributed across multiple stations, where station purity constraints restrict the set of fleet types that can serve each airport. In addition, the airline may utilize alternative codeshare agreements with partner carriers that provide additional passenger capacity under predefined contractual conditions.

Uncertainty in the system arises from two main sources: stochastic passenger demand and stochastic non-cruise time (NCT). Passenger demand varies across scenarios and affects reservation levels, passenger acceptance, and potential denied boarding outcomes. Non-cruise time captures variability in operational processes such as taxi-out, take-off, descent, landing, and taxi-in durations. Variations in NCT influence actual departure and arrival times, which in turn affect delay propagation along aircraft routes and the feasibility of passenger connections. These uncertainties motivate the use of a scenario-based stochastic programming framework.

The decision process follows a three-stage structure. In the first stage, scenario-independent structural decisions are determined, including FA, AR, SP and CA selections. These decisions define the structural backbone of the schedule. In the second stage, announced departure times are selected within allowable time windows to improve FS robustness and reduce potential delay propagation. In the third stage, scenario-dependent operational outcomes are realized, including actual departure and arrival times, delay levels, passenger acceptance, OB levels, denied boarding, and missed passenger connections. The objective function maximizes the expected profit by balancing ticket revenues with operational costs, delay costs, spill penalties, and contractual codeshare costs.

The model assumes a fixed scheduled flight structure and fleet-specific maintenance bases. Cruise speeds are allowed to vary within predefined limits, and minimum passenger connection times must be satisfied. Passenger show-up probabilities are assumed to be fixed across scenarios. Station purity constraints are strictly enforced, meaning that each airport can only be served by a predefined subset of fleet types. In addition, idle time and delay time are modeled separately in order to distinguish between aircraft utilization inefficiencies and delay propagation effects within the network. For clarity, the mathematical formulation presented in the next section follows the same three-stage decision structure.

Mathematical Model

We formulate the integrated airline planning problem as a three-stage stochastic mixed-integer optimization model. The complete formulation of the base FSFAAR–SP–CA–OB model is

presented in Kızıloğlu and Sakallı (2026). For brevity, the core structure of the model is summarized here, while the crew-feasibility extension introduced in this study is detailed in Section 2.2.

Let F denote the set of flights, K the set of fleet types, S the set of stochastic scenarios, FC the set of fare classes, and St the set of stations. For each flight $i \in F$, O_i and $H_i$represent the sets of predecessor and successor flights, respectively, while YB_i denotes the set of flights receiving connecting passengers from flight i. Sets IU_k and SU_k define the initial and terminal flights associated with fleet type k. Furthermore, Υ represents the set of codeshare partner airlines and P denotes the set of available codeshare agreement types.

Each flight i is associated with a departure time window $\left[T_i^{min}, T_i^{max}\right]$. Fleet availability is given by AN_k, while aircraft seat capacities and overbooking limits are represented by Kap_{kh} and OB_{kh}, respectively. Passenger-related revenue and service costs are defined by $fare_{ih}$and $cost_{ih}$, whereas spill penalties are represented by DY_{ih}. Uncertainty in the system is represented through stochastic passenger demand $D_{ihs}$and stochastic non-cruise time η_{is}. Cruise time bounds and turnaround times are denoted by CT_{ikl}^{min}, $CT_{iku}^{max}$and TA_{ik}.

Codeshare-related parameters include the passenger capacity Cap_{vpih}, contractual cost $code_{vpih}$, and overbooking limit OBC_{vpih}. The total allowable codeshare expenditure is limited by the budget parameter BUD, while θ represents the maximum proportion of passenger capacity that may be outsourced via codeshare agreements. Operational cost parameters include delay cost DC_i, aircraft idle-time cost BOS_k, and missed connection cost KY_i. Furthermore, pass_{ij} denotes the number of passengers connecting from flight i to flight j, and r represents the denied boarding penalty multiplier applied to passenger fares.

The model includes decision variables associated with each stage of the stochastic planning process. First-stage binary variables x_{ijk}^1, f_{ik}^1, and e_{ik}^1determine fleet assignment and aircraft routing decisions. Variable q_{vpi}^1selects the applicable codeshare agreement for flight i. Second-stage variables a_i^2represent the announced departure times selected within allowable time windows. Third-stage scenario-dependent variables include the actual departure and arrival times $b_{is}^3$and c_{is}^3, cruise time d_{iks}^3, delay del_{is}^3, idle time IT_{iks}^3, accepted passengers π_{ihs}^3, codeshare passengers πc_{ihs}^3, reservation levels PNR_{ihs}^3, denied boarding db_{ihs}^3, and missed connection indicator w_{ijs}^3.

The objective function maximizes the expected profit across all scenarios:

$$
\begin{aligned}
&Maximize\ Z \\
&= \sum_{s \in S} pr_s \Bigg[\underbrace{\left(\sum_{i \epsilon F} \sum_{h \in FC} (PNR^3_{ihs}) * fare_{ih} \right)}_{Ticket\ Revenue} - \underbrace{\left(\sum_{i \epsilon F} \sum_{h \in FC} db^3_{ihs} * r * fare_{ih} \right)}_{Denied\ Boarding\ Penalty} \\
&\quad - \underbrace{\left(\sum_{i \epsilon F} \sum_{h \in FC} \pi^3_{ihs} * cost_{ih} \right)}_{Passenger\ Service\ Cost} - \underbrace{\left(\sum_{i \epsilon F} \sum_{\upsilon \epsilon Y} \sum_{p \epsilon P} \sum_{h \in FC} code_{\upsilon pih} * Cap_{\upsilon pih} * q^1_{\upsilon pi} \right)}_{Codshare\ Agreement\ Cost} \\
&\quad - \underbrace{\left(\sum_{i \epsilon F} \sum_{\upsilon \epsilon Y} \sum_{p \epsilon P} \sum_{h \in FC} \max\left(0, D_{ihs} - PNR^3_{ihs}\right) * q^1_{\upsilon pi} * \left(fare_{ih} - code_{\upsilon pih}\right) \right)}_{Unserved\ Codeshare\ Passenger\ Penalty} \\
&\quad - \underbrace{\left(\sum_{i \epsilon F} \sum_{k \epsilon K} \sum_{h \in FC} \max(0, D_{ihs} - PNR^3_{ihs}) * \left(\sum_{j \epsilon O_i} x^1_{jik} + f^1_{ik} \right) * DY_{ih} \right)}_{Spilled\ Passenger\ Cost} \\
&\quad - \underbrace{\left(\sum_{i \epsilon F} \sum_{k \epsilon K} IT^3_{iks} * BOS_k \right)}_{Idle\ Time\ Cost} - \underbrace{\left(\sum_{i \epsilon F} DC_i * del^3_{is} \right)}_{Delay\ Time\ Cost} \\
&\quad - \underbrace{\left(\sum_{i \epsilon F} \sum_{j \epsilon YB_i} KY_j * pass_{ij} * w^3_{ijs} \right)}_{Missed\ Connection\ Cost} - \underbrace{\left(\sum_m \lambda_m V_m(x) \right)}_{Crew\ Penalty\ Cost} \Bigg]
\end{aligned}
\tag{1}
$$

The objective function (Eq. 1) captures the economic consequences of operational decisions under uncertainty. Ticket revenues are generated from accepted passenger reservations, while various operational costs account for passenger service, delays, missed connections, denied boarding, and codeshare agreements. The crew-feasibility penalty term introduced in this study is described in Section 2.4.

The mathematical formulation includes several groups of constraints that ensure operational feasibility and logical consistency within the integrated planning framework.

Flight Assignment and Routing Constraints ensure that each flight is either assigned to an internal fleet type or outsourced through a codeshare agreement, while aircraft rotations satisfy flow conservation and fleet availability limits.

Base and Station Compatibility Constraints enforce aircraft base requirements and station purity rules, ensuring that fleet types are only assigned to compatible stations.

Departure Time Window Constraints restrict announced departure times to lie within predefined allowable intervals for internally operated flights.

Operational Timing Constraints link departure times, arrival times, cruise times, turnaround requirements, and idle times to ensure physically feasible aircraft routing under stochastic non-cruise time realizations.

Capacity and Demand Constraints guarantee that accepted passenger numbers do not exceed aircraft or codeshare capacity and remain consistent with stochastic demand realizations.

Overbooking and Denied Boarding Constraints regulate reservation levels according to overbooking policies and maintain consistency between show-up passengers, boarded passengers, and denied boarding outcomes.

Finally, **binary and non-negativity constraints** define the domains of all decision variables.

Crew Feasibility Integration

Although the aircraft rotations generated by the base stochastic FSFAAR model are operationally feasible with respect to fleet availability, timing, and capacity constraints, they may still violate crew-related regulations such as duty-time limits, base compatibility requirements, minimum turnaround times, and maximum leg constraints.

Explicitly integrating crew pairing constraints into the stochastic model would require the introduction of pairing variables, time-indexed duty constraints, and additional flow-balance relationships. Such formulations significantly increase the dimensionality of the problem and may lead to substantial computational burden, particularly in a scenario-based stochastic setting.

To preserve scalability while still accounting for crew feasibility considerations, we adopt a soft-constraint penalty mechanism embedded within the heuristic search framework. In this approach, crew regulations are not enforced as hard constraints within the proposed model formulation. Instead, potential violations are detected ex-post for each candidate solution and incorporated into the objective function through penalty terms during solution evaluation.

This strategy enables the search process to balance economic performance and regulatory feasibility while preserving the mathematical structure and computational tractability of the base stochastic planning model.

Crew Violation Definition

For a given candidate solution x, aircraft rotations are first reconstructed from the routing decisions. Crew feasibility is then evaluated at the rotation level according to four regulatory dimensions (Guardo-Martínez et al. 2026):

- Base compatibility (BASE): violation if a rotation does not start and end at an authorized crew base,
- Maximum duty time (DUTY): violation if total duty duration exceeds the regulatory limit,
- Minimum turnaround (TA): violation if ground time between consecutive legs is insufficient from a crew perspective,
- Maximum number of legs (LEG): violation if the number of flight segments within a duty period exceeds the allowable threshold.

Let $R(x)$denote the set of aircraft rotations implied by solution x. For each violation type $m \in \{BASE, DUTY, TA, LEG\}$, the total number of violations is defined in Eq. (2)

$$V_m(x) = \sum_{r \in R(x)} v_{mr}(x) \quad (2)$$

where $v_{mr}(x)$denotes the number of violations of type $m$observed on rotation r.

By counting violations, the penalty mechanism captures the severity of infeasibility while differentiating between minor and severe violations.

Penalized Evaluation Function

Let $Z(x)$denote the expected profit obtained from the base stochastic model, including ticket revenues, operating costs, delay and idle-time costs, spill penalties, and codeshare-related effects. Crew feasibility is incorporated through the penalized evaluation function in Eq. (3)

$$\Phi(x) = Z(x) - \sum_{m} \lambda_m V_m(x) \quad (3)$$

where $\lambda_m > 0$ is the penalty coefficient associated with violation type m.

The penalized objective $\Phi(x)$is used as the fitness value within the metaheuristic search. This soft-constraint formulation discourages crew-infeasible solutions while maintaining sufficient flexibility to explore economically attractive regions of the solution space. Unlike hard constraints, the penalty mechanism avoids prematurely excluding high-quality solutions while guiding the search toward feasible and robust schedules.

Integration within the Heuristic Search

Crew feasibility evaluation is performed dynamically during the iterative search process. For each newly generated solution:

1. Aircraft rotations are reconstructed from routing decisions.

2. Duty time, turnaround feasibility, leg count, and base compatibility are computed.

3. Violations are counted for each regulatory category.

4. The penalized objective $\Phi(x)$is evaluated.

5. Solution acceptance is determined according to the metaheuristic's selection rule.

No additional decision variables, Big-M constraints, or scenario-dependent crew variables are introduced into the proposed model. Crew feasibility is handled entirely at the evaluation stage, preserving the computational efficiency of the stochastic optimization framework.

Sensitivity to Penalty and Codeshare Parameters

Penalty coefficients $\lambda_m$and the codeshare capacity ratio parameter θjointly control the trade-off between profitability and crew feasibility. Higher penalty levels increasingly discourage infeasible rotations, while relaxed codeshare limits may reduce crew-duty violations by increasing operational flexibility. The combined effects of these parameters on profitability, violation frequency, and solution structure are examined in the computational experiments.

Methodological Contribution

The proposed approach provides a tractable approximation of fleet–crew coordination in large-scale stochastic airline planning. Rather than solving a full crew pairing problem, the framework:

- Generates aircraft rotations via stochastic optimization,
- Evaluates crew feasibility ex-post at the rotation level,
- Incorporates regulatory compliance through a graded penalty mechanism.

This layered architecture balances economic optimality, regulatory realism, and computational scalability, while providing practicality for large integrated airline planning problems under uncertainty.

Solution Approach

Hybrid SAA–Metaheuristic Framework

The integrated FSFAAR–SP–CA–OB model exhibits a tightly coupled structure in which first-stage fleet assignment and routing decisions directly influence second-stage scheduling feasibility and third-stage stochastic performance. The combinatorial complexity increases rapidly with the number of flights, fleet types, and scenarios, rendering exact solution approaches computationally impractical for realistic instances.

To ensure tractability while preserving stochastic fidelity, we adopt a hybrid Sample Average Approximation (SAA)–Metaheuristic framework, building upon the stochastic structure introduced in Kızıloğlu and Sakallı (2026). The approach combines the statistical robustness of SAA with the search capabilities of a metaheuristic engine.

Under SAA, the stochastic objective is approximated by solving multiple deterministic sample problems. For each replication $m = 1, \dots, M$, a scenario sample of size $S$is generated. The resulting deterministic problem is solved via metaheuristic search, yielding a candidate solution x_S^m. Each candidate is subsequently evaluated on a larger validation sample $S' \gg S$to estimate its expected objective value and variance. Statistical bounds and optimality gap estimates are computed across replications, and the solution with the smallest statistically reliable gap is selected. By solving the model over multiple scenario samples, the approach improves the statistical reliability of the solution estimates while maintaining a tractable optimization size.

Metaheuristic Engine: SAASA

Each SAA subproblem is solved using SAASA (Simulated Annealing–Enhanced SAA), which operates primarily on first-stage decisions—namely fleet assignment, aircraft routing, and codeshare selection—since these decisions determine downstream operational feasibility and stochastic performance. Parameter settings (initial temperature, cooling rate, and iteration limits) are adopted from the empirical calibration study reported in Kızıloğlu and Sakallı (2026), where extensive computational experiments were conducted on large-scale instances of the stochastic airline planning model. These calibrated values were shown to provide a balanced trade-off between solution quality and computational time. The algorithm, therefore, begins with a sufficiently high temperature to enable broad exploration and gradually shifts toward intensification as the temperature decreases. The search space consists of feasible combinations of fleet assignments, aircraft routing arcs, and codeshare selections that collectively define the structural backbone of the integrated schedule.

Neighboring solutions are generated by applying problem-specific perturbations to the current schedule structure. These moves modify the assignment and routing decisions while preserving the overall feasibility of the schedule. In particular, neighborhood moves include reassigning a flight to an alternative compatible fleet type, exchanging routing arcs between consecutive flights, and activating or deactivating codeshare options for selected flights.

Such perturbations allow the search process to explore alternative aircraft rotations and capacity allocation patterns while maintaining the structural consistency of the integrated schedule. Each candidate solution is evaluated through the stochastic objective function combined with the crew-feasibility penalty mechanism described in Eq. (3). According to the simulated annealing acceptance rule, improving solutions are always accepted, whereas non-improving solutions may be accepted with a probability that depends on the current temperature level. This mechanism helps the search escape local optima during early iterations and gradually intensifies the search toward high-quality feasible solutions as the temperature decreases.

Statistical Evaluation and Solution Selection

For each SAA replication:

- The best metaheuristic solution is validated on a larger scenario sample S'.
- Variance estimates are computed.
- Confidence intervals and optimality gaps are derived.

Let $\bar{\mu}_S$ denote the mean objective value over replications and $obj_{S'}(x_S^m)$ the large-sample evaluation of candidate x_S^m. The estimated optimality gap is (Eq. 4):

$$gap = \bar{\mu}_S - obj_{S'}(x_S^m) \quad (4)$$

The final solution is selected as the one with the smallest statistically reliable gap, ensuring both economic quality and statistical robustness.

Advantages of the Framework

The proposed hybrid structure offers:

- **Scalability:** Metaheuristic search efficiently handles large deterministic subproblems generated by SAA.
- **Statistical robustness:** SAA provides confidence bounds and gap estimation.
- **Feasibility preservation:** Operational constraints are enforced during neighborhood generation.
- **Crew-awareness without combinatorial explosion:** Crew feasibility is approximated via graded penalty evaluation rather than full crew pairing integration.

Together, these components form a computationally tractable and statistically grounded solution framework for large-scale stochastic airline planning under uncertainty.

Computational Experiments

The computational study evaluates the economic and structural impact of incorporating crew-feasibility penalties into the stochastic FSFAAR–SP–CA-OB framework. The primary objective is to quantify the extent to which crew-regulation enforcement influences profitability, routing structure, and codeshare utilization under uncertainty.

Experiments are conducted on problem instances containing 30, 127, and 180 flights with six fleet types. Passenger demand is generated from a uniform distribution within the interval [0.8*Cmin, 1.2*Cmax], while non-cruise time follows a calibrated normal distribution reflecting operational variability. The model is solved using the hybrid SAASA framework. For each configuration, 10 independent SAA replications are performed, and the best candidate solution from each replication is evaluated using 1000 long-run validation scenarios to obtain statistically reliable performance estimates.

Crew feasibility is incorporated through penalty costs applied to violations of duty time, base compatibility, maximum leg count, and turnaround constraints. Penalty coefficients are defined as percentages of average route contribution margins and calibrated at three levels, as summarized in Table 1.

Table 1. Crew Penalty Levels (% of Route Contribution Margin)

Level	Duty (%)	Base (%)	Leg (%)	Turnaround (%)
Low	5	3	2	1
Medium	10	7	5	3
High	15	11	8	5

Codeshare flexibility is controlled by the parameter θ, which represents the maximum proportion of total capacity allocated to codeshare agreements. Two levels are tested (θ =0.40 and θ =0.70) to evaluate how cooperation flexibility mitigates the economic impact of crew-feasibility enforcement.

Performance is assessed using the long-run mean profit (SAA estimate), the standard deviation across replications, total crew violations, the codeshare utilization ratio (CA%), and structural adjustment indicators such as fleet reassignments and arc changes (Tables 2–3). The 30-flight instance is used to illustrate routing-level structural effects, whereas the 127- and 180-flight instances are employed to evaluate scalability and solution robustness under increased combinatorial complexity (Table 4).

Table 2. Effects of crew-feasibility penalties and codeshare flexibility (θ) for the 30-flight instance.

Case (30 flights)	Penalty	θ	Profit	DUTY	BASE	LEG	TA	Total Violations	CA
Case 0 (No-crew)	None	0.40	377330.380	5	8	0	13	26	9
Case 1 (Crew-on)	low	0.40	350423.431	3	7	0	11	21	12
Case 2 (Crew + CA relax)	low	0.70	350816.056	2	6	0	9	17	15
Case 1 (Crew-on)	High	0.40	293854.884	3	7	0	11	21	12
Case 2 (Crew + CA relax)	High	0.70	304986.568	2	6	0	9	17	15

The results indicate a clear feasibility–profit trade-off. Introducing crew-feasibility penalties reduces the number of violations but also decreases expected profit, as stricter operational constraints limit routing and capacity flexibility. When codeshare flexibility increases (θ = 0.70), the number of codeshare flights rises and profitability improves slightly compared with the corresponding crew-on configuration. This suggests that codeshare agreements partially compensate for the operational rigidity introduced by crew-feasibility enforcement, helping the network maintain feasibility with smaller economic losses.

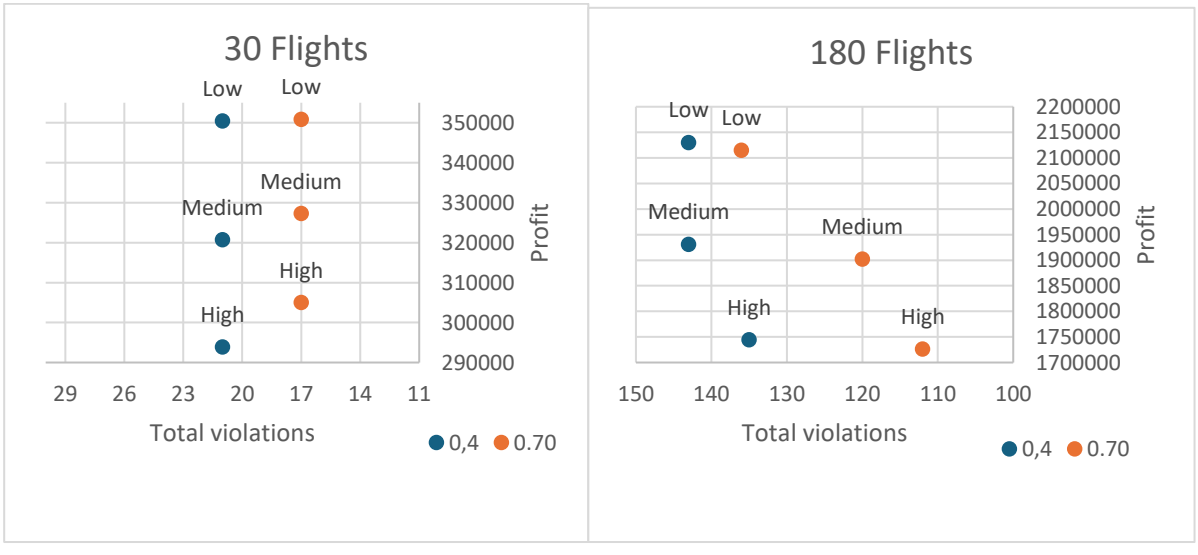
Table 3. Structural routing changes under different crew penalty levels and codeshare flexibility

Case (30 flights)	Penalty	θ	Fleet Reassignments	Arc Changes	CA Changes
Case 0 (No-crew)	None	0.40	8 routes	13 legs	9 flights
Case 1 (Crew-on)	low	0.40	7 routes	11 legs	12 flights
Case 2 (Crew + CA relax)	low	0.70	6 routes	9 legs	15 flights
Case 1 (Crew-on)	High	0.40	7 routes	11 legs	12 flights
Case 2 (Crew + CA relax)	High	0.70	6 routes	9 legs	15 flights

Table 3 shows that crew-feasibility enforcement also affects the structural composition of the schedule. Compared with the baseline solution, several aircraft routes and routing arcs are modified when crew penalties are introduced. As codeshare flexibility increases, the number of fleet reassignments and arc changes decreases, while the number of codeshare flights increases. This indicates that codeshare agreements absorb part of the operational adjustment required to satisfy crew feasibility, thereby reducing the need for extensive routing modifications within the airline network.

Table 4. Performance results of the proposed algorithm for the instances under different crew penalty levels and codeshare flexibility (θ).

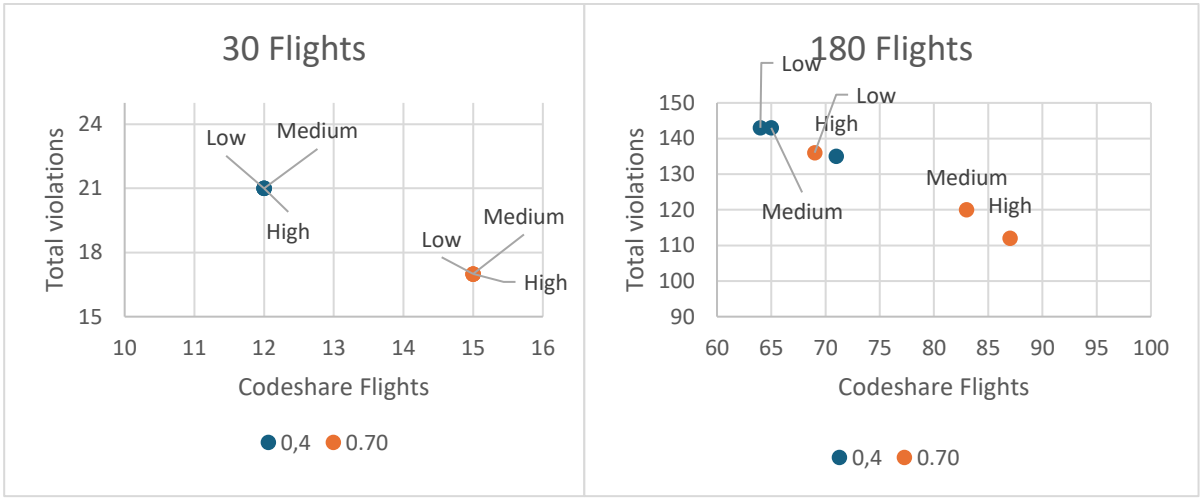
	Algorithm	Penalty	Theta	Profit (S' mean)	GAP	Std Dev	Time (s)	Total Violations	CA
30	SAASA	Low	0.40	350,423.431	33.239	2,295.989	1,104.094	21	12
30	SAASA	Low	0.70	350,816.056	110.937	2,601.581	907.361	17	15
30	SAASA	Medium	0.40	320,659.643	183.277	2,583.726	1,117.730	21	12
30	SAASA	Medium	0.70	327,268.472	49.496	2,652.068	910,556	17	15
30	SAASA	High	0.40	293,854.884	120.046	2,358.411	1,098.615	21	12
30	SAASA	High	0.70	304,986.568	42.60	2,450.747	878.752	17	15
127	SAASA	Low	0.40	1,706,592.632	2,665.369	8,128.548	22,929.468	120	33
127	SAASA	Low	0.70	1,710,451.424	599.558	7,616.909	22,874.239	119	35
127	SAASA	Medium	0.40	1,551,997.127	4,575.291	8,732.015	22,820.534	113	36
127	SAASA	Medium	0.70	1,565,255.834	533.2924	6,454.423	21,731.322	107	42
127	SAASA	High	0.40	1,410,714.285	2,596.539	4,593.383	21,711.290	101	46
127	SAASA	High	0.70	1,394,468.347	8,348.885	5,916.229	19,362.710	94	51
180	SAASA	Low	0.40	2,130,308.869	6,791.959	7,168.908	45,012.447	143	64
180	SAASA	Low	0.70	2,115,077.359	1,304.440	12,695.732	40,282.221	136	69
180	SAASA	Medium	0.40	1,930,762.719	918.979	6,879.405	43,996.555	143	65
180	SAASA	Medium	0.70	1,902,396.636	4,796.944	8,042.059	38,426.219	120	83
180	SAASA	High	0.40	1,744,329.234	1,111.917	6,365.036	40,551.549	135	71
180	SAASA	High	0.70	1,726,145.127	1,939.906	6,285.513	34,665.611	112	87



(a) (b)

Figure 1. *Profit versus total crew-feasibility violations under different penalty levels: (a) 30-flight instance and (b) 180-flight instance.*

Based on the data obtained from Table 4, Figure 1 illustrates the relationship between expected profit and total crew-feasibility violations for the 30-flight and 180-flight instances under different penalty levels (low, medium, and high). As the penalty level increases, the number of violations generally decreases, indicating improved compliance with crew-related regulations. However, this improvement in feasibility is accompanied by a reduction in expected profit, highlighting the trade-off between regulatory feasibility and economic performance. Stricter penalties limit routing flexibility and operational adjustments, which, in turn, reduce the schedule's overall profitability. Although the absolute scale of profit and violations increases with the number of flights, a similar pattern can be observed across both network sizes.



(a) (b)

Figure 2. Codeshare utilization versus total crew-feasibility violations under different penalty levels: (a) 30 flights, (b) 180 flights.

Similarly, Figure 2 is constructed based on the data presented in Table 4 and illustrates the relationship between codeshare utilization and total crew-feasibility violations for the 30-flight and 180-flight instances. The results indicate that higher levels of codeshare utilization are generally associated with fewer violations. This suggests that codeshare agreements provide additional operational flexibility by allowing part of the demand to be accommodated through partner airlines. A similar pattern is observed across all network sizes, indicating that codeshare flexibility is an effective mechanism for mitigating crew-feasibility violations in stochastic airline planning environments.

The computational results further show that the proposed penalty-based mechanism effectively reduces crew-feasibility violations while maintaining operational feasibility within the integrated stochastic FSFAAR–SP–CA framework. Increasing penalty levels consistently leads to lower violation counts, indicating improved compliance with crew-related regulations. However, the economic impact of stricter enforcement of feasibility varies with problem size. While small-scale instances may maintain competitive profit levels, larger instances exhibit a stronger trade-off between feasibility and profitability. These findings suggest that penalty-based feasibility mechanisms provide a practical approximation for incorporating crew considerations, although their effectiveness may decrease as network complexity increases.

Conclusion

This study develops a three-stage stochastic integrated airline planning framework that simultaneously considers FS–FA–AR, codeshare agreements (CA), station purity constraints (SP), and overbooking policies (OB) under uncertainty. To capture the operational impact of crew-related restrictions without introducing large-scale crew pairing formulations, a penalty-based crew-feasibility mechanism is incorporated into the planning model. This approach enables crew-related considerations to be reflected within strategic and tactical airline planning decisions while preserving computational tractability.

The computational experiments show that the proposed mechanism effectively reduces crew-related violations and improves the operational feasibility of the resulting schedules. However, the results reveal a clear feasibility–profit trade-off. For smaller network instances, the penalty-based mechanism reduces violations while maintaining competitive profit levels, whereas in larger instances profitability does not improve in a corresponding manner. This outcome indicates that penalty-based feasibility enforcement provides a practical approximation for incorporating crew considerations but cannot fully capture the complex interactions between crew scheduling and aircraft routing decisions in larger networks.

The results also highlight the role of codeshare flexibility as a complementary operational mechanism. Increasing the allowable level of codeshare cooperation helps reduce feasibility violations and partially mitigates the economic impact of stricter crew-feasibility enforcement. These findings suggest that explicitly integrating crew scheduling decisions into stochastic airline planning frameworks could further improve solution quality, particularly for large-scale networks.

References

Ahmed, M. B., Hryhoryeva, M., Hvattum, L. M., & Haouari, M. (2022). A matheuristic for the robust integrated airline fleet assignment, aircraft routing, and crew pairing problem. *Computers & Operations Research*, *137*, 105551. https://doi.org/10.1016/j.cor.2021.105551

Cacchiani, V., & Salazar-González, J. J. (2013). A heuristic approach for an integrated fleet-assignment, aircraft-routing and crew-pairing problem. *Electronic Notes in Discrete Mathematics*, *41*, 391-398. https://doi.org/10.1016/j.endm.2013.05.117

Cacchiani, V., & Salazar-González, J. J. (2020). Heuristic approaches for flight retiming in an integrated airline scheduling problem of a regional carrier. *Omega*, *91*, 102028. https://doi.org/10.1016/j.omega.2019.01.006

Foukolaei, P. Z. (2025). Two-stage stochastic robust programming based on MOPSSCA for flight crew scheduling problem. *European Journal of Industrial Engineering*, *20*(2), 251-277. https://doi.org/10.1504/ejie.2025.10066439

Guardo-Martinez, E., Onggo, S., Kunc, M., Padrón, S., & Tomasella, M. (2026). Robust airline scheduling with turnaround under uncertainty: towards collaborative airline scheduling. *Transportation Research Part E: Logistics and Transportation Review*, *205*, 104440. https://doi.org/10.1016/j.tre.2025.104440

Jamili, A. (2017). A robust mathematical model and heuristic algorithms for integrated aircraft routing and scheduling, with consideration of fleet assignment problem. *Journal of Air Transport Management*, *58*, 21-30. https://doi.org/10.1016/j.jairtraman.2016.08.008

Kızıloğlu K, & Sakallı Ü. S. (2026). A Novel Stochastic Framework for Integrated Airline Operation Planning: Addressing Codeshare Agreements, Overbooking, and Station Purity. *Aerospace*, *13(1)*, 82. https://doi.org/10.3390/aerospace13010082

Salazar-González, J. J. (2014). Approaches to solve the fleet-assignment, aircraft-routing, crew-pairing and crew-rostering problems of a regional carrier. *Omega*, *43*, 71-82. https://doi.org/10.1016/j.omega.2013.06.006

Shao, S., Sherali, H. D., & Haouari, M. (2017). A novel model and decomposition approach for the integrated airline fleet assignment, aircraft routing, and crew pairing problem. *Transportation Science*, *51*(1), 233-249. https://doi.org/10.1287/trsc.2015.0623

Stojković, G., Soumis, F., Desrosiers, J., & Solomon, M. M. (2002). An optimization model for a real-time flight scheduling problem. *Transportation Research Part A: Policy and Practice*, *36*(9), 779-788. https://doi.org/10.1016/s0965-8564(01)00039-8

Şafak, Ö., Çavuş, Ö., & Aktürk, M. S. (2018). Multi-stage airline scheduling problem with stochastic passenger demand and non-cruise times. *Transportation Research Part B: Methodological*, *114*, 39-67. https://doi.org/10.1016/j.trb.2018.05.012

Xu, Y., Wandelt, S., & Sun, X. (2021). Airline integrated robust scheduling with a variable neighborhood search based heuristic. *Transportation Research Part B: Methodological*, *149*, 181-203. https://doi.org/10.1016/j.trb.2021.05.005

RSM-BASED METAMODELING OF UAV THRUST AND POWER UNDER HIGH-ALTITUDE AND VARIABLE ENVIRONMENTAL CONDITIONS

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ABSTRACT

Thrust generation and power requirements of unmanned aerial vehicles (UAVs) under high-altitude and variable environmental conditions constitute fundamental parameters that directly affect flight performance, mission endurance, and operational reliability. However, the high cost of experimental campaigns conducted under such conditions, limited testing capabilities, and the restricted number of measurement points significantly hinder the effective utilization of the obtained data in design and operational processes. In this context, Response Surface Methodology (RSM) offers a powerful modeling and decision-support approach for aerospace applications due to its ability to mathematically represent complex and multivariable system behavior based on a limited number of experimental data points. In the present study, experimental thrust and power data representing high-altitude and varying environmental conditions were transformed into mathematical metamodel equations using an FCCD (Face-Centered Central Composite Design)-based RSM approach. The individual and interaction effects of motor speed and environmental parameters on thrust and power outputs were systematically investigated within the RSM framework, and separate metamodel structures were established for systems with physically distinct characteristics. In this manner, the conventional evaluation approach, which is generally limited to graphical interpretation of experimental results, was extended to obtain closed-form, interpretable, and computationally efficient mathematical expressions with rapid prediction capability. The statistical adequacy and predictive performance of the RSM-based metamodel equations were assessed using standard goodness-of-fit metrics and analysis of variance. The developed models demonstrated high accuracy and consistency. The results indicate that Response Surface Methodology enables reliable and repeatable performance predictions in experimentally challenging aerospace problems such as high-altitude and variable environmental conditions, even

when only limited data are available. In this respect, the study highlights the strategic role of RSM in aerospace applications and provides a comprehensive and applicable metamodeling framework for integrating experimental UAV thrust and power performance evaluations into design and operational decision-making processes.

Keywords: Response Surface Methodology (RSM), Unmanned Aerial Vehicles (UAVs), Metamodeling, Design of Experiments (FCCD), High-Altitude.

INTRODUCTION

The operational performance of unmanned aerial vehicles (UAVs) particularly under high-altitude and variable environmental conditions, is directly governed by their thrust generation capability and power requirements. Variations in atmospheric pressure and temperature significantly affect propeller and rotor aerodynamics, engine operating characteristics, and overall system energy consumption, leading to critical implications for UAV mission range, endurance, and operational reliability. Experimental studies conducted under high-altitude conditions clearly demonstrate that low-pressure and low-temperature environments result in thrust degradation and substantial variations in power demand (Scanavino et al., 2014).

Propeller and rotor systems used in small-scale unmanned aerial vehicles generally operate under low Reynolds number conditions, which makes their thrust and power characteristics highly sensitive to environmental variations. In this context, experimental studies conducted at low Reynolds numbers have demonstrated that thrust generation and efficiency values can deviate significantly from those observed under conventional sea-level conditions (Brandt and Selig, 2011; Ruiz et al., 2022). Similarly, wind tunnel experiments indicate that measurement uncertainties and scale effects remain unavoidable even under controlled conditions, thereby limiting the generalizability of experimental data (Jdiobe et al., 2022).

In the literature, theoretical approaches such as blade element momentum theory are widely employed in the evaluation of UAV propeller performance; however, the accuracy of these methods largely depends on experimental data (MacNeill and Verstraete, 2017). However, the experimental representation of flight conditions such as high altitude, low pressure, and varying temperature involves significant practical constraints due to the need for specialized testing infrastructure, limited measurement points, and high operational costs (Scanavino et al., 2014). For this reason, experimental studies are often limited to specific operating points, which makes it difficult to utilize the obtained results in a rapid and flexible manner within design and operational decision-making processes. To overcome these limitations, data-driven and metamodeling approaches based on experimental data have begun to appear in the literature for the prediction of UAV thrust performance (Deters et al., 2014; Konar, 2019).

Such approaches aim to enhance the informational content of limited experimental data; however, in many cases they do not provide closed-form mathematical expressions and fail to explicitly reveal interactions among variables, which leads to limitations in terms of interpretability for engineering applications. At this point, the need becomes evident for methods that can statistically represent system behavior based on a limited number of experimental data points and clearly quantify both the individual and interaction effects of the governing variables. Response Surface Methodology (RSM) emerges as a powerful metamodeling approach that directly addresses this need. Through statistical models derived from experimental data, RSM enables complex and multivariable system behavior to be expressed in closed-form mathematical equations, thereby allowing performance predictions to become rapid, interpretable, and directly applicable from an engineering perspective (Lamidi et al., 2022; Susaimanickam et al., 2023; Hadiyat et al., 2022). This capability provides a significant advantage, particularly in experimentally challenging

aerospace problems such as high-altitude and variable environmental conditions, by enabling reliable performance estimation based on limited data.

In light of the aforementioned literature background, this study aims to predict UAV thrust and power performance under high-altitude and variable environmental conditions through an RSM-based metamodeling approach. Using experimentally obtained thrust and power data, the effects of motor speed and environmental parameters on performance outputs are systematically modeled, thereby moving beyond purely graphical evaluations based on experimental measurements and yielding analytical and generalizable mathematical expressions that can be utilized in design and operational decision-making processes. In this respect, the study demonstrates the effectiveness of RSM in aerospace applications and presents an original and applicable framework for strengthening experimental data-driven UAV performance analyses through metamodeling-based approaches.

MATERIALS AND METHODS

In this study, experimentally reported thrust and power data available in the literature were utilized as the primary dataset. Performance outputs for isolated rotor and full vehicle configurations were evaluated under motor speed, altitude, and temperature parameters representing high-altitude and variable environmental conditions. These variables were selected to capture the combined influence of environmental factors and propulsion system operating conditions on overall UAV performance. The experimental datasets were modeled within the framework of RSM using a Face-Centered Central Composite Design (FCCD) approach in order to systematically investigate both individual and interaction effects of the governing parameters. Second-order polynomial equations were derived to represent the relationships between the input variables and the performance responses. The statistical adequacy, goodness of fit, and predictive capability of the developed models were assessed based on determination coefficients and analysis of variance, ensuring the reliability and consistency of the proposed metamodeling framework.

Experimental Data Set and Problem Definition

The experimental dataset used in this study was obtained from controlled tests conducted to investigate the effects of high-altitude and variable environmental conditions on the thrust and power performance of UAVs. The experiments were performed under conditions in which atmospheric pressure and ambient temperature were systematically varied, thereby enabling the experimental representation of environmental effects encountered in real flight environments (Scanavino et al., 2014). The experimental dataset includes thrust and power values measured at different motor speeds. Thrust represents the aerodynamic force generated by the rotor or propeller system, while power denotes the mechanical or electrical energy consumed to produce this thrust. These quantities were considered as the primary outputs for evaluating UAV performance.

The main problem addressed in this study is the reliable prediction of UAV thrust and power performance under high-altitude and variable environmental conditions based on a limited number of experimental measurements. Since the experimental data represent only specific operating points, they need to be supported by generalizable mathematical models. Accordingly, the experimental dataset was used as the primary input for developing RSM based metamodel equations that represent the relationship between thrust and power outputs and the governing environmental conditions and motor speed.

Response Surface Methodology-Based Metamodeling Approach

In this study, RSM was employed to mathematically model the thrust and power performance of UAVs under high-altitude and variable environmental conditions based on experimental data. RSM enables the derivation of closed-form metamodel equations that represent the relationship between system inputs and performance outputs using a limited number of experimental measurements, thereby transforming experimental findings into a generalizable and computationally efficient predictive framework. The experimental data utilized in this work were obtained from systematic tests conducted under low-pressure and varying temperature conditions and include both isolated rotor and full vehicle configurations as detailed in the literature (Scanavino et al., 2014).

In the referenced study, thrust and mechanical power measurements were conducted for the isolated rotor configuration, whereas thrust and electrical power measurements were performed for the full vehicle configuration. These four performance quantities were considered as the response variables within the RSM-based metamodeling process.

Definition of Factors and Response Variables

Within the scope of the RSM application, two primary independent variables, factors, were defined to represent the physical content of the experimental dataset:

• Altitude, A

• Motor speed, n

• Temperature, t

These factors were determined in accordance with the conditions used in the experimental study. Accordingly, altitude was considered within the range of 0 to 9000 m, while motor speed was defined within the range of 2000 to 6000 rpm. This selection represents the environmental and operational range encountered under real UAV operating conditions.

A total of four response variables were defined in the study:

• T_{iso}: Isolated rotor thrust

• $P_{iso,mec}$: Isolated rotor mechanical power

• T_{fv}: Full vehicle thrust

• $P_{fv,elec}$: Full vehicle electrical power

These responses allow for the simultaneous evaluation of both aerodynamic performance and energy requirements.

RSM Model Structure for the Isolated Rotor

For the isolated rotor configuration, RSM analyses were performed under two distinct environmental scenarios. In the first scenario, ambient temperature was maintained at a constant value of 20 °C, and RSM models for isolated rotor thrust (T_{iso}) were developed using a FCCD under altitude ranging from 0 to 9000 m and motor speed ranging from 2000 to 6000 rpm (Table 1). This structure enables a systematic analysis of the linear, quadratic, and interaction effects of altitude and motor speed on thrust.

Table 1. FCCD design points for T_{iso} and $P_{iso,mec}$ responses at constant temperature of 20 °C

Run	A (coded)	B (coded)	Altitude (m)	Motor Speed (rpm)
1	-1	-1	0	2000
2	+1	-1	9000	2000
3	-1	+1	0	6000
4	+1	+1	9000	6000
5	-1	0	0	4000
6	+1	0	9000	4000
7	0	-1	4500	2000
8	0	+1	4500	6000
9	0	0	4500	4000

For the statistical modeling procedure, the actual factor levels were transformed into coded variables to ensure numerical stability and comparability of regression coefficients. The coded transformation for altitude was defined as Eq. (1):

$$A = \frac{\text{Altitude} - 4500}{4500} \tag{1}$$

Where, 4500 m represents the center point of the design space and 4500 m corresponds to the step size. This normalization allows the factor levels to vary between −1 and +1 within the FCCD framework, facilitating consistent estimation of linear, quadratic, and interaction effects within the quadratic RSM formulation.

Table 2. FCCD design points for T_{iso} and $P_{iso,mec}$ responses under constant pressure of 990 mbar

Run	A (coded)	B (coded)	Temperature (°C)	Motor Speed (rpm)
1	-1	-1	0	2000
2	+1	-1	40	2000
3	-1	+1	0	6000
4	+1	+1	40	6000
5	-1	0	0	4000
6	+1	0	40	4000
7	0	-1	20	2000
8	0	+1	20	6000
9	0	0	20	4000

In the second scenario, ambient pressure was fixed at 990 mbar, and a separate FCCD-based RSM model for isolated rotor thrust was developed under temperature ranging from 0 to 40 °C and motor speed ranging from 2000 to 6000 rpm (Table 2). This approach allows the separation of the effects of thermal conditions and motor operating points on thrust generation. The same factor configurations were also applied to isolated rotor mechanical power ($P_{iso,mec}$) and independent RSM metamodel equations were derived to represent the relationship between thrust and power requirements (Table 1 and Table 2). Within the RSM framework, this allowed the systematic

estimation of linear, quadratic, and interaction effects of the governing variables on mechanical power consumption. The use of the same FCCD design ensured consistency in coefficient estimation and enabled direct comparison between thrust and power models within a unified statistical structure. This integrated modeling approach provides a coherent basis for evaluating propulsion efficiency under varying environmental and operational conditions.

RSM Model Structure for the Full Vehicle

For the full vehicle configuration, RSM analyses were conducted to represent system-level performance evaluation. In this context, FCCD-based RSM models were developed for full vehicle thrust (T_{fv}) and full vehicle electrical power ($P_{fv,elec}$) under altitude ranging from 0 to 9000 m and motor speed ranging from 2000 to 6000 rpm (Table 3).

Table 3. FCCD design points for T_{fv} and $P_{fv,elec}$ responses for the Full Vehicle at constant temperature of 20 °C

Run	A (coded)	B (coded)	Altitude (m)	Motor speed (rpm)
1	-1	-1	0	2000
2	+1	-1	9000	2000
3	-1	+1	0	6000
4	+1	+1	9000	6000
5	-1	0	0	4000
6	+1	0	9000	4000
7	0	-1	4500	2000
8	0	+1	4500	6000
9	0	0	4500	4000

Table 4. FCCD design points for T_{fv} and $P_{fv,elec}$ responses for the Full Vehicle under constant pressure of 990 mbar

Run	A (coded)	B (coded)	Temperature (°C)	Motor speed (rpm)
1	-1	-1	-40	2000
2	+1	-1	40	2000
3	-1	+1	-40	6000
4	+1	+1	40	6000
5	-1	0	-40	4000
6	+1	0	40	4000
7	0	-1	0	2000
8	0	+1	0	6000
9	0	0	0	4000

In addition, ambient pressure was maintained at 990 mbar, and separate RSM models were developed for both full vehicle thrust and full vehicle electrical power ($P_{fv,elec}$) under temperature ranging from –40 °C to +40 °C and motor speed ranging from 2000 to 6000 rpm (Table 4). This structure enables the quantitative assessment of the sensitivity of system-level power consumption to environmental and operational variables.

RSM Model Formulation and Validation Approach

For all response variables, the RSM models were expressed using second-order quadratic polynomials in order to adequately capture the nonlinear behavior of the system within the defined factor space. This formulation allows the simultaneous representation of linear effects, curvature effects, and two-factor interactions between the governing variables. By incorporating quadratic and interaction terms, the model structure enables a more comprehensive characterization of the response surface compared to purely linear regression approaches. In addition, the use of coded variables ensures numerical stability in coefficient estimation and facilitates the interpretation of factor contributions within the statistical framework. The general model form is defined as follows:

$$y = \beta_o + \sum_{i=1}^{k} \beta_i x_i + \sum_{i=1}^{k} \beta_{ii} x_i^2 + \sum_{i=1}^{k-1} \sum_{j=i+1}^{k} \beta_{ij} x_i x_j \quad (2)$$

Where, y represents the corresponding performance response, x_i denotes the factors, and β coefficients represent the linear, quadratic, and interaction terms. The validity of the developed RSM models was evaluated using both the design points defined within the FCCD framework and additional off-design test points. During the model validation process, experimental results were compared with RSM predictions, and model adequacy was assessed based on the coefficient of determination (R^2), the adjusted coefficient of determination (R^2_{adj}), and the predicted coefficient of determination (R^2_{pred}). This approach aims to demonstrate that the proposed metamodel equations provide reliable predictive capability not only at the design points but also under intermediate operating conditions.

RESULTS

The derived RSM-based metamodel equations demonstrate a strong representational capability with respect to the experimental findings reported in the literature (Scanavino et al., 2014). The high agreement between the predicted responses and the experimentally measured thrust and power values indicates that the developed quadratic formulations successfully capture the underlying physical trends observed in the reference study. In particular, the consistency of the determination coefficients and the close alignment between experimental data points and model predictions confirm that the proposed metamodels preserve the essential aerodynamic and energetic characteristics documented in the studies of Scanavino et al., 2014. This strong representational fidelity highlights the robustness of the RSM framework in translating experimentally observed performance behavior into analytically tractable and generalizable mathematical expressions.

Isolated Rotor – Thrust Metamodel

The quadratic RSM model developed at a constant temperature of 20 °C represents the experimental data with high accuracy. The model coefficients indicate that altitude has a negative linear effect on thrust, which is physically consistent with the reduction in air density at higher altitudes (Table 5).

Table 5. Coded RSM equation and associated statistical metrics for Isolated Rotor Thrust experimental results at constant temperature of 20 °C

Isolated Rotor Thrust 20 °C (A: Altitude, B: Motor Speed)		
R^2	R^2_{adj}	R^2_{pred}
0.992	0.987	0.922
Coded	$T_{iso} = 4.034 - 3.45A + 5.125B - 3.175AB + 0.856A^2 + 1.51B^2$	

The positive effect of motor speed confirms that thrust production increases with increasing rotational speed. The negative interaction term further indicates that, under high-altitude conditions, the contribution of motor speed to thrust enhancement may be limited. Under constant pressure of 990 mbar, the developed model reveals that motor speed is the dominant governing parameter. The linear and quadratic speed terms reflect the nonlinear nature of thrust behavior, while the effect of temperature remains comparatively limited (Table 6).

Table 6. Coded RSM equation and associated statistical metrics for Isolated Rotor Thrust experimental results under constant pressure of 990 mbar

Isolated Rotor Thrust 990 mbar (A: Temperature, B: Motor Speed)		
R^2	R^2_{adj}	R^2_{pred}
0.999	0.999	0.998
Coded	$T_{iso} = 7.76 - 0.44A + 8.68B - 0.465AB - 0.08A^2 + 2.64B^2$	

Moreover, experimental and RSM comparisons conducted at off-design test points outside the FCCD design space show that the data cluster closely around the y=x line (Figure 1 and Figure 2). This finding demonstrates that the developed metamodel provides strong predictive capability not only within the design space but also under intermediate operating conditions.

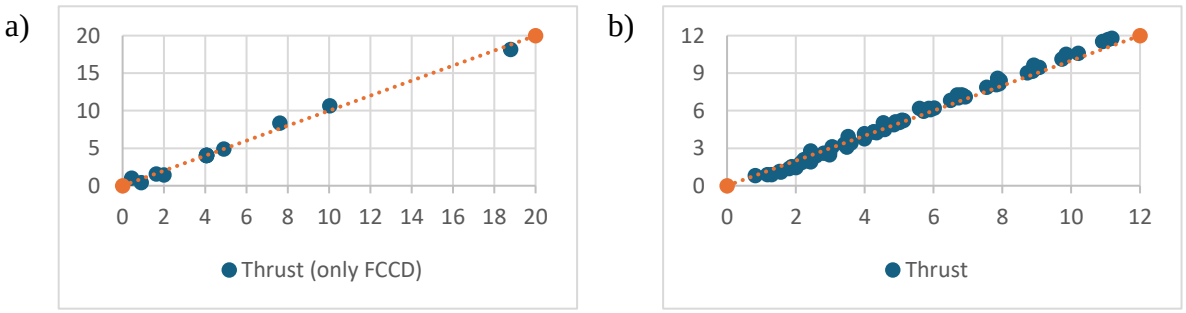


Figure 1. Comparison of experimental Isolated Thrust results and corresponding RSM model predictions at constant temperature of 20 °C: (a) FCCD design points, (b) all data points

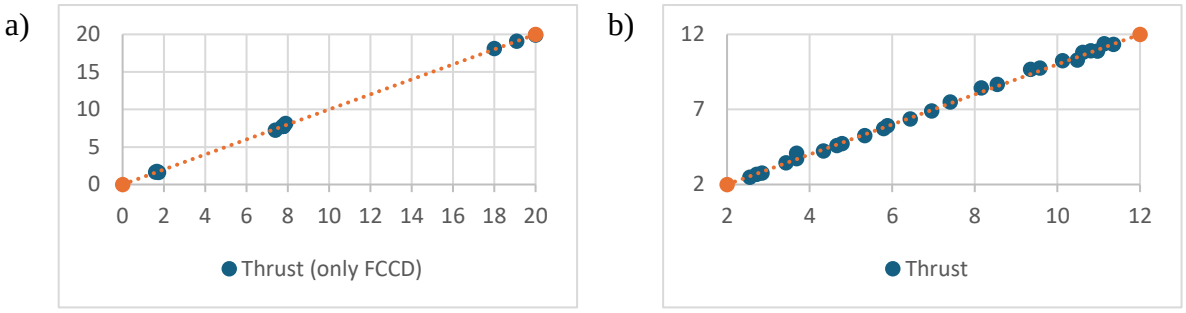


Figure 2. Comparison of experimental Isolated Thrust results and corresponding RSM model predictions under constant pressure of 990 mbar: (a) FCCD design points, (b) all data points

Isolated Rotor – Mechanical Power Metamodel

The isolated rotor mechanical power response is a critical performance indicator for quantitatively evaluating the energy cost associated with thrust generation. Under constant temperature at 20 °C (A: Altitude, B: Motor Speed), the developed quadratic RSM model demonstrates a high level of representational capability (Table 7). The model coefficients indicate that motor speed is the dominant factor governing mechanical power demand through both linear and quadratic terms. The negative linear effect of altitude reflects the variation in power requirement associated with changes in rotor loading characteristics under reduced air density conditions. The negative interaction term further indicates that the influence of motor speed on power exhibits a nonlinear behavior at higher altitudes. Although the predicted coefficient is relatively lower compared to the second scenario, the experimental and RSM comparisons at off-design test points show that the data are tightly clustered around the y=x line. This confirms that the model provides acceptable predictive performance also within intermediate operating regions.

Table 7. Coded RSM equation and associated statistical metrics for Isolated Rotor Mechanical Power experimental results at constant temperature of 20 °C

Isolated Rotor Mechanical Power 20 °C (A: Altitude, B: Motor Speed)		
R^2	R^2_{adj}	R^2_{pred}
0.989	0.982	0.893
Coded	$P_{iso,mec} = 33.367 - 29.45A + 57.81B - 31.375AB + 6.89A^2 + 26.16B^2$	

Under constant pressure at 990 mbar (A: Temperature, B: Motor Speed), the obtained model is statistically very strong (Table 8).

Table 8. Coded RSM equation and associated statistical metrics for Isolated Rotor Mechanical Power experimental results under constant pressure of 990 mbar

Isolated Rotor Mechanical Power 990 mbar (A: Altitude, B: Motor Speed)		
R^2	R^2_{adj}	R^2_{pred}
0.999	0.999	0.999
Coded	$P_{iso,mec} = 60.54 - 3.93A + 95.77B - 4.31AB + 0.2362A^2 + 44.54B^2$	

The dominance of motor speed in both linear and quadratic terms indicates a pronounced increase in mechanical power demand with increasing rotational speed. Although the temperature effect is comparatively limited, its inclusion in both linear and quadratic forms suggests that power behavior may exhibit nonlinear characteristics within certain temperature ranges.

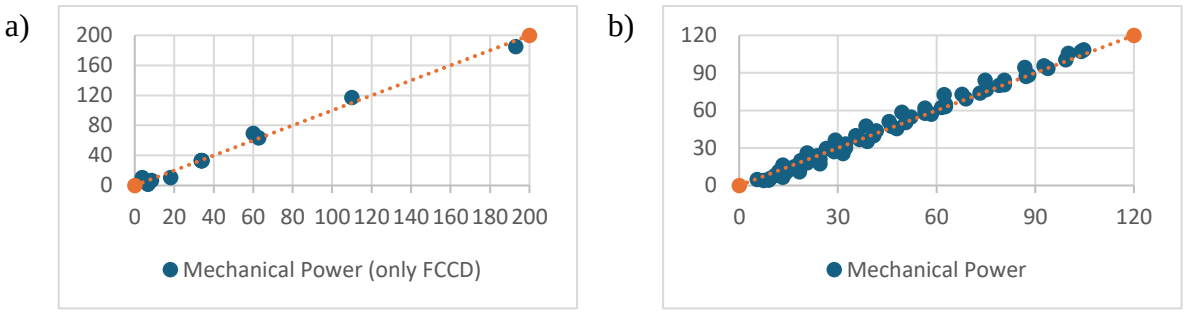


Figure 3. Comparison of experimental Isolated Mechanical Power results and corresponding RSM model predictions at constant temperature of 20 °C: (a) FCCD design points, (b) all data points

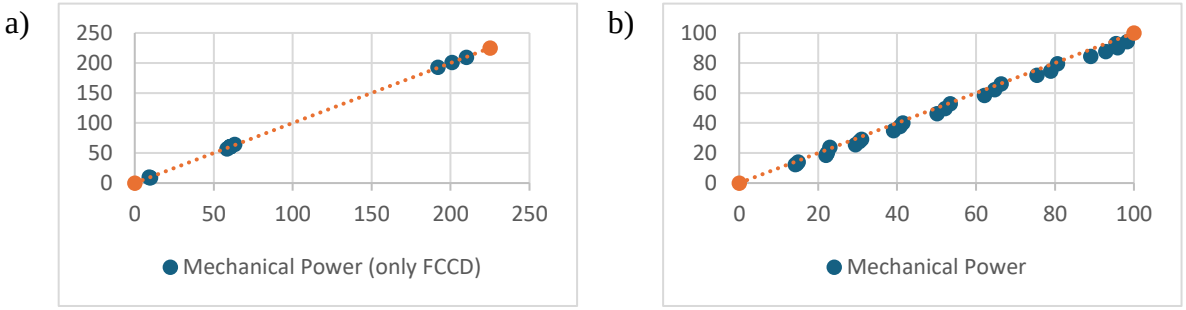


Figure 4. Comparison of experimental Isolated Mechanical Power results and corresponding RSM model predictions under constant pressure of 990 mbar: (a) FCCD design points, (b) all data points

The comparison between experimental results and RSM predictions demonstrates a high level of agreement around the y=x line for both FCCD design points and off-design test points, confirming the robustness and generalizability of the developed metamodel (Figure 3 and Figure 4).

Full Vehicle – Thrust Metamodel

In the full vehicle configuration, the thrust response includes not only rotor aerodynamics but also system-level flow interactions and the power–thrust conversion characteristics. Therefore, the RSM metamodel equations obtained for the full vehicle case are of critical importance for representing the overall system behavior in a closed-form analytical structure. Under constant 20 °C conditions, the developed quadratic model represents the experimental data with high determination coefficients (Table 9).

Table 9. Coded RSM equation and associated statistical metrics for Full Vehicle Thrust experimental results at constant temperature of 20 °C

Full Vehicle Thrust 20 °C (A: Altitude, B: Motor Speed)		
R^2	R^2_{adj}	R^2_{pred}
0.993	0.988	0.932
Coded	$T_{fv} = 16.40 - 12.81A + 19.07B - 11.46AB + 3.09A^2 + 4.94B^2$	

The model coefficients clearly indicate that increasing altitude reduces thrust, while motor speed provides a dominant and positive contribution. The negative interaction term shows that the thrust gain obtained by increasing motor speed becomes limited at higher altitudes, confirming the governing role of environmental rarefaction effects at the system level. The presence of significant quadratic terms further indicates nonlinear behavior within specific operating regions.

Under the constant 990 mbar pressure scenario, the model maintains very high statistical agreement (Table 10).

Table 10. Coded RSM equation and associated statistical metrics for Full Vehicle Thrust experimental results under constant pressure of 990 mbar

Full Vehicle Thrust 990 mbar (A: Altitude, B: Motor Speed)		
R^2	R^2_{adj}	R^2_{pred}
0.999	0.999	0.995
Coded	$T_{fv} = 31.91 - 5.97A + 33.24B - 5.04AB + 0.2731A^2 + 9.06B^2$	

Motor speed remains the dominant parameter affecting thrust, whereas temperature exhibits a comparatively smaller but statistically meaningful influence. The negative interaction term suggests that the combined effect of temperature and motor speed can modify the thrust growth trend.

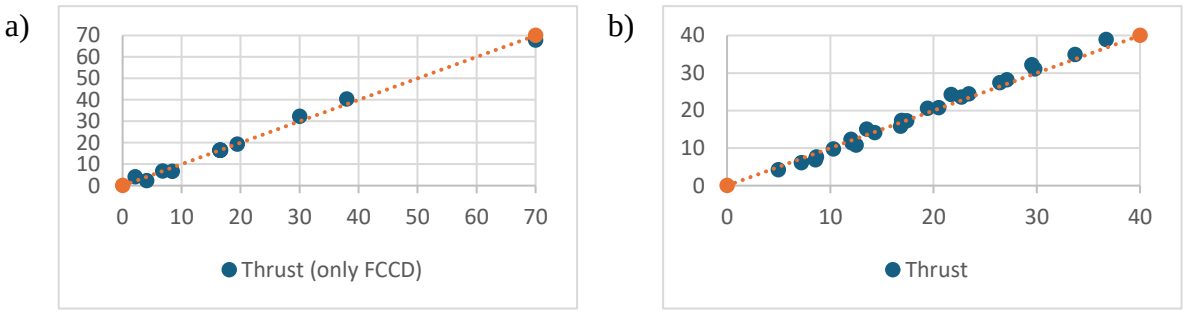


Figure 5. Comparison of experimental Full Vehicle Thrust results and corresponding RSM model predictions at constant temperature of 20 °C: (a) FCCD design points, (b) all data points

The comparison between experimental measurements and RSM predictions demonstrates that both FCCD design points and off-design test points cluster closely around the y=x line, confirming the strong representational capability and generalization performance of the developed metamodel at the system level (Figure 5 and Figure 6).

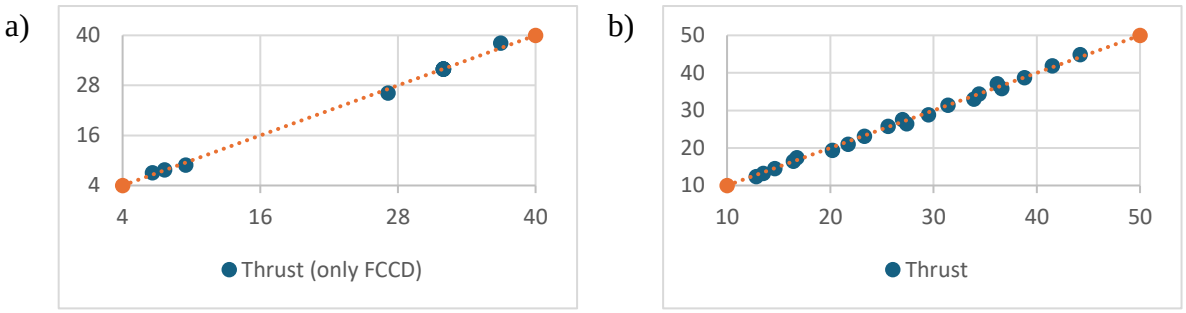


Figure 6. Comparison of experimental Full Vehicle Thrust results and corresponding RSM model predictions under constant pressure of 990 mbar: (a) FCCD design points, (b) all data points

Full Vehicle – Electric Power Metamodel

In the full vehicle configuration, electric power consumption represents the system-level energy requirement and constitutes a key response variable governing mission endurance and energy management. Therefore, the RSM metamodel developed for electric power provides a critical analytical tool for evaluating the performance–energy balance. Under constant 20 °C conditions, the quadratic model represents the experimental data with high accuracy (Table 11).

Table 11. Coded RSM equation and associated statistical metrics for Full Vehicle Electric Power experimental results at constant temperature of 20 °C

Full Vehicle Electric Power 20 °C (A: Altitude, B: Motor Speed)		
R^2	R^2_{adj}	R^2_{pred}
0.997	0.994	0.967
Coded	$P_{fv,elec} = 187.48 - 148A + 295.92B - 148.25AB + 17.31A^2 + 141.06B^2$	

The model coefficients clearly indicate that motor speed has a dominant and nonlinear increasing effect on electric power consumption. The negative linear altitude term and the pronounced negative interaction term demonstrate that the combined effect of altitude and motor speed significantly shapes the energy consumption behavior. The magnitude of the interaction term, in particular, highlights the necessity of multivariable modeling and confirms that single-parameter evaluations would be insufficient to capture the system response.

Under constant 990 mbar pressure conditions, the model exhibits extremely strong statistical agreement (Table 12).

Table 12. Coded RSM equation and associated statistical metrics for Full Vehicle Electric Power experimental results under constant pressure of 990 mbar

Full Vehicle Electric Power 990 mbar (A: Altitude, B: Motor Speed)		
R^2	R^2_{adj}	R^2_{pred}
0.999	0.999	0.999
Coded	$P_{fv,elec} = 343.62 - 44.17A + 543.17B - 43.25AB + 8.33A^2 + 254.33B^2$	

Motor speed emerges as the primary governing parameter of electric power consumption through both its linear and quadratic terms, indicating a distinctly nonlinear growth behavior. Although the

temperature effect is comparatively smaller, its statistically significant contribution to the model suggests that thermal conditions cannot be neglected within certain operating regions. The close clustering of experimental data and RSM predictions around the y=x line, both at design and off-design test points, confirms the strong generalization capability and reliability of the developed metamodel (Figure 7 and Figure 8).

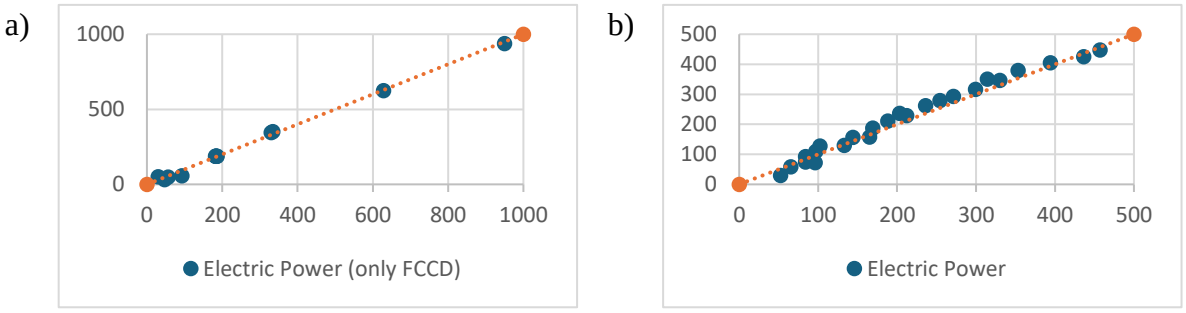


Figure 7. Comparison of experimental Full Vehicle Electric Power results and corresponding RSM model predictions at constant temperature of 20 °C: (a) FCCD design points, (b) all data points

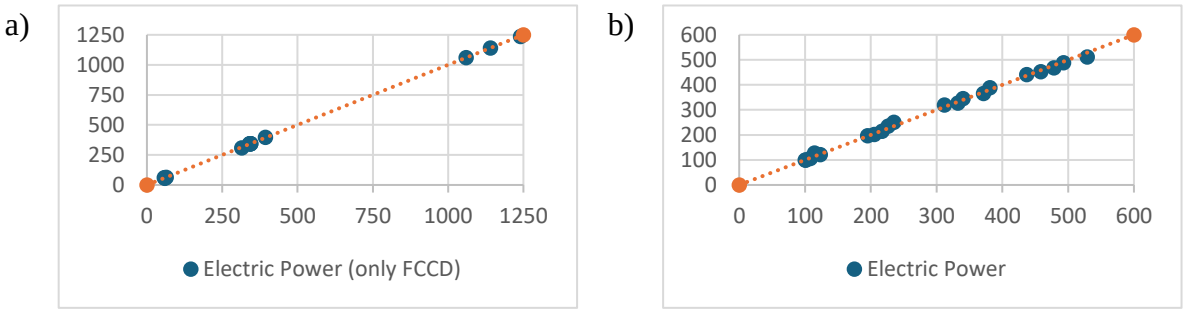


Figure 8. Comparison of experimental Full Vehicle Electric Power results and corresponding RSM model predictions under constant pressure of 990 mbar: (a) FCCD design points, (b) all data points

DISCUSSION

When the obtained results are evaluated collectively, it is observed that the second-order quadratic RSM approach represents the experimental performance behavior with high accuracy for both isolated rotor and full vehicle configurations. In particular, the high R^2_{pred} values obtained under the constant 990 mbar pressure scenarios indicate that the developed metamodel equations provide strong generalization capability beyond the FCCD design points within the temperature–motor speed factor space. Under constant 20 °C conditions, the thrust and full vehicle electric power models demonstrate high predictive performance, whereas the isolated rotor mechanical power model exhibits a comparatively lower R^2_{pred} value. This result suggests that the power response may present a more complex behavior in intermediate operating regions and should be further supported through diagnostic and residual analyses.

For all models, the inclusion of both main effects and interaction terms confirms that the performance responses cannot be adequately explained by single-variable trends. The interaction between altitude or temperature and motor speed plays a decisive role in shaping both thrust and power outputs. This finding highlights the necessity of jointly evaluating environmental conditions and motor operating parameters when assessing UAV propulsion performance. Furthermore, the

close clustering of experimental measurements and RSM predictions around the y=x line, observed for both FCCD design points and off-design test points, demonstrates that the developed metamodels are not only statistically robust but also practically reliable for engineering applications. By transforming a limited set of experimental measurements into analytical, interpretable, and computationally efficient closed-form equations, the RSM framework provides a solid basis for performance estimation, intermediate-condition evaluation, and subsequent optimization or decision-support studies.

CONCLUSIONS

In this study, a RSM-based metamodeling approach grounded on experimental data was developed to predict the thrust and power performance of unmanned aerial vehicles under high-altitude and variable environmental conditions. Quadratic models established for the isolated rotor and full vehicle configurations under altitude–motor speed and temperature–motor speed factor pairs represented the experimental behavior with high R^2, R^2_{adj}, and R^2_{pred} values. The linear, quadratic, and interaction terms included in the model equations clearly revealed the combined influence of environmental conditions and motor speed on performance, demonstrating the inherently nonlinear nature of the system response. Thus, the experimental dataset was transformed beyond discrete measurement points into analytical, generalizable, and interpretable mathematical models.

Within the scope of this study:

- UAV thrust and power performance under high-altitude conditions were modeled through a systematic RSM-based metamodeling framework.
- Closed-form quadratic equations were obtained for four different performance responses at both isolated rotor and full vehicle levels.
- The interaction effects between altitude or temperature and motor speed were quantitatively identified.
- Experimental data were converted into analytical models enabling rapid prediction under intermediate operating conditions.
- The proposed methodology provides an extendable infrastructure that can be integrated with optimization and decision-support approaches.

In this respect, the study demonstrates that RSM is not merely a statistical tool in aerospace applications, but a powerful engineering approach for design-oriented performance evaluation and predictive modeling.

Acknowledgements

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REFERENCES

Brandt, J. and Selig, M., 2011. Propeller performance data at low Reynolds numbers. In: *49th AIAA Aerospace Sciences Meeting including the New Horizons Forum and Aerospace Exposition*. p.1255.

Deters, R.W., Ananda Krishnan, G.K. and Selig, M.S., 2014. Reynolds number effects on the performance of small-scale propellers. In: *32nd AIAA Applied Aerodynamics Conference*. p.2151.

Hadiyat, M.A., Sopha, B.M. and Wibowo, B.S., 2022. Response surface methodology using observational data: a systematic literature review. *Applied Sciences*, 12(20), 10663.

Jdiobe, M., Rouser, K., Paul, R. and Rouser, A., 2022. Validation of a wind tunnel propeller dynamometer for Group 2 unmanned aircraft. *Applied Sciences*, 12(17), 8908.

Konar, M., 2019. GAO algoritma tabanlı YSA modeliyle İHA motorunun performansının ve uçuş süresinin maksimizasyonu. *Avrupa Bilim ve Teknoloji Dergisi*, 15, pp.360–367.

Lamidi, S., Olaleye, N., Bankole, Y., Obalola, A., Aribike, E. and Adigun, I., 2022. Applications of response surface methodology (RSM) in product design, development, and process optimization. In: *IntechOpen*.

MacNeill, R. and Verstraete, D., 2017. Blade element momentum theory extended to model low Reynolds number propeller performance. *The Aeronautical Journal*, 121(1240), pp.835–857.

Ruiz, M.C., Scanavino, M., D'Ambrosio, D., Guglieri, G. and Vilardi, A., 2022. Experimental and numerical analysis of hovering multicopter performance in low-Reynolds number conditions. *Aerospace Science and Technology*, 128, 107777.

Scanavino, M., Avi, A., Vilardi, A. and Guglieri, G., 2020. UAS testing in low pressure and temperature conditions. In: *2020 International Conference on Unmanned Aircraft Systems (ICUAS)*. pp.1757–1765. IEEE.

Susaimanickam, A., Manickam, P. and Joseph, A.A., 2023. A comprehensive review on RSM-coupled optimization techniques and its applications. *Archives of Computational Methods in Engineering*, 30(8), pp.4831–4853.

THE IMPORTANCE OF RENEWABLE ENERGY SOURCES FOR NATIONAL SECURITY: THE CASE OF COUNTRY GEORGIA

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ABSTRACT

Energy security has emerged as one of the most critical and strategic issues of the twenty-first century, shaping state sovereignty, geopolitical influence, and domestic political stability. The management and accessibility of energy resources are directly linked to national security and a state's ability to compete successfully within the global system. For developing states such as Georgia, energy policy represents not only a foundation for economic sustainability but also a key instrument for preserving political independence.

Located at the crossroads between Eastern and Western Europe, Georgia occupies a geopolitically strategic position that simultaneously creates opportunities and vulnerabilities in the field of energy security. Historically, the country's energy system has been characterized by a high level of dependence on imported energy resources, exposing it to external political and economic pressures. However, through the modernization of energy infrastructure and the systematic development of renewable energy sources, Georgia has the potential to substantially reduce this dependence and strengthen both domestic and regional energy autonomy.

Renewable energy sources such as hydropower, solar, and wind energy are not only an economic alternative but also a political instrument of strategic importance. Their expansion decreases reliance on fossil-fuel-exporting states, a factor of critical relevance in Georgia's complex geopolitical environment. At the same time, renewable energy development enhances Georgia's international attractiveness by facilitating foreign investment, strengthening cooperation with the European Union, and aligning national energy policy with global climate and decarburization agendas.

This paper analyses the political opportunities and challenges associated with renewable energy development, with particular emphasis on energy independence, investment mobilization, and Georgia's potential role as a regional energy hub. The study argues that renewable energy should be understood not merely as an environmental or technological initiative, but as a cornerstone of sustainable state development and political security. By advancing renewable energy, Georgia can strengthen its resilience to external pressures, improve long-term stability, and secure a sustainable and politically autonomous future within the evolving global energy order.

Keywords: Energy Security, Political Sovereignty, National Security, Regional Energy Hub.

Introduction

Energy security has become one of the defining strategic concerns of the twenty-first century, reshaping the relationship between energy policy, national security, and state sovereignty. In an international system characterized by geopolitical instability, market volatility, and accelerating climate change, access to reliable and affordable energy is no longer a purely economic or technical

issue. Rather, it constitutes a central dimension of political power, influencing states' strategic autonomy, foreign policy choices, and internal stability.

Traditionally, energy security debates have focused on fossil fuel supply, transportation routes, and producer–consumer relations, particularly in the context of oil and natural gas geopolitics. While these perspectives remain relevant, they increasingly fail to capture the structural transformation currently underway in the global energy system. The ongoing energy transition—marked by the gradual shift from fossil fuels to renewable energy sources—has introduced new political dynamics, redistributing power, altering dependency patterns, and redefining the foundations of national security. As a result, renewable energy has emerged not merely as an environmental response to climate change, but as a strategic instrument with profound political and security implications.

For small and developing states, the security implications of energy policy are particularly pronounced. Limited domestic resources, restricted bargaining power, and high levels of import dependence often translate into heightened vulnerability to external political pressure and supply disruptions. In such contexts, energy dependence can undermine political sovereignty and constrain strategic decision-making. Consequently, the diversification of energy sources and the expansion of domestic energy production have become essential components of national security strategies.

Georgia represents a compelling case for examining the nexus between renewable energy and national security. Located at the crossroads of Eastern and Western Europe, Georgia occupies a geopolitically sensitive position shaped by regional power competition, transit dynamics, and evolving energy corridors. Historically, the country's energy system has been characterized by significant dependence on imported fossil fuels, exposing Georgia to economic risks and external political influence. These structural vulnerabilities have directly affected the country's strategic autonomy and have underscored the importance of energy policy as a national security priority.

At the same time, Georgia possesses substantial renewable energy potential, particularly in hydropower, as well as growing opportunities in wind and solar energy. The development of these resources offers a pathway toward reducing import dependence, enhancing system resilience, and strengthening political autonomy. Moreover, renewable energy development aligns Georgia's domestic policy objectives with broader international frameworks, including European energy integration, climate governance, and decarburization agendas. This alignment carries not only economic benefits but also significant political and strategic value, reinforcing Georgia's international positioning and credibility.

Despite the growing recognition of renewable energy's strategic importance, existing academic literature on Georgia has largely emphasized its role as an energy transit country or has focused on the technical and economic aspects of energy development. Comparatively little attention has been devoted to the political and security implications of renewable energy within Georgia's national context. This paper seeks to address this gap by conceptualizing renewable energy as a core component of national security and by analyzing its role in enhancing Georgia's strategic resilience and political sovereignty.

The central research question guiding this study is: How does the development of renewable energy sources contribute to national security in the case of Georgia? The paper advances the argument that renewable energy should be understood as a strategic political instrument that strengthens national security by reducing external dependency, increasing system resilience, and supporting long-term state stability. Through a qualitative case-study approach grounded in political science and security studies, the research examines the political opportunities and challenges associated with renewable energy development in Georgia.

Research Aim

The primary aim of this study is to examine the strategic importance of renewable energy sources for national security, using Georgia as a case study. The research seeks to conceptualize renewable energy not merely as an environmental or economic policy instrument, but as a core component of national security and political sovereignty. By situating renewable energy development within the broader framework of security studies and political science, the study aims to demonstrate how energy policy can function as a mechanism for enhancing state resilience, strategic autonomy, and long-term stability.

Scientific Novelty

The scientific novelty of this research lies in its analytical reframing of renewable energy as a central pillar of national security policy rather than a peripheral environmental or technological concern. While existing literature on energy security has traditionally focused on fossil fuel geopolitics, supply routes, and transit vulnerabilities, this study advances the field by systematically integrating renewable energy into the national security discourse.

The study's policy-oriented approach adds practical value by identifying the political conditions under which renewable energy development can strengthen national security. These findings have broader applicability beyond Georgia, offering insights for other states facing similar challenges related to energy dependence, geopolitical exposure, and security uncertainty.

Methodology (Political and Strategic Analysis)

This study employs a qualitative political and strategic analysis to examine the relationship between renewable energy development, political risk mitigation, and regional security in the Caucasus. The research applies a regional security studies approach, focusing on Georgia as a case study within the South Caucasus geopolitical environment. It integrates political risk assessment to identify vulnerabilities related to energy dependence, external influence, and regional conflicts. Conceptual and normative analysis is used to evaluate renewable energy as a strategic instrument for enhancing state autonomy, resilience, and bargaining power. The methodology relies on document analysis of policy frameworks, academic literature, and international energy and security reports.

Background of the Subject

Energy security has progressively moved to the forefront of national security debates in the twenty-first century, reflecting the growing interdependence between energy systems, geopolitical stability, and state sovereignty. Traditionally, energy issues were predominantly examined through economic or technical lenses. However, contemporary political science increasingly recognizes energy as a strategic asset that directly shapes power relations between states, influences foreign policy choices, and affects internal political stability.

The intensification of geopolitical tensions, recurrent energy supply disruptions, and the global transition toward decarburization has fundamentally altered the strategic landscape of energy governance. Fossil-fuel dependency has proven to be a structural vulnerability for many states, particularly small and developing countries with limited bargaining power in international energy markets. In this context, renewable energy has emerged as a critical component of energy security strategies, offering not only environmental benefits but also political and strategic advantages.

For Georgia, the subject of renewable energy and national security is especially salient. As a small state located in a geopolitically sensitive region, Georgia has historically experienced energy insecurity driven by high import dependence and exposure to external political pressure. These structural constraints have directly affected the country's strategic autonomy and policy flexibility. Consequently, the development of renewable energy sources represents not merely an economic

or environmental objective, but a broader political strategy aimed at strengthening national resilience, reducing external vulnerability, and enhancing long-term security.

Political Risks and Regional Security in the Caucasus Context

The strategic deployment of renewable energy in the Caucasus region carries significant implications for political stability and regional security. Historically, the region has been characterized by complex geopolitical tensions, territorial disputes, and energy transit vulnerabilities. Georgia, positioned at the crossroads of Eastern Europe and Western Asia, faces challenges related to dependence on imported fossil fuels, exposure to regional conflicts, and the influence of major energy powers. In this context, renewable energy development is not only an economic and environmental priority but also a critical tool for enhancing national and regional resilience.

Energy dependence on foreign suppliers has historically created political and economic leverage for external actors in the Caucasus. Reliance on imported oil and gas from politically sensitive regions exposes countries like Georgia to price volatility, supply disruptions, and coercive diplomacy. By investing in hydropower, solar, and wind infrastructure, Georgia can significantly reduce its vulnerability to external pressures, securing a degree of strategic autonomy in energy policy. This autonomy translates into stronger bargaining power in regional political affairs and greater flexibility in navigating complex alliances and partnerships.

The development of domestic renewable energy also mitigates the risks of regional conflicts over energy resources. Territorial disputes, competing claims to pipelines, and disagreements over transit rights have historically generated tension in the South Caucasus. Diversified renewable energy sources decrease dependency on contested fossil fuel routes and reduce potential triggers for interstate disputes. By promoting energy self-sufficiency and regional cooperation, renewable energy can act as a stabilizing factor, supporting both national security and broader regional stability.

Furthermore, renewable energy projects foster economic and social resilience, which is closely linked to political stability. Decentralized solar and wind installations empower local communities, especially in remote or politically sensitive areas, reducing the potential for social unrest associated with energy scarcity. Rural development through biomass, small hydropower plants, and local energy production enhances socioeconomic equity, strengthens local governance, and decreases the likelihood of conflict over resources. Energy access in underserved regions thereby becomes a tool for political cohesion and nation-building.

In the broader regional context, renewable energy offers opportunities for strategic partnerships and cross-border collaboration. Georgia’s hydropower potential allows it to supply electricity to neighboring countries, increasing its influence in regional energy networks and fostering cooperative frameworks. Such collaboration can reduce dependence on dominant energy actors in the region, enhance mutual security, and create conditions for shared economic growth. International partnerships in renewable energy development also provide access to advanced technologies, financing, and expertise, reinforcing Georgia’s capacity to manage political and energy-related risks.

Climate change and environmental instability further compound regional security risks. Extreme weather events, such as floods, droughts, or storms, can disrupt energy infrastructure, threaten energy supply, and exacerbate political tensions. Renewable energy systems, with their diversified and decentralized nature, increase resilience against such disruptions. By reducing vulnerability to environmental shocks, renewable energy strengthens both national security and regional stability, ensuring continuity of energy supply even in times of crisis.

Finally, the promotion of renewable energy aligns with international norms and frameworks, enhancing Georgia's geopolitical positioning. By contributing to global climate goals and energy transition initiatives, the country can leverage renewable energy development to attract foreign investment, integrate into European and international energy markets, and strengthen diplomatic relations. This proactive engagement reduces external dependency, limits exposure to coercive energy diplomacy, and enhances regional strategic influence.

In summary, renewable energy in the Caucasus serves as a multifaceted tool for mitigating political risks, reinforcing national and regional security, and promoting geopolitical stability. For Georgia, harnessing domestic hydropower, solar, and wind resources reduces dependence on external actors, limits vulnerability to regional conflicts, and strengthens both internal resilience and regional leadership. The strategic integration of renewable energy is therefore a cornerstone of not only sustainable development but also long-term political and security planning in the South Caucasus.

Results

The findings of the study indicate that renewable energy development significantly enhances Georgia's national security in multiple and interrelated ways. First, the expansion of renewable energy reduces structural dependence on imported fossil fuels, thereby limiting exposure to external political leverage and supply disruptions. This contributes directly to strengthening Georgia's strategic autonomy.

Second, renewable energy investment increases system resilience by diversifying the energy mix and promoting decentralized energy production. Such diversification reduces the vulnerability of the national energy system to both geopolitical shocks and climate-related risks, which are increasingly recognized as security threats.

Third, the study finds that renewable energy development enhances Georgia's international political positioning. Alignment with global decarburization agendas and European energy standards improves cooperation with the European Union and increases the country's attractiveness to foreign investors. This, in turn, reinforces Georgia's economic security and political legitimacy.

Finally, the research demonstrates that renewable energy development supports Georgia's long-term ambition to function as a regional energy hub. By expanding domestic generation capacity and export potential, renewable energy strengthens Georgia's role in regional energy governance and contributes to broader strategic stability.

Reference

International Energy Agency (2023). *Energy Security and Clean Energy Transitions*. Paris: IEA.

International Renewable Energy Agency (2023). *World Energy Transitions Outlook 2023*. Abu Dhabi: IRENA.

World Bank (2022). *Georgia: Energy Sector Review and Policy Recommendations*. Washington, DC: World Bank.

European Commission (2022). *REPowerEU Plan*. Brussels: European Union.

BP (2023). *Statistical Review of World Energy 2023*. London: BP.

Ministry of Economy and Sustainable Development of Georgia (2020). *Georgia's Energy Strategy 2030*. Tbilisi: Government of Georgia.

Georgian State Electrosystem (2022). *Ten-Year Network Development Plan (TYNDP)*. Tbilisi: GSE.

National Statistics Office of Georgia (2023). *Energy Balance of Georgia*. Tbilisi: Geostat.

United Nations (2015). *Paris Agreement on Climate Change*. New York: United Nations.

NATO (2021). *Energy Security: Strategic Awareness and Policy Implications*. Brussels: NATO.

IDENTIFICATION RISK GROUPS AMONG TUBERCULOSIS PATIENTS IN ALBANIA, 2015–2024

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ABSTRACT

Tuberculosis (TB) remains a major public health issue, particularly in vulnerable groups. In low-incidence countries like Albania, TB is concentrated in at-risk populations, migrants, homeless people, drug users, alcoholics, and prisoners, prompting targeted active case-finding strategies to improve early diagnosis and control. This study aims to identify and analyze risk groups among TB patients in Albania, using epidemiological data from a sample of 3,518 patients for the period 2015–2024. Of these, 1583 patients (45%) were identified as being part of at-risk groups. The most frequent at-risk groups were smokers, 630 (40%), and alcohol users, 573 (36%), which account for over a third of total cases. Others include immigrants, 149 (9.4%), the Roma community, 92 (5.8%), prisoners, 41 (2.6%), miners, 33 (2.1%), health workers, 32 (2%), intravenous drug users, 15 (0.9%), the homeless, 11 (0.7%), people with mental health issues 7 (0.4%) and HIV positive patients, 44 (,2.8%). Based on analysis of TB forms, 1180 cases (74.5%) were pulmonary TB, and 403 cases (25.5%) were extrapulmonary TB, with a ratio of 3:1 in favor of the pulmonary form. Comparisons showed that the distribution of forms varied according to social and risk factors, as well as by gender: males, 1213 (76.6%), and females, 370 (23.4%). Lifestyle factors, such as smoking and alcohol, contribute to increased susceptibility to TB by weakening the immune system. Statistical analysis showed a significant association between the year of study and risk groups (Chi-square, $p < 0.05$). Social factors, particularly migration and incarceration, are strongly linked to TB burden, with pulmonary TB predominant in other groups. The findings emphasize the need for targeted screening, interventions for smokers and alcohol users, protective measures for professionals, integration with mental health and addiction services, and education and monitoring for vulnerable populations

Keywords: Tuberculosis, risk groups, prevention, social factors

INTRODUCTION

Tuberculosis (TB), caused by *Mycobacterium tuberculosis*, remains one of the most significant infectious diseases worldwide and a persistent public health challenge. According to the World Health Organization, millions of new cases are reported each year, with the highest burden occurring in low- and middle-income countries. Although the infection may remain latent for years, a proportion of infected individuals progress to active disease, particularly those belonging

to high-risk groups. The identification of risk groups among TB patients is essential for early intervention, effective prevention, and reduction of disease transmission. These groups include individuals with compromised immune systems, such as people living with HIV, patients with diabetes mellitus or other chronic conditions, as well as socially vulnerable populations, including those living in overcrowded conditions, poverty, or with limited access to healthcare services. Furthermore, factors such as malnutrition, tobacco use, and prolonged exposure to active TB cases significantly increase the risk of developing active disease.

MATERIALS AND METHODS

This study was designed as an observational analysis aimed at identifying risk groups among patients diagnosed with tuberculosis. Data were collected retrospectively, in accordance with the study design, from the clinical records of patients treated for TB over a defined time period. The study population included patients of all age groups with a confirmed diagnosis of pulmonary or extrapulmonary TB. The analysis encompassed patients registered and treated for TB during the period 2015–2024 at University Hospital 'Shefqet Ndroqi', a national referral center for pulmonary diseases, in collaboration with the structures of the National Tuberculosis Control Program. The variables collected included demographic characteristics (age, sex, and place of residence), socioeconomic factors, HIV infection status, diabetes mellitus, and tobacco or alcohol use. Statistical analysis was performed using descriptive and analytical methods. Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS).

RESULTS

A total of 1,583 patients were included in this study. The age-group distribution showed a clear concentration of cases among middle-aged and older adults. The highest number of patients was observed in the 15–34 years age group, with 565 cases (35.7%), making it the most represented category. The 45–54 years and ≥65 years age groups were also significantly represented, with 249 (15.7%) and 391 (24.7%) cases, respectively. Overall, more than two-thirds of patients were adults and elderly individuals, while children and adolescents (0–14 years) accounted for only 0.1% of the total, reflecting a strong concentration of morbidity among adult age groups. The highest proportion of smokers was observed in the 15–34-year age group, indicating a notable presence among young and middle-aged adults. However, a considerable number of smokers were also identified among patients aged ≥65 years, suggesting that tobacco use remains prevalent even in older age groups. This distribution highlights the persistent impact of smoking as a risk factor across the entire age spectrum. Alcohol-related cases showed a progressive increase with advancing age. While alcohol use was present among younger individuals, its impact became more pronounced in older age groups, possibly reflecting long-term exposure to this risk factor. Migration-related factors were more prevalent in the 25–34-year age group and gradually decreased with increasing age. This suggests that this social category is more concentrated among young and economically active adults.

Table 2. Risk Factors by Age Group

Risk factor / Age group	**0–14**	**15–34**	**35–44**	**45–54**	**55–64**	**>65**	**Number of patients**	**Percentage (%)**
Tobacco	1	290	110	80	200	121	630	40
Alcohol	0	120	90	110	189	216	573	36
Emigrant	0	60	35	25	20	9	149	9,4
Roma	0	30	20	15	15	12	92	5,8
Prison	0	20	10	5	3	3	41	2,6
Miner	0	15	10	5	2	1	33	2,1
Healthcare personnel	0	20	5	3	2	2	32	2
Injecting drug user	0	5	2	3	7	23	15	0,9
Living alone	0	2	1	2	3	3	11	0,7
Mental illness	0	3	1	1	1	1	7	0,4
Total	1	565	284	249	442	391	1583	100
Percentage %	**0.1**	**35,7**	**17,9**	**15,7**	**27,9**	**24,7**	**100**	

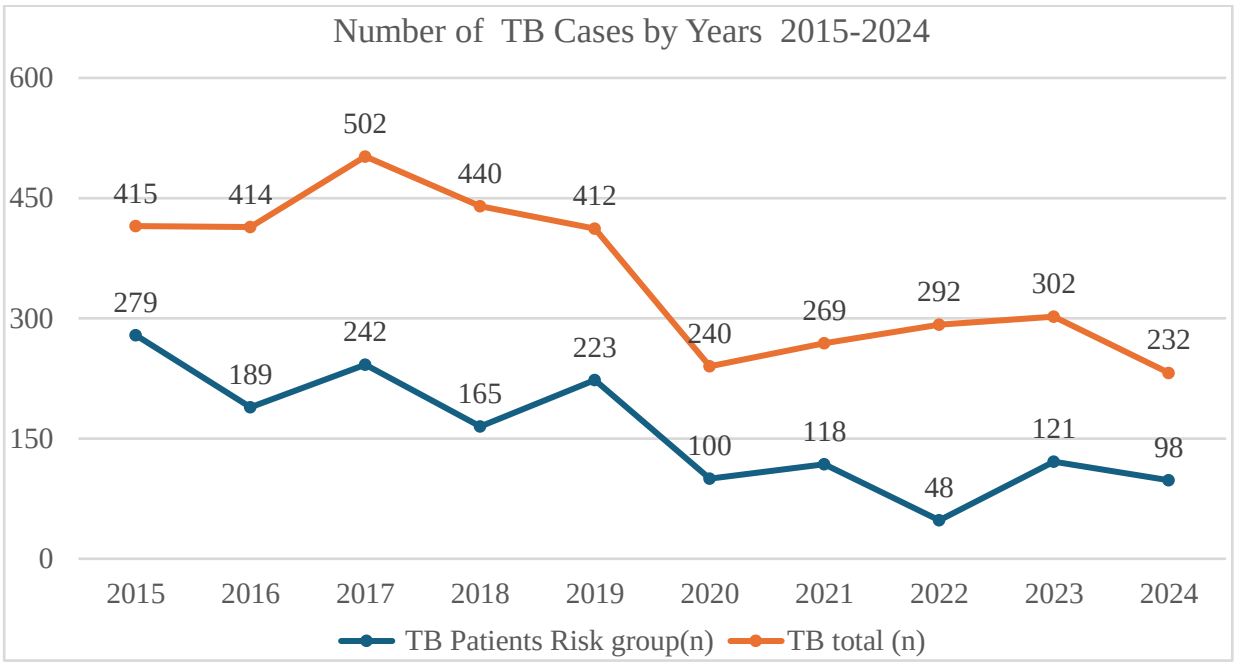
The analysis of risk factor distribution showed that the most frequent risk groups were smokers (630 patients; 40%) and alcohol users (573 patients; 36%), together accounting for over three-quarters of the total cases. Other identified risk categories included immigrants (149; 9.4%), individuals from the Roma community (92; 5.8%), prisoners (41; 2.6%), miners (33; 2.1%), healthcare workers (32; 2%), intravenous drug users (15; 0.9%), homeless individuals (11; 0.7%), individuals with mental health disorders (7; 0.4%), and HIV-positive patients (44; 2.8%). These findings indicate a clear predominance of lifestyle-related factors compared to social and occupational factors.

Table 1. Risk Factors by Age Group

Year	Tobacco	Alcohol	Emigrant	Roma population	Prison	Miner	Healthcare personnel	Injecting drug user	Living alone	Mental illness	%
2015	107	122	28	11	0	1	2	2	2	4	17,6
2016	44	50	34	30	22	1	2	5	1	0	11,9
2017	81	87	28	16	9	10	6	5	0	0	15,3
2018	64	61	13	13	3	5	2	2	2	0	10,4
2019	105	80	8	8	6	8	6	0	2	0	14,1
2020	60	27	4	0	0	1	5	1	2	0	6,3
2021	45	59	1	5	0	2	4	0	0	2	7,5
2022	15	18	5	3	0	4	1	0	2	0	3,0
2023	53	52	8	4	0	1	3	0	0	0	7,6
2024	56	17	20	2	1	0	1	0	0	1	6,2
Total	630	573	149	92	41	33	32	15	11	7	100,0

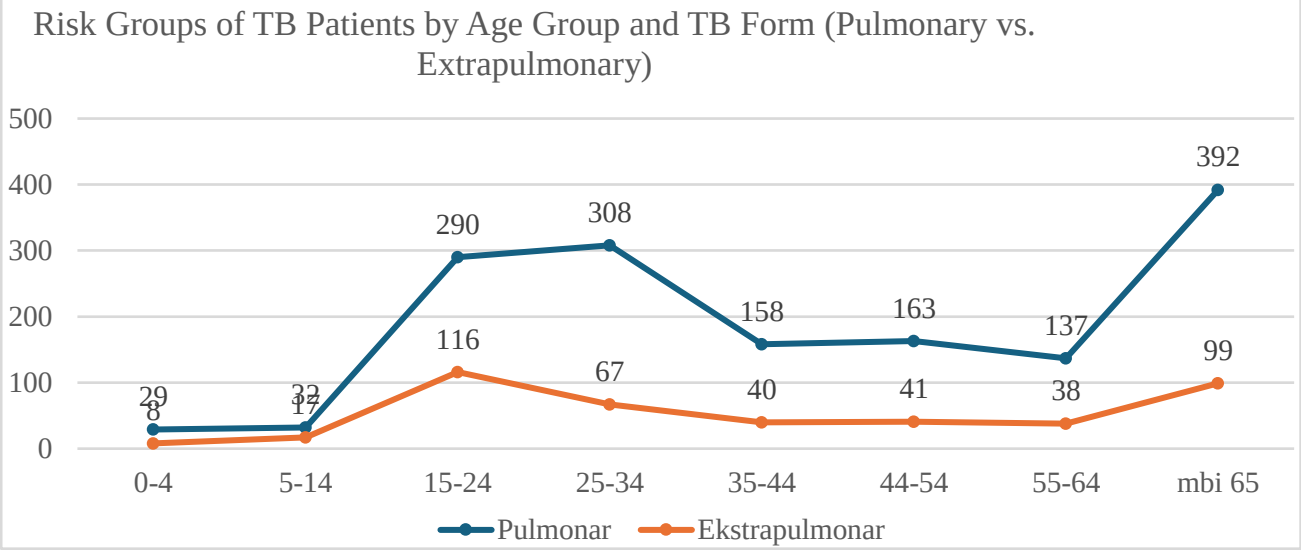
The data presented below provide an analysis of tuberculosis distribution according to clinical forms and age groups. The study aims to identify key trends and highlight the proportion of individuals belonging to high-risk groups. According to the analysis, approximately 45% of individuals in these groups are affected or at risk, indicating the need for increased attention and targeted interventions for disease prevention and treatment. The distribution by age and clinical form helps identify the most vulnerable segments of the population, enabling more effective planning of preventive programs, monitoring strategies, and health education initiatives.

Figure 1. Number of TB Cases by Years, 2015-2024



The figure illustrates the distribution of pulmonary and extrapulmonary TB cases across age groups. Overall, pulmonary TB predominates in all age categories, indicating that it is the most common clinical form regardless of age. Pulmonary TB cases show a marked increase from childhood to young adulthood, rising sharply in the 15–24 and 25–34 age groups, where high case numbers are observed. After a decline in the 35–64 age range, a pronounced peak is evident in patients aged ≥65 years, representing the highest burden of pulmonary TB. This pattern suggests a bimodal distribution, with increased vulnerability among young adults and the elderly. Extrapulmonary TB follows a similar but less pronounced age-related trend. Cases increase from childhood to young adulthood, peaking in the 15–24 age group, followed by a gradual decline in middle-aged adults. As with pulmonary TB, a secondary increase is observed in patients aged ≥65 years, although the absolute numbers remain substantially lower than those of pulmonary TB. The consistently lower counts of extrapulmonary TB across all age groups indicate that, while present throughout the lifespan, this form contributes a smaller proportion of the total TB burden. The parallel increase of both TB forms in older age groups suggests that advancing age is associated with a higher overall susceptibility to TB, likely related to immunosenescence and the accumulation of comorbidities

Figura 2: Risk Groups of TB Patients by Age Group and TB Form (Pulmonary vs. Extrapulmonary)



DISCUSSION

The data analysis reveals a clear patient profile in relation to age and risk factors. The high concentration of cases among individuals over 55 years old, and especially those over 65, suggests that older adults are more exposed to morbidity or complications associated with lifestyle-related risk factors. This finding aligns with existing literature, which often reports an increased prevalence of chronic diseases and risk factors in older populations. The primary risk factors in this population are tobacco and alcohol use, which together account for approximately 76% of cases. The significant impact of these lifestyle factors highlights the need for preventive interventions, such as smoking cessation programs and education on moderate alcohol consumption, particularly targeting both younger and older age groups. Among younger individuals (15–34 years), the predominance of tobacco use indicates that preventive measures should begin early to reduce long-term health consequences. Conversely, in older adults, the progressive increase in alcohol-related cases suggests that cumulative alcohol consumption over the years may be an important contributor to the development of chronic diseases. Social and occupational factors—including migration, Roma ethnicity, history of incarceration, and work as a miner—showed lower prevalence and were mainly observed in the active age group (15–44 years). This indicates that, although social and policy interventions are important for social equity, their impact may be more limited compared to lifestyle factors in this population.

CONCLUSION

The study population demonstrates a notable concentration of cases among middle-aged and older adults, indicating that advancing age is associated with higher health risk. The primary risk factors are largely lifestyle-related, including tobacco use and alcohol consumption, emphasizing the importance of targeted preventive interventions. Among younger individuals, particularly those aged 15–34, interventions should focus on preventing the initiation of tobacco use and providing education on alcohol consumption. In contrast, programs for older adults should address the long-term consequences of alcohol use and promote the maintenance of a healthy lifestyle. Although social and occupational factors are less prevalent, they remain important for shaping social policies and community programs targeting the active age groups. Furthermore, unusual findings, such as

the presence of older adults who are injecting drug users, suggest the need for further studies on the long-term impact of these factors on population health. Overall, these data underscore the necessity of integrated preventive and policy strategies that address both lifestyle and social determinants, aiming to reduce health risks and improve the overall well-being of patients.

REFERENCES

Asgharzadeh, V., Seyyed Rezaei, S.A., et al. (2025). Host Risk Factors for Tuberculosis. *Infect Disord Drug Targets, 25*(4), e18715265304343.

Author(s) of systematic review on healthcare workers] (2025). Prevalence and associated factors of tuberculosis among healthcare workers: a systematic review with meta-analysis. *[Journal]*.

Centers for Disease Control and Prevention (2024). Tuberculosis Risk Factors. CDC.

Centers for Disease Control and Prevention (2025). Reported Tuberculosis in the United States, 2023: Risk Factors. CDC.

Chauhan, A et al. (2024). Prevalence of Tuberculosis Infection among Various Risk Groups in India: A Systematic Review and Meta-Analysis. *Indian J Community Med, 49*(5), 669680.

Nicholson, T. et al. (2023). A systematic review of risk factors for mortality among tuberculosis patients in South Africa. *Syst Rev, 12*, 23.

Simou, Britton, and LeonardiBee (2018) – This meta-analysis found that individuals with high alcohol consumption had a significantly increased risk of developing tuberculosis compared with those with low or no intake.

World Health Organization (2013). Systematic Screening for Active Tuberculosis: Principles and Recommendations. WHO. **World Health Organization (2025).** Tuberculosis among populations at high risk and people in vulnerable situations: policy brief. Geneva: WHO.

Zhou et al. (2022) – A systematic review and meta-analysis identifying advanced age (over 60) and smoking among factors increasing risk for hospital-acquired infections in TB patients

EFFECTS OF A 3-MONTH STRUCTURED EXERCISE PROGRAM ON QUALITY OF LIFE (QOL) IN POSTPARTUM WOMEN

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ABSTRACT

The postpartum period represents a critical transitional phase marked by substantial physical, psychological, and social changes that can negatively affect women's quality of life (QoL). Common challenges include reduced physical capacity, persistent fatigue, emotional fluctuations, and altered body image. Structured physical activity has emerged as an effective approach to support recovery and enhance overall well-being, yet evidence on its multidimensional impact remains limited.

This study aimed to evaluate the effects of a 3-month structured exercise program on physical, psychological, and social components of QoL in postpartum women. Fifty women aged 24–45 years, at three months postpartum, were randomly assigned to an experimental group (n=25) or a control group (n=25). The experimental group engaged in a 12-week supervised program, consisting of three 60-minute sessions per week that included moderate-intensity aerobic exercise, strengthening of the lower back, abdominal, and pelvic floor muscles, as well as relaxation techniques. The control group received standard postpartum care.

Quality of life was assessed using the SF-36 questionnaire at baseline and post-intervention. Following the program, the experimental group showed statistically significant improvements in physical functioning, emotional well-being, and social functioning compared to controls. Participants also reported reduced fatigue and enhanced body image perception.

These findings demonstrate that structured exercise programs during the postpartum period can significantly improve multidimensional quality of life, addressing both physical and psychological needs. Integrating such programs into routine postpartum care offers a practical, non-pharmacological strategy to promote maternal recovery, enhance well-being, and support long-term health outcomes. This study underscores the critical role of targeted physical activity interventions in optimizing postpartum quality of life.

Keywords: Physical activity, women, postpartum period, quality of life, well-being.

INTRODUCTION

The postpartum period is a critical transitional phase in a woman's life, characterized by physiological, psychological, and social changes that can significantly impact overall well-being and quality of life. Many women experience fatigue, reduced physical capacity, sleep disturbances, mood fluctuations, and changes in body image, which may interfere with daily functioning (Bø et al., 2020; Kołomańska and Mazur-Bialy, 2021). Beyond physical recovery, emotional adaptation and social reintegration are essential for maintaining maternal health.

Physical activity has been recognized as an effective strategy to support recovery and enhance well-being during the postpartum period. Structured exercise programs, including moderate-intensity aerobic activity, core and pelvic muscle strengthening, and relaxation techniques, have been shown to improve physical functioning, reduce fatigue, and promote psychological health (Sanchez-Garcia et al., 2022; Ryhtä et al., 2023).

Despite these benefits, comprehensive evaluation of combined physical, emotional, and social outcomes remains limited. This study aims to assess the effects of a 3-month structured exercise program on postpartum women, focusing on physical functioning, emotional well-being, and overall quality of life.

METHODOLOGY

This randomized controlled study evaluated the effects of a structured exercise program on postpartum women's quality of life. Fifty women, aged 25–45 years and six months postpartum, were randomly assigned to an experimental group (n=25) or a control group (n=25).

The experimental group participated in a 12-week exercise program, three sessions per week (60 minutes each), including moderate-intensity aerobic activity, lower back, abdominal, and pelvic floor strengthening exercises, and relaxation techniques. The control group continued their usual daily routines without structured exercise.

Quality of life was assessed using the SF-36 questionnaire, focusing on physical functioning, emotional well-being, and social functioning. For quantitative analysis, responses were converted into numerical scores, which were then summed and normalized to create composite scores for each dimension.

This approach allowed a precise comparison between groups, showing how structured exercise influenced physical, emotional, and social health during the postpartum period.

Table 1. Quality of Life Responses in the Experimental Group (n=25)

Question	Response	Frequency (n)	Percentage (%)
1. How easy or difficult is it for you to perform daily activities (e.g., washing, dressing, walking at home)?	A little Very little Not at all	3 12 7	12.00% 48.00% 28.00%
2. Do you feel physically tired during the day?	A little Very little Not at all	3 15 7	12.00% 60.00% 28.00%
3. How often do you feel worried or stressed during the day?	A little Very little Not at all	5 13 7	20.00% 52.00% 28.00%
4. Do you feel happy and satisfied with your life?	Very much A little Not at all	17 5 3	68.00% 20.00% 12.00%
5. How did you feel during physical activity?	Very good Good Bad	25 0 0	100.00% 0.00% 0.00%
6. Compared to three months ago, how is your psycho-emotional health today after physical activity?	Very good Good Bad	25 0 0	100.00% 0.00% 0.00%

Table 2. Quality of Life Responses in the Control Group (n=25)

Question	Response	Frequency (n)	Percentage (%
1. How easy or difficult is it for you to perform daily activities (e.g., washing, dressing, walking at home)?	A little Very little Not at all	17 5 3	68.00% 20.00% 12.00%
2. Do you feel physically tired during the day?	A little Very little Not at all	16 5 4	64.00% 20.00% 16.00%
3. How often do you feel worried or stressed during the day?	A little Very little Not at all	18 5 2	72.00% 20.00% 8.00%
4. Do you feel happy and satisfied with your life?	Very much A little Not at all	12 7 6	48.00% 28.00% 24.00%
5. How did you feel during physical activity?	Very good Good Bad	0 0 0	0.00% 0.00% 0.00%
6. Compared to three months ago, how is your psycho-emotional health today?	Very good Good Bad	7 13 5	28.00% 52.00% 20.00%

Table 3. Comparative Quality of Life Responses Between Experimental and Control Groups (n=25 each)

Question	Response	Experimental Group n (%)	Control Group n (%)
1. How easy or difficult is it for you to perform daily activities (e.g., washing, dressing, walking at home)?	A little Very little Not at all	3 (12.00%) 12 (48.00%) 7 (28.00%)	17 (68.00%) 5 (20.00%) 3 (12.00%)
2. Do you feel physically tired during the day?	A little Very little Not at all	3 (12.00%) 15 (60.00%) 7 (28.00%)	16 (64.00%) 5 (20.00%) 4 (16.00%)
3. How often do you feel worried or stressed during the day?	A little Very little Not at all	5 (20.00%) 13 (52.00%) 7 (28.00%)	18 (72.00%) 5 (20.00%) 2 (8.00%)
4. Do you feel happy and satisfied with your life?	Very much A little Not at all	17 (68.00%) 5 (20.00%) 3 (12.00%)	12 (48.00%) 7 (28.00%) 6 (24.00%)
5. How did you feel during physical activity?	Very good Good Bad	25 (100.00%) 0 (0.00%) 0 (0.00%)	0 (0.00%) 0 (0.00%) 0 (0.00%)
6. Compared to three months ago, how is your psycho-emotional health today?	Very good Good Bad	25 (100.00%) 0 (0.00%) 0 (0.00%)	7 (28.00%) 13 (52.00%) 5 (20.00%)

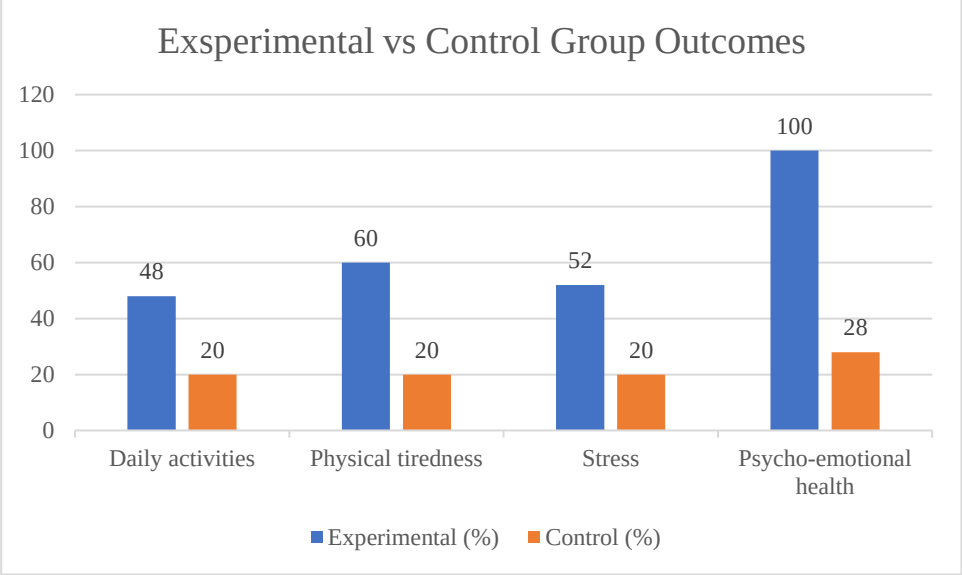


Figure 1. Comparison of physical and psycho-emotional outcomes between groups

RESULTS

The present study evaluated the impact of a 3-month structured exercise program on the quality of life of postpartum women. Fifty women participated, with 25 assigned to the experimental group and 25 to the control group. The SF-36 questionnaire was used to assess physical, psychological, and social components of well-being.

Analysis of the experimental group responses indicated substantial improvements across all dimensions. Specifically:

- **Physical Functioning:** Only 12% of women reported minor difficulty performing daily activities, while 48% reported very little difficulty, and 28% reported none at all.
- **Fatigue:** 12% felt slightly tired during the day, 60% reported very little fatigue, and 28% reported no fatigue.
- **Stress Levels:** 20% felt slightly worried or stressed, 52% reported very little, and 28% reported no stress.
- **Life Satisfaction:** 68% reported feeling very happy and satisfied with life, 20% a little, and 12% not at all.
- **Experience During Exercise:** All participants (100%) reported feeling "very good" during the physical activity sessions.
- **Psycho-Emotional Health Compared to Three Months Ago:** Again, all participants (100%) reported significant improvement ("very good") in their psycho-emotional well-being following the exercise program.

Comparative analysis with the control group revealed that women who did not participate in structured physical activity experienced more fatigue, stress, and lower overall satisfaction with life. Only 28% of control participants reported improved psycho-emotional health compared to three months prior, while the experimental group showed 100% improvement.

These results strongly indicate that structured exercise interventions in the postpartum period significantly enhance physical, psychological, and social well-being, reduce fatigue and stress, and improve overall life satisfaction. Integrating structured physical activity programs into postpartum care can provide a practical and effective strategy to support comprehensive maternal recovery.

DISCUSSION

This study showed that a 3-month structured exercise program significantly improved quality of life in postpartum women. Participants in the experimental group reported less difficulty with daily activities, reduced fatigue, lower stress, and higher life satisfaction compared to baseline and to the control group.

These findings are consistent with recent studies showing that moderate-intensity exercise enhances physical recovery, emotional well-being, and self-perception after childbirth (Sanchez-Garcia et al., 2022; Kołomańska and Mazur-Bialy, 2021; Molina-García et al., 2022). The improvements in psycho-emotional health suggest that structured activity can reduce postpartum stress and promote a positive body image.

Control group data indicate that women who did not participate in structured exercise reported higher fatigue and stress, confirming that regular physical activity is a key factor in postpartum recovery (Giallo et al., 2022).

Structured exercise programs are practical, non-pharmacological interventions that can be integrated into postpartum care to support comprehensive maternal recovery. Limitations include reliance on self-reported measures and incomplete control group data, highlighting the need for larger, longitudinal studies with objective assessments.

CONCLUSIONS

The 3-month structured exercise program had a clear positive impact on postpartum women's quality of life. Physical functioning, emotional well-being, and psycho-social health improved significantly in the experimental group compared to the control group.

These results suggest that regular, moderate-intensity physical activity is an effective, non-pharmacological strategy to support maternal recovery after childbirth. Integrating structured exercise into postpartum care can reduce fatigue, lower stress, improve life satisfaction, and enhance body image.

Future research should include larger samples, objective measures, and long-term follow-up to confirm these benefits and guide implementation in postpartum health programs.

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REFERENCES

Bø K, Hilde G, Tennfjord MK, Engh ME 2020. Pelvic floor muscle training and physical activity in the postpartum period: a systematic review and meta-analysis. British Journal of Sports Medicine, 54(23): 1371-1378.

Davenport MH, Ruchat SM, Poitras VJ, et al. 2020. 2019 Canadian guideline for physical activity throughout pregnancy and the postpartum period. British Journal of Sports Medicine, 54(23): 1389-1396.

Dias N, Pereira A, Fonseca J, et al. 2021. Effects of a postpartum exercise program on pelvic floor muscle strength and quality of life: randomized controlled trial. International Urogynecology Journal, 32(5): 1253-1261.

Fisch KM, Sadeh-Sharvit S, Fitzsimmons-Craft EE, et al. 2021. A randomized controlled trial of a postpartum exercise intervention to improve body image and psychological well-being. Body Image, 37: 119-128.

Giallo R, Cooklin A, D'Esposito F, et al. 2022. Physical activity, fatigue and quality of life in women during the postpartum period: a longitudinal study. BMC Pregnancy and Childbirth, 22: 214.

Kołomańska D, Mazur-Bialy A 2021. Physical activity and depressive symptoms in postpartum women: systematic review and meta-analysis. International Journal of Environmental Research and Public Health, 18(13): 6812.

Molina-García P, Hidalgo-Lopezosa P, et al. 2022. Effectiveness of structured exercise programs in improving health-related quality of life in postpartum women: systematic review. Healthcare, 10(4): 742.

Poyatos-León R, Sanabria-Martínez G, Garcia-Hermoso A, et al. 2020. Effects of exercise-based interventions on postpartum depression: meta-analysis of randomized controlled trials. Journal of Clinical Medicine, 9(6): 1653.

Ryhtä I, Kazemi K, Niela-Vilen H, et al. 2023. The effectiveness of an online exercise program on physical activity and quality of life in postpartum women. International Journal of Nursing Studies, 137: 104391.

Sanchez-Garcia JC, Aguilar-Cordero MJ, Montiel-Troya M, et al. 2022. Quality of life in postpartum recovery after a hypopressive exercise program: randomized clinical trial. Journal of Clinical Medicine, 11(19): 5592.

Siani S, Smith L, Jones D, et al. 2023. Associations between physical activity levels and quality of life among postpartum women. Journal of Obstetrics and Gynaecology Research, 49(3): 1012-1020.

Teychenne M, Abbott G, Ball K 2020. Physical activity and depressive symptoms in the postpartum period: prospective cohort study. Mental Health and Physical Activity, 19: 100344.

Vargas-Terrones M, Barakat R, Santacruz B, et al. 2021. Physical exercise programme during postpartum improves health perception and physical recovery: randomized controlled trial. Women and Birth, 34(2): e173-e180.

Wilcox S, Liu J, Sevoyan M, et al. 2024. Effects of a behavioral intervention on physical activity and health-related quality of life in postpartum women: randomized controlled trial. BMC Pregnancy and Childbirth, 24: 808.

Zhou C, Li X, Wang Y, et al. 2022. Postpartum exercise interventions and multidimensional quality of life outcomes: systematic review and meta-analysis. International Journal of Environmental Research and Public Health, 19(21): 14231.

COMPARISON OF PERCEPTIONS OF PHYSICAL ACTIVITY DURING PREGNANCY ACROSS TWO DIFFERENT TIME PERIODS

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ABSTRACT

Physical activity during pregnancy is increasingly recognized as a key factor for maternal physical and psychological well-being, as well as for optimal fetal development. However, cultural, informational, and socio-economic factors have historically influenced women's attitudes and practices regarding prenatal exercise.

This study aimed to analyze changes in perceptions and practices of physical activity among pregnant women by comparing data from 2015 and 2025. A total of 830 pregnant women (400 in 2015 and 430 in 2025) were recruited from three maternal healthcare centers in Tirana and Durrës, Albania. A mixed-methods approach was used, combining structured questionnaires and in-depth interviews to assess knowledge, attitudes, and engagement in physical activity.

The results show a positive trend in both prenatal and postpartum physical activity. Engagement in physical activity at least once in a lifetime increased from 56.3% in 2015 to 63.5% in 2025, while the proportion of women who did not engage in any activity during pregnancy decreased from 15.3% to 12.3%. Interest in attending gyms postpartum also increased from 22.3% to 30.0%. These findings reflect improved awareness and perceptions regarding the benefits of physical activity during and after pregnancy.

In conclusion, there is a clear shift toward more active lifestyles and greater openness to structured postpartum fitness programs. Despite progress, cultural and infrastructural barriers remain, highlighting the need for educational programs, community interventions, and supportive policies to promote safe and sustainable physical activity among pregnant women.

Keywords: Physical activity, perception, pregnancy, postpartum fitness, prenatal education.

INTRODUCTION

Physical activity during pregnancy is a key component for the physical and psychological well-being of the mother, as well as for optimal fetal development. Studies have shown that women who engage in regular physical activity during the prenatal period have a lower risk of complications such as hypertension, gestational diabetes, and psychological stress (Adem, 2025; AlBlooshi et al., 2023; Alhemedi et al., 2025). Furthermore, physical activity during pregnancy is associated with faster postpartum recovery and a reduction in musculoskeletal and postural discomfort (Shum et al., 2022; Ma et al., 2023).

However, perceptions and practices related to physical activity during pregnancy have historically been influenced by cultural, educational, and socio-economic factors (Dudonienė & Kuisma, 2023; Suberu & Adeoye, 2024). In some cultures, traditional beliefs encourage women to limit physical activity in order to avoid perceived risks to the fetus, despite evidence-based recommendations (Saghir et al., 2025; Shum et al., 2022).

The role of healthcare professionals is crucial in shaping women's attitudes toward physical activity by providing personalized advice and safe exercise programs (Cannon et al., 2023; Benyian, 2024). Additionally, prenatal awareness and education have been shown to increase active participation and modify negative perceptions regarding exercise during pregnancy (Dudonienė & Kuisma, 2023; May et al., 2024).

The aim of this study was to compare perceptions and practices regarding physical activity during pregnancy between 2015 and 2025 in the cities of Tirana and Durrës, evaluating changes in knowledge, attitudes, and actual engagement (Alhemedi et al., 2025; Shum et al., 2022). Through this comparison, the study seeks to identify factors that have influenced the evolution of perceptions and to provide recommendations for educational and policy interventions that promote a healthy and active pregnancy (May et al., 2024; Suberu & Adeoye, 2024).

METHODOLOGY

This study was based on a mixed quantitative and qualitative approach. A total of 830 pregnant women were included, divided into two time groups: 400 women in 2015 and 430 women in 2025. Participants were selected from three healthcare centers in the cities of Tirana and Durrës.

Data were collected through a moderated structured questionnaire and in-depth interviews. The focus was on perceptions of physical activity during pregnancy and postpartum, gym attendance, as well as previous physical activity practices.

Statistical analysis was conducted to compare percentages, means, and differences between 2015 and 2025, while thematic interpretation helped identify factors influencing the evolution of perceptions.

RESULTS

Table 1. Key results of the questionnaire – Year 2015 (N = 400)

Category / Question	Number of participants	Percentage (%)
Engagement in physical activity / sports at least once in lifetime	225	56.3%
Did not engage in physical activity during pregnancy	61	15.3%
Wish to attend gyms / fitness centers postpartum	89	22.3%

Table 2. Key results of the questionnaire – Year 2025 (N = 430)

Category / Question	Number of participants	Percentage (%)
Engagement in physical activity / sports at least once in lifetime	273	63.5%
Did not engage in physical activity during pregnancy	53	12.3%
Wish to attend gyms / fitness centers postpartum	129	30.0%

Table 3. Comparison of percentages between the years 2015 and 2025

Category / Question	Year 2015 (%)	Year 2025 (%)	Change (%)
Engagement in physical activity / sports at least once in lifetime	56.3%	63.5%	+7.2%
Did not engage in physical activity during pregnancy	15.3%	12.3%	-3.0%
Wish to attend gyms / fitness centers postpartum	22.3%	30.0%	+7.7%

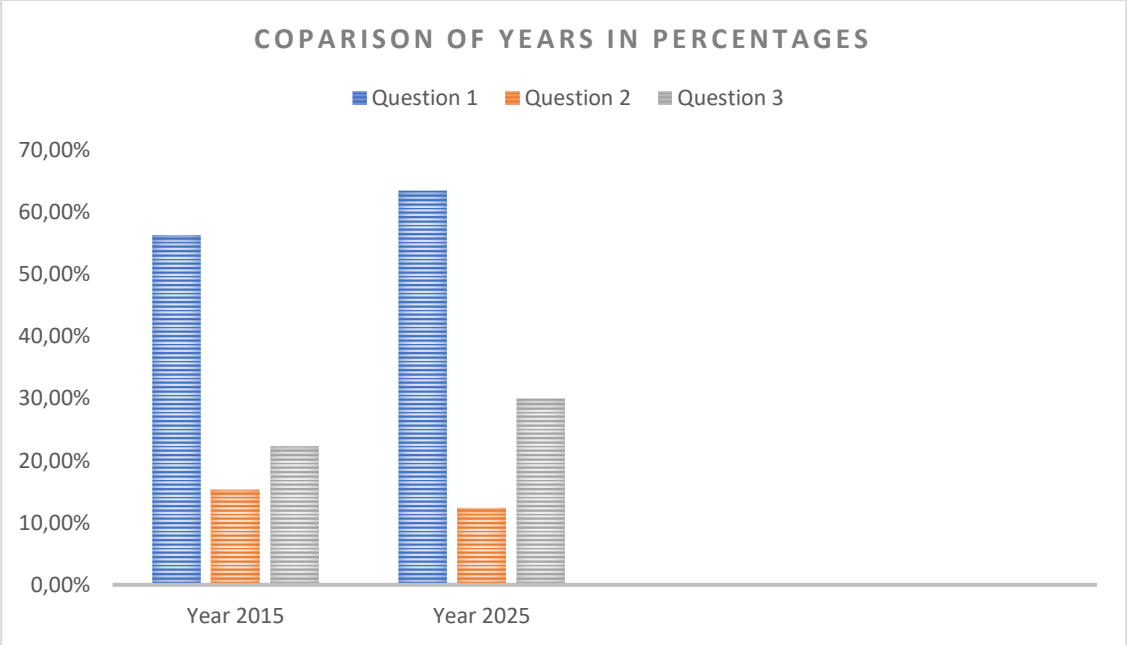


Figure 1. Comparison of physical activity percentages during and after pregnancy (2015 vs 2025)

The comparison of data from 2015 and 2025 indicates a positive trend in both participation in physical activity and postpartum fitness intentions.

- **Engagement in physical activity at least once in a lifetime** increased from **56.3% in 2015** to **63.5% in 2025**, showing a **7.2% increase**.
- The percentage of women who **did not engage in any physical activity during pregnancy** decreased from **15.3% in 2015** to **12.3% in 2025**, representing a **3.0% reduction**.
- The number of women expressing a **wish to attend gyms or fitness centers postpartum** increased from **22.3% in 2015** to **30.0% in 2025**, a **7.7% increase**.

These results reflect improvements in both knowledge and perceptions regarding the benefits of physical activity during and after pregnancy. Overall, there is a clear shift toward more active lifestyles and greater openness to structured postpartum fitness programs.The comparison of the data shows a positive trend: an increase in participation in physical activity and gym attendance, as well as a decrease in the number of women who did not engage in activity during pregnancy. This change reflects improvements in perceptions and knowledge regarding physical activity.

DISCUSSION

This study demonstrates a clear positive shift in perceptions and engagement in physical activity among pregnant women in Albania over the past decade. Increased awareness, prenatal education, and professional guidance appear to have contributed to higher participation in prenatal and postpartum physical activity, consistent with international evidence highlighting the importance of structured fitness interventions (Adem, 2025; AlBlooshi et al., 2023; Cannon et al., 2023).

The rising interest in attending gyms and fitness centers postpartum underscores the value of continuous support and health promotion programs in fostering long-term active lifestyles (Benyian, 2024; Dudonienė, 2023; May et al., 2024). These findings align with studies showing that prenatal and postpartum exercise not only enhances maternal physical well-being but also positively impacts psychological health, reducing anxiety and stress (Alhemedi et al., 2025; Ma et al., 2023).

Despite these improvements, cultural and logistical barriers continue to influence participation. Traditional norms, limited access to appropriate facilities, and gaps in professional guidance can hinder engagement in physical activity during pregnancy (McKeough et al., 2022; Shum et al., 2022; Suberu & Adeoye, 2024). Addressing these challenges through targeted community interventions and supportive policies is essential for sustaining safe and effective prenatal exercise practices.

Overall, this study confirms a gradual shift toward evidence-based perceptions of physical activity in Albania. The findings provide a foundation for developing educational programs, community-oriented initiatives, and policy measures that encourage healthy, active pregnancies and address persistent cultural barriers (Benyian, 2024; Dudonienė & Kuisma, 2023).

CONCLUSIONS

The study shows that perceptions and knowledge regarding physical activity during and after pregnancy have significantly improved from 2015 to 2025. The increase in participation in physical activity and interest in attending gyms postpartum reflects a more open and evidence-based approach to active living. The decrease in the number of women who did not engage in activity during pregnancy, from 61 to 53, indicates a positive trend toward active participation, highlighting the impact of education and professional guidance.

Cultural barriers, lack of institutional support, and inadequate infrastructure remain important challenges, requiring sustained community-level interventions and supportive policies from healthcare and local institutions.

The results of this study suggest the need for:

- Integrated prenatal and postnatal educational programs
- Continuous support for gym attendance and physical activity postpartum
- Policies that promote a safe and accessible environment for physical activity among pregnant women

Ultimately, this study provides a strong foundation for future research and the development of practical strategies aimed at improving maternal and fetal health through safe and moderate physical activity.

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REFERENCES

Adem A 2025. Prenatal physical activity: Trends and health outcomes. Journal of Maternal Health, 12(3): 145-157.

AlBlooshi F, Ahmed R, Khan S 2023. Exercise during pregnancy: Knowledge, attitudes, and practices among expectant mothers. International Journal of Women's Health, 15: 221-233.

Alhemedi AJ, Beni Yonis OB, Abdo N, Salem HA, Alomari E, Alrosan RF, Alfaqeh Q, Hamza EM, Naser AY 2025. Knowledge, attitudes, and practices of pregnant Jordanian women towards physical activity in pregnancy: A cross-sectional study. Medicine, 104(15): e42149.

Benyian D 2024. Promoting maternal health through prenatal exercise programs: A global perspective. Maternal and Child Health Review, 18(2): 89-104.

Cannon K, Hayman L, Lastella M 2023. The impact of structured prenatal fitness interventions on maternal wellbeing. BMC Pregnancy and Childbirth, 23: 56.

Dudonienė V 2023. Perceptions of physical activity among pregnant women: A cross-cultural study. Eurpean Journal of Obstetrics & Gynecology, 45(1): 33-44.

Dudonienė V, Kuisma R 2023. Women's knowledge and perceptions of the effect of exercise during pregnancy: A cross-sectional study. International Journal of Environmental Research and Public Health, 20(3): 1822.

Lawson R, Michler L 2014. Maternal exercise and pregnancy outcomes: Evidence from longitudinal studies. Health Science Reports, 9(2): 101-112.

Ma N, Chau JP, Zang Y, Deng Y, Wong CL, Thompson DR 2023. Perceptions and experiences of exercise among pregnant women. Midwifery, 125: 103792.

May C, Johnson T, Li H 2024. Policy interventions to support prenatal physical activity: A systematic review. Journal of Public Health Policy, 45: 78-95.

McKeough C, Blanchard C, Piccinini-Vallis H 2022. Barriers and facilitators to physical activity in pregnany: A mixed-methods study. Women & Health, 62(7): 654-670.

Shum R, Wong P, Lee C 2022. Cultural influences on prenatal exercise adherence. Global Health Journal, 11(4): 199-212.

Suberu O, Adeoye O 2024. Socio-cultural determinants of physical activity participation among pregnant women in urban settings. African Journal of Reproductive Health, 28(1): 55-68.

THE ROLE OF OXIDATIVE STRESS IN MALE REPRODUCTIVE HEALTH: A COMPARATIVE ANALYSIS OF 8-ISOPROSTAGLANDIN AND RAFTLIN LEVELS

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ABSTRACT

Oxidative stress is a major contributor to male infertility; however, conventional semen analysis often fails to reflect underlying molecular alterations. This study aimed to evaluate seminal plasma levels of 8-isoprostaglandin F2α (8-iso-PGF2α) and raftlin in men with different sperm abnormalities and to investigate their potential associations with sperm dysfunction.

This cross-sectional study included 119 male participants who underwent routine semen analysis. According to World Health Organization criteria, participants were classified into five groups: normospermia (n = 40), oligoteratospermia (n = 25), teratospermia (n = 26), asthenospermia (n = 12), and azoospermia (n = 16). Seminal plasma was separated following semen analysis, and 8-iso-PGF2α and raftlin levels were measured using enzyme-linked immunosorbent assays (ELISA). Statistical comparisons among groups were performed using appropriate parametric or nonparametric tests.

No significant differences were observed among the groups in terms of age or semen volume ($p > 0.05$). In contrast, seminal 8-iso-PGF2α and raftlin levels differed significantly between groups ($p < 0.05$). Both biomarkers were significantly elevated in infertile groups compared with normospermic controls, with the highest levels detected in the azoospermic group. A similar distribution pattern was observed for both parameters, suggesting a parallel relationship between oxidative lipid peroxidation and membrane-associated alterations.

These findings indicate that increased seminal 8-iso-PGF2α and raftlin levels are associated with male infertility. The combined assessment of oxidative stress and membrane-associated biomarkers may provide complementary information to conventional semen analysis in the evaluation of male reproductive dysfunction.

Keywords: Male infertility; Seminal plasma; Oxidative stress; 8-Isoprostaglandin; Raftlin; Sperm abnormalities

INTRODUCTION

Male infertility represents a significant global health problem and contributes to approximately 40–50% of infertility cases among couples worldwide (Agarwal et al., 2021). Conventional semen

analysis, including sperm concentration, motility, and morphology, remains the cornerstone of male fertility assessment. However, these parameters often fail to fully explain idiopathic infertility, highlighting the need for complementary molecular and biochemical biomarkers that reflect underlying pathophysiological mechanisms (Barratt et al., 2018; Kumar and Singh, 2020).

Oxidative stress has been widely recognized as a central factor in male reproductive dysfunction. Spermatozoa are particularly vulnerable to oxidative damage due to the high polyunsaturated fatty acid content of their plasma membranes and their limited intrinsic antioxidant capacity (Aitken and Baker, 2006). Excessive production of reactive oxygen species (ROS) disrupts sperm membrane integrity, impairs mitochondrial function, induces DNA fragmentation, and ultimately compromises fertilization potential (Tremellen, 2008).

Among oxidative stress biomarkers, 8-isoprostaglandin F2α (8-iso-PGF2α) is considered a reliable and stable indicator of lipid peroxidation in vivo (Dutta et al., 2019; Milne et al., 2007). Elevated levels of 8-isoprostaglandins have been reported in various pathological conditions associated with oxidative damage, including male infertility, and have been correlated with impaired sperm quality parameters (Dutta et al., 2019). Measurement of 8-iso-PGF2α in seminal fluid provides a direct reflection of oxidative injury within the male reproductive tract.

In addition to oxidative stress markers, emerging evidence suggests that membrane-associated proteins involved in lipid raft organization may play a critical role in sperm function. Raftlin is a lipid raft–associated protein essential for maintaining membrane microdomain integrity and regulating signal transduction processes (Saeki et al., 2009). While raftlin has been extensively studied in immune cell signaling and membrane dynamics, its role in reproductive biology remains largely unexplored. Disruption of lipid raft structures has been implicated in altered sperm capacitation, motility, and acrosome reaction, suggesting that raft-associated proteins may influence male fertility outcomes (Saeki et al., 2009).

Despite growing interest in oxidative stress and membrane biology in reproductive medicine, data evaluating the combined assessment of 8-isoprostaglandin and raftlin levels in seminal fluid are extremely limited. To date, few studies have investigated raftlin in the context of male infertility, and its potential association with oxidative stress–related sperm dysfunction has not been clearly defined.

Therefore, the present study aimed to evaluate seminal fluid levels of 8-isoprostaglandin and raftlin in fertile and infertile men with different sperm abnormalities and to explore their potential associations with conventional sperm parameters.

MATERIALS AND METHODS

Study Design and Participants

This cross-sectional study was conducted between April and June 2024 at the In Vitro Fertilization (IVF) Center of Kahramanmaraş Sütçü İmam University Faculty of Medicine. A total of 119 male participants who were referred for semen analysis due to infertility evaluation were included after obtaining written informed consent.

Infertility was defined as the inability to achieve pregnancy after at least 12 months of regular unprotected sexual intercourse (Brannigan et al., 2024). Participants with a history of chronic systemic disease, acute infection, malignancy, radiotherapy or chemotherapy exposure, varicocele surgery, or known genetic abnormalities were excluded. In addition, individuals who were active smokers, consumed alcohol regularly, or used antioxidant supplements were not included in the study.

Semen Collection and Analysis

Semen samples were obtained by masturbation into sterile containers following 3–5 days of sexual abstinence. All samples were allowed to liquefy at room temperature and analyzed within one hour of collection.

Semen analysis was performed according to the World Health Organization (WHO) Laboratory Manual for the Examination and Processing of Human Semen (WHO, 2021). Semen volume, sperm concentration, total motility, progressive motility, and morphology were evaluated.

Based on sperm parameters, participants were classified into five groups:

Group 1: Normospermia

Group 2: Oligoteratospermia

Group 3: Teratospermia

Group 4: Asthenospermia

Group 5: Azoospermia

Preparation of Seminal Plasma

After completion of routine semen analysis, samples were centrifuged at 3000 rpm for 15 minutes to separate seminal plasma from cellular components. The supernatant was carefully collected and stored at −80 °C until biochemical analysis. Repeated freeze–thaw cycles were avoided.

Measurement of 8-Isoprostaglandin and Raftlin Levels

Seminal plasma concentrations of 8-isoprostaglandin F2α and raftlin were measured using commercially available enzyme-linked immunosorbent assay (ELISA) kits, in accordance with the manufacturers' instructions. All samples were analyzed in duplicate, and absorbance values were read using a microplate ELISA reader.

Ethical Approval

The study protocol was approved by the Kahramanmaraş Sütçü İmam University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee. All procedures were performed in accordance with the principles of the Declaration of Helsinki (World Medical Association, 2013). Written informed consent was obtained from all participants prior to enrollment.

Statistical Analysis

Statistical analyses were performed using SPSS software (version 22.0; IBM Corp., USA). Data distribution was assessed using the Shapiro–Wilk test. Comparisons among groups were conducted using one-way analysis of variance (ANOVA) or the Kruskal–Wallis test as appropriate. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 119 male participants were included in the study and classified into five groups according to semen analysis parameters: normospermia (n = 40), oligoteratospermia (n = 25), teratospermia (n = 26), asthenospermia (n = 12), and azoospermia (n = 16).

Demographic and Semen Characteristics

No statistically significant differences were observed among the groups regarding age or semen volume ($p > 0.05$), indicating comparable baseline characteristics across the study groups (Table 1).

Seminal 8-Isoprostaglandin Levels

Seminal plasma 8-isoprostaglandin levels differed significantly among the groups ($p < 0.05$). Infertile groups showed higher concentrations compared with the normospermic control group. The highest levels were observed in the azoospermia group, followed by the teratospermia, asthenospermia, and oligoteratospermia groups, whereas the lowest values were detected in the normospermic group (Table 1, Figure 1).

Seminal Raftlin Levels

Raftlin concentrations also differed significantly among the study groups ($p < 0.05$). All infertile groups exhibited elevated raftlin levels compared with normospermic individuals. The highest raftlin levels were observed in the azoospermia group, whereas the lowest values were found in the normospermic group (Table 1, Figure 1).

Comparative Pattern of Oxidative and Membrane-Associated Markers

Both 8-isoprostaglandin and raftlin levels showed a similar distribution pattern across the groups, with progressively higher concentrations observed in infertile conditions. This parallel increase suggests a potential association between oxidative stress-related lipid peroxidation and alterations in membrane-associated signaling components.

Table 1. Seminal plasma raftlin and 8-isoprostaglandin levels according to sperm abnormality groups

Parameter	Normospermia (n=40)	Oligoteratospermia (n=25)	Teratospermia (n=26)	Asthenospermia (n=12)	Azoospermia (n=16)	p-value
Raftlin (ng/mL)	1.84 ± 0.59^{a}	2.71 ± 0.80^{b}	3.81 ± 0.57^{c}	3.52 ± 1.02^{c}	5.03 ± 0.85^{d}	<0.05
8-Isoprostaglandin (ng/mL)	1.31 ± 0.38^{a}	1.96 ± 0.52^{b}	2.66 ± 0.70^{c}	2.53 ± 1.09^{c}	5.37 ± 0.58^{d}	<0.05

Footnote: Values are expressed as mean ± SD. Different superscript letters (a–d) indicate statistically significant differences between groups based on post hoc multiple comparison tests. Overall group comparisons were performed using one-way ANOVA for normally distributed variables or the Kruskal–Wallis test for non-normally distributed variables. A p-value <0.05 was considered statistically significant.

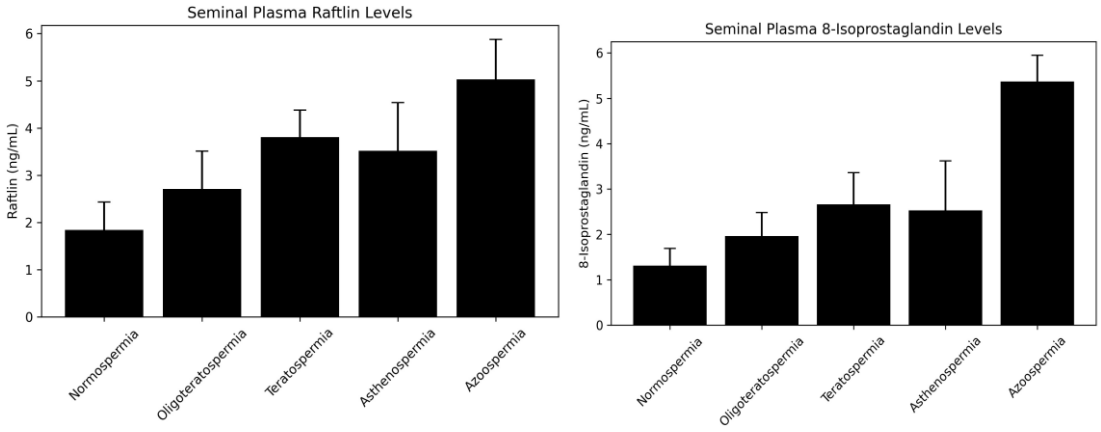


Figure 1. Seminal plasma Raftlin and 8-isoprostaglandin levels. Values are expressed as mean ± SD.

DISCUSSION

The present study demonstrates that seminal plasma levels of 8-isoprostaglandin F2α (8-iso-PGF2α) and raftlin are significantly elevated in infertile men compared with normospermic controls. Notably, the highest concentrations of both biomarkers were observed in the azoospermic group. These findings provide further evidence supporting the contribution of oxidative stress and membrane-associated alterations to male reproductive dysfunction.

Conventional semen analysis remains the cornerstone of male infertility evaluation; however, its diagnostic capacity is limited to descriptive parameters such as sperm concentration, motility, and morphology. Increasing evidence indicates that these parameters alone may not fully capture the underlying molecular disturbances associated with impaired fertility. Contemporary clinical guidelines emphasize the importance of integrating mechanistically informative biomarkers into male infertility assessment, particularly in cases where standard semen parameters offer incomplete explanations (Brannigan et al., 2024).

Oxidative stress has been widely recognized as a central pathogenic factor in male infertility. Spermatozoa are especially susceptible to oxidative damage due to the high content of polyunsaturated fatty acids in their plasma membranes and their limited intrinsic antioxidant defenses (Aitken and Baker, 2006). In this context, F2-isoprostanes, including 8-iso-PGF2α, are considered robust and stable indicators of lipid peroxidation in vivo (Montuschi et al., 2004; Roberts and Milne, 2009). Elevated seminal 8-isoprostane levels have been previously associated with impaired sperm quality and motility defects (Khosrowbeygi and Zarghami, 2008). Consistent with these observations, our findings reveal progressively higher 8-iso-PGF2α concentrations across infertile phenotypes, with the most pronounced elevations detected in azoospermia. This pattern suggests that oxidative lipid injury may be strongly linked not only to functional sperm abnormalities but also to more severe spermatogenic disturbances.

The markedly elevated levels observed in the azoospermic group may reflect more profound disturbances within the testicular microenvironment. Azoospermia is frequently associated with severe spermatogenic impairment, Sertoli cell dysfunction, and altered redox homeostasis. Increased oxidative stress under such conditions may arise from disrupted germ cell turnover, mitochondrial dysfunction, and inflammatory processes within the seminiferous epithelium. Consequently, the pronounced elevation of both 8-iso-PGF2α and raftlin may represent a biochemical signature of extensive cellular and membrane remodeling rather than solely functional sperm abnormalities.

Beyond oxidative stress, membrane organization plays a fundamental role in sperm function. Lipid rafts are dynamic membrane microdomains that regulate signaling pathways essential for sperm maturation, capacitation, and fertilization competence (Simons and Ikonen, 1997; van Gestel et al., 2005). Raftlin, a major lipid raft–associated protein, is known to contribute to membrane microdomain stability and signal transduction in various cell types (Saeki et al., 2003). Although raftlin has been extensively studied in immune cells, its role in reproductive biology remains largely unexplored.

In the present study, raftlin levels exhibited a distribution pattern closely paralleling that of 8-iso-PGF2α. All infertile groups showed elevated raftlin concentrations, with the highest levels again observed in azoospermia. This parallel increase may reflect a biologically coherent interaction between oxidative lipid damage and membrane microdomain remodeling. Oxidative stress is known to alter membrane lipid composition, fluidity, and protein organization, potentially disrupting raft-associated signaling processes critical for sperm viability and function (Dutta et al.,

2019). Therefore, increased raftlin levels may represent a compensatory response to membrane instability or an indicator of altered membrane dynamics under oxidative conditions.

The concordant elevation of oxidative stress and membrane-associated markers supports an integrated pathophysiological model in male infertility. Rather than acting as isolated processes, oxidative damage and membrane disorganization likely interact to exacerbate sperm dysfunction. This concept aligns with emerging evidence suggesting that lipid peroxidation products can influence membrane structure and signaling pathways, thereby affecting sperm physiology at multiple levels (Mottola et al., 2024; Rodak et al., 2025).

From a clinical perspective, these findings highlight the potential utility of combined biomarker assessment. While oxidative stress markers alone provide valuable insights, integrating membrane-associated proteins such as raftlin may enhance the understanding of sperm dysfunction mechanisms. Such multidimensional evaluation strategies may be particularly relevant in patients with unexplained infertility or discordant semen parameters.

Nevertheless, several limitations should be considered. The cross-sectional design precludes causal interpretation of the observed associations. Additionally, functional sperm parameters, including DNA fragmentation and capacitation markers, were not evaluated. Future studies incorporating longitudinal designs and mechanistic analyses are warranted to clarify the biological significance of raftlin alterations and their relationship with oxidative stress pathways.

CONCLUSION

In conclusion, the present study demonstrates that seminal plasma levels of 8-isoprostaglandin and raftlin are significantly elevated in infertile men compared with normospermic controls. These findings suggest that oxidative lipid peroxidation and membrane microdomain–associated alterations may jointly contribute to sperm dysfunction. The combined assessment of these biomarkers may provide complementary information to conventional semen analysis and support a more comprehensive evaluation of male infertility.

LIMITATIONS

This study has several limitations. First, its single-center, cross-sectional design limits causal interpretation of the observed associations. Second, functional sperm parameters such as DNA fragmentation or capacitation markers were not evaluated, which could further clarify the biological relevance of raftlin alterations. Finally, longitudinal and interventional data were not available to determine whether modulation of oxidative stress influences raftlin levels or reproductive outcomes. Future multi-center studies incorporating functional and molecular analyses are warranted.

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REFERENCES

- Agarwal A, Baskaran S, Parekh N, Cho CL, Henkel R, Vij S, Arafa M, Panner Selvam MK, Shah R 2021. Male infertility. *Lancet*, 397(10271): 319–333.

- Aitken RJ, Baker MA 2006. Oxidative stress, sperm survival and fertility control. *Molecular and Cellular Endocrinology*, 250(1–2): 66–69.
- Barratt CLR, De Jonge CJ, Sharpe RM 2018. 'Man Up': The importance and strategy for placing male reproductive health centre stage in the political and research agenda. *Human Reproduction*, 33(4): 541–545.
- Brannigan RE, Hermanson L, Kaczmarek J, Kim SK, Kirkby E, Tanrikut C 2024. Updates to Male Infertility: AUA/ASRM Guideline (2024). *Journal of Urology*, 212(6): 789–799.
- Dutta S, Majzoub A, Agarwal A 2019. Oxidative stress and sperm function: A systematic review on evaluation and management. *Arab Journal of Urology*, 17(2): 87–97.
- Khosrowbeygi A, Zarghami N 2008. Seminal plasma levels of free 8-isoprostane and its relationship with sperm quality parameters. *Indian Journal of Clinical Biochemistry*, 23(1): 49–52.
- Kumar N, Singh NK 2020. Emerging role of novel seminal plasma biomarkers in male infertility: A review. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, 253: 170–179.
- Milne GL, Yin H, Brooks JD, Sanchez S, Jackson Roberts L 2nd, Morrow JD 2007. Quantification of F2-isoprostanes in biological fluids and tissues as a measure of oxidant stress. *Methods in Enzymology*, 433: 113–126.
- Montuschi P, Barnes PJ, Roberts LJ 2nd 2004. Isoprostanes: Markers and mediators of oxidative stress. *FASEB Journal*, 18(15): 1791–1800.
- Mottola F, Palmieri I, Carannante M, Barretta A, Roychoudhury S, Rocco L 2024. Oxidative stress biomarkers in male infertility: Established methodologies and future perspectives. *Genes*, 15(5): 539.
- Roberts LJ 2nd, Milne GL 2009. Isoprostanes. *Journal of Lipid Research*, 50(Suppl): S219–S223.
- Rodak K, Kokot I, Faundez R, Gilowska I, Kratz EM 2025. Biomarkers and mechanisms of male infertility: Evaluation of antioxidant enzymes and arachidonic acid derivatives in seminal plasma from fertile and infertile men. *Antioxidants*, 14(12): 1470.
- Saeki K, Miura Y, Aki D, Kurosaki T, Yoshimura A 2003. The B cell-specific major raft protein, Raftlin, is necessary for the integrity of lipid raft and BCR signal transduction. *EMBO Journal*, 22(12): 3015–3026.
- Saeki K, Fukuyama S, Ayada T, Nakaya M, Aki D, Takaesu G, Hanada T, Matsumura Y, Kobayashi T, Nakagawa R, Yoshimura A 2009. A major lipid raft protein raftlin modulates T cell receptor signaling and enhances Th17-mediated autoimmune responses. *Journal of Immunology*, 182(10): 5929–5937.
- Sengupta P, Pinggera GM, Calogero AE, Agarwal A 2024. Oxidative stress affects sperm health and fertility—time to apply facts learned at the bench to help the patient. *Reproductive Medicine and Biology*, 23: e1259.
- Serafini S, O'Flaherty C 2025. Novel insights into lipid signalling in human spermatozoa. *Human Reproduction*, 40(8): 1440–1451.
- Simons K, Ikonen E 1997. Functional rafts in cell membranes. *Nature*, 387(6633): 569–572.

- Suhaiman L, Belmonte SA 2024. Lipid remodeling in acrosome exocytosis: Unraveling key players in human sperm. *Frontiers in Cell and Developmental Biology*, 12: 1457638.
- van Gestel RA, Brewis IA, Ashton PR, Helms JB, Brouwers JF, Gadella BM 2005. Capacitation-dependent concentration of lipid rafts in the apical ridge head area of porcine sperm cells. *Molecular Human Reproduction*, 11(8): 583–590.
- Tremellen K 2008. Oxidative stress and male infertility: A clinical perspective. *Human Reproduction Update*, 14(3): 243–258.

DIGITAL TRANSFORMATION OF PHYSIOTHERAPY EDUCATION: INSIGHTS FROM THE E-PHYSIO PROJECT

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ABSTRACT

Background:The COVID-19 pandemic accelerated the shift to online education, disrupting traditional hands-on physiotherapy training but also opening opportunities to modernize curricula. Telerehabilitation has emerged as an innovative approach, expanding access to care, improving adherence, and creating new pathways for digital health integration. However, higher education institutions in low- and middle-income countries, including Albania, have limited experience embedding telerehabilitation into physiotherapy education.

Methods:The E-Physio project at the Sports University of Tirana was developed to modernize physiotherapy education in Western Balkan countries. The initiative included curriculum reform to integrate competencies in tele-rehabilitation and digital health, investment in technological infrastructure such as secure video platforms and telemonitoring devices, faculty training through workshops and mentoring programs, and pilot programs to test implementation. Student performance, engagement, and feedback were monitored through surveys, faculty evaluations, and observation in simulated and real telerehabilitation scenarios.

Results:Preliminary outcomes highlight increased student interest in digital health, with learners gaining skills in remote consultation, digital exercise program design, and patient progress monitoring. Faculty members reported enhanced expertise in technology-supported teaching, strengthening the overall academic environment. The project also fostered collaboration with regional and European partners, promoting knowledge transfer and harmonization of educational standards.

Conclusion:Integrating telerehabilitation into physiotherapy education represents a transformative step for higher education in Albania and the Western Balkans. The E-Physio project equips students and faculty with essential digital competencies, enhances patient-centered care delivery, and expands access to rehabilitation services in underserved areas. Ongoing evaluation is needed to refine the curriculum and ensure sustainable implementation.

Keywords: Telerehabilitation, physiotherapy education, digital health, curriculum reform, Western Balkans, e-learning.

Introduction

The pandemic has affected the education of physiotherapists in many ways with hands-on education and the use of online learning. However, this rapid change has also created opportunities to reexamine the foundations of vocational education; review the curriculum and learning outcomes; and to seek optimal teaching, learning and assessment approaches to deliver more flexible programs that maximize the use of online technologies and maintain the quality of learning experiences.

This new global situation has served to highlight the need for education that supports the development of physiotherapists (Wordl Physiotherapy, 2021). Students are the next generation of any profession or discipline in which the use of telerehabilitation can increase. Many studies found that students' interest in e-health is high, as it presents a new opportunity in the job market. A study conducted by Seçer and Tosun in 2022 (Başer Seçer, M., & Çeliker Tosun, Ö., 2022) regarding the assessment of telerehabilitation knowledge, awareness and opinions of physical therapy professionals and rehabilitation students showed that the majority of respondents stated that even if the topic is of interest to large, they were not prepared for telerehabilitation, due to lack of learning.

Numerous studies have shown that telehealth is a good choice in supplementing higher education resources (Seron, P. et al., 2021). Until now, the educational offer of HEIs regarding telerehabilitation is very limited. Currently According to existing research, the main needs in telerehabilitation are its inclusion in health curricula in higher education and the development of evidence of cost-effectiveness and implementation, especially in low- and middle-income countries where access, investment and digital knowledge health are limited, like Albania and Kosovo (Baroni, M. P. et al., 2023).

In an age where digital technology is reshaping every aspect of our lives, the field of physiotherapy is no exception. The "E-Physio" project, an innovative initiative aimed at modernizing physiotherapy education for Bachelor's degrees in Western Balkan (WB) countries, is leading this transformation. By integrating innovative ideas and digital technology, the project aims to raise the standards of physiotherapy education and practice. The Sports University of Tirana, known for its commitment to excellence in sports and rehabilitation education, is at the forefront of this change (Macellari, V. Et al., 2008). This article explores the implementation of the E-Physio project at the university, its impact on both education and patient care, and the promising future it holds for the physiotherapy and rehabilitation profession.

Telerehabilitation

Telerehabilitation and the delivery of physical therapy services at a distance, through telecommunication technologies, has emerged as a promising approach to increase access to health care and improve patient outcomes. This modality offers numerous advantages, including increased access to care for individuals in remote areas, improved patient adherence to exercise programs, and increased efficiency in the delivery of health care services (Suso-Martí, L. et al., 2021).

Recognizing the transformative potential of tele-rehabilitation, the Sports University of Tirana, a leading institution in sports science, physical education and rehabilitation, has undertaken an important initiative to integrate this innovative approach into its rehabilitation sciences-physiotherapy curriculum. This effort, undertaken as part of the E-physio project, aims to modernize physiotherapy education by incorporating digital technologies and promoting a digital approach to patient care.

In Albania, every year, information and communication technology penetrates deeper into different spheres of educational activity. While there is a very rapidly increasing level of telemedicine use

(Latifi, R. et al., 2020), the emergence of Telerehabilitation is still sporadic. Albania needs a shift in medical education from factual knowledge to telerehabilitation skills, improvement of IT facilities and IT staff skills. We can conclude that engaging teachers and students in the path of digital transformation and increasing digital skills and competencies for telerehabilitation is a priority in higher education in the countries of the Western Balkans, but also at the European level. The training of students for new technologies and the development of new skills is required in direct relation to the demands of the labor market (Hermens, H. Et al., 2008). There is an acute need for higher education institutions to develop educational programs related to online rehabilitation.

The E-physio project

The E-Physio project was created to modernize physiotherapy education and practice in Western Balkan countries by integrating innovative digital technologies. This project addresses the evolving needs of physiotherapy students and healthcare providers, ensuring they are well equipped with the skills and knowledge needed to thrive in a digital world (Erasmus+ project).

The main objectives of the project include the development of a comprehensive digital curriculum for physiotherapy students, the implementation of tele-rehabilitation services and the enhancement of research capabilities within physiotherapy departments. By adopting these advances, the project aims to foster a new generation of physiotherapists who are adept at using technology to improve patient outcomes. The project has been instrumental in introducing interactive learning modules, virtual labs and simulation-based training, which provide students with hands-on experience with modern tools and techniques. Furthermore, E-Physio highlights the importance of tele-rehabilitation in providing accessible healthcare, especially in regions where traditional physiotherapy services may be scarce.

The project aims to contribute to solving this gap through the development of the capacities of the HEIs of the partner countries in terms of modernization and improvement of the educational process. This will include the development of an international cooperation system to improve curricula, scientific cooperation and knowledge transfer, the development of digital skills for teachers and the development of e-learning platforms within participating WB HEIs.

Achieving this goal will ensure that the human resources involved in the rehabilitation sector are equipped with the relevant knowledge and skills needed to implement telerehabilitation. At the same time, the project encourages the development and implementation of digital education strategies in participating HEIs through the accreditation of the proposed curricula for the e-Telerehabilitation course and the development of a virtual space that can form the basis for a telemedicine platform (Giacomozzi, C. et al., 2008).

With this dual approach, the project aims to make the digital transformation as understandable and comprehensive as possible. At the EU level, the project will foster regional and inter-regional cooperation by providing European expertise, guidelines, examples and best practice recommendations to harmonize university curricula related to telerehabilitation in the EU.

Materials and Methods

The E-physio project at the Sports University of Tirana includes a multifaceted approach to the integration of tele-rehabilitation:

- Curriculum reform: The physiotherapy curriculum has been revised to incorporate core competencies in tele-rehabilitation. This comprehensive reform equips students with the knowledge and skills necessary for successful remote patient care. Key areas of focus include understanding the ethical and legal frameworks governing tele-rehabilitation, mastering the use of

various technologies such as videoconferencing platforms and telemonitoring devices, and adapting clinical reasoning and intervention strategies for effective assessment and treatment planning in the remote setting. Furthermore, the curriculum emphasizes patient-centered care by fostering strong patient education and adherence to treatment plans through the development and delivery of effective home exercise programs and ongoing remote patient support.

- Technological Infrastructure Development: The University has invested in improving its technological infrastructure, including high-speed Internet connectivity, secure video conferencing platforms and telemonitoring equipment.
- Faculty Development: Faculty members have undergone comprehensive training programs on the principles, technologies and best practices of tele-rehabilitation. This includes workshops, seminars and mentoring programs to ensure effective transfer and application of knowledge.
- Pilot programs and evaluation: Pilot programs are being conducted to evaluate the effectiveness of tele-rehabilitation education and to identify areas for improvement. Data collection methods include student surveys, faculty feedback, and observation of student performance in simulated and real telerehabilitation scenarios.

At the Sports University of Tirana, the E-Physio project has been implemented in several phases. The first phase involves the development of digital platforms that facilitate online learning and rehabilitation services. This platform includes features such as video conferencing, digital patient records, and real-time monitoring of patient progress, making it a valuable resource for both education and clinical practice.

To ensure the effective use of these technologies, the university has developed extensive training programs for faculty members and students. These sessions focus on familiarizing them with digital tools and integrating them into their daily practices. Furthermore, the university has collaborated with other WB countries and international institutions to share best practices and improve the overall quality of physiotherapy education and care in the region.

Findings and Discussion

Preliminary findings from the E-Physio project show some positive initial results. An important result is the increased engagement and interest among students in tele-rehabilitation, as they recognize its potential to enhance their future professional careers and improve the quality of patient care. This commitment is reflected in their enthusiastic participation in the program and a great interest in mastering new digital tools. Additionally, students are gaining a number of essential skills, such as using tele-rehabilitation technologies, conducting virtual consultations effectively, developing and delivering remote exercise programs tailored to individual needs and using data analytics for comprehensive patient monitoring and progress tracking.

Moreover, the project has also resulted in the increase of the faculty's expertise in tele-rehabilitation. Faculty members have gained valuable knowledge and practical experience that have significantly improved their teaching skills, allowing them to provide a more effective and engaging learning experience for students. This dual enhancement of student competencies and faculty expertise positions the E-Physio project as a key initiative in modernizing physiotherapy education and practice in the Western Balkans.

Conclusion and Recommendations

The integration of tele-rehabilitation in the physiotherapy curriculum at the Sports University of Tirana represents a substantial advance in the modernization of physiotherapy education in

Albania. This initiative is designed to equip future physiotherapists with the knowledge and skills needed to effectively incorporate tele-rehabilitation into their practice, thereby addressing several critical areas.

First, it increases access to quality physiotherapy services, particularly for individuals in remote areas or those with limited mobility, enabling them to receive care without the need for physical travel. Second, it aims to improve patient outcomes by promoting better adherence to treatment plans through regular virtual check-ups, facilitating timely interventions and increasing the overall effectiveness of treatments. Finally, this integration is poised to advance the physiotherapy profession by positioning it at the forefront of adopting innovative technologies, thereby promoting the delivery of high-quality, patient-centered care.

Through these objectives, the initiative aims to transform the practice and education of physiotherapy, ensuring that graduates are well prepared to meet the challenges of contemporary healthcare. Ongoing research and evaluation are essential to further improve the telerehabilitation curriculum, to assess the long-term impact on student learning and clinical practice, and to address any challenges encountered during implementation.

References

Baroni, M. P., Jacob, M. F. A., Rios, W. R., Fandim, J. V., Fernandes, L. G., Chaves, P. I., Fioratti, I., & Saragiotto, B. T. (2023). The state of the art in telerehabilitation for musculoskeletal conditions. Archives of Physiotherapy, 13(1), 1. https://doi.org/10.1186/s40945-022-00155-0

Başer Seçer, M., & Çeliker Tosun, Ö. (2022). Examination of telerehabilitation knowledge, awareness, and opinions of physical therapy and rehabilitation students. Medical Science Educator, 32(6), 1355–1365. https://doi.org/10.1007/s40670-022-01649-z

Erasmus+. (n.d.). Erasmus+ project: 101128600. Retrieved from https://erasmus-plus.ec.europa.eu/projects/search/details/101128600

Giacomozzi, C., Campobello, G., Huijgens, B., Ilsbroukx, S., Macellari, V., Magni, R., Ratti, A., Rogante, M., Scattareggia Marchese, S., Schifini, M. F., Termos, J. M., & Cordella, D. (2008). Tele-rehabilitation and e-learning: The HELLODOC educational experience. Annali dell'Istituto Superiore di Sanità, 44(2), 145–153. PMID: 18660564

Hermens, H., Huijgen, B., Giacomozzi, C., Ilsbroukx, S., Macellari, V., Prats, E., Rogante, M., Schifini, M. F., Spitali, M. C., Tasies, S., Zampolini, M., & Vollenbroek-Hutten, M. (2008). Clinical assessment of the HELLODOC tele-rehabilitation service. Annali dell'Istituto Superiore di Sanità, 44(2), 154–163. PMID: 18660565

Latifi, R., Parsikia, A., Boci, A., Doarn, C. R., & Merrell, R. C. (2020). Increased access to care through telemedicine in Albania: An analysis of 2,724 patients. Telemedicine and e-Health, 26(2), 164–175. https://doi.org/10.1089/tmj.2018.0338

Macellari, V., Scattareggia Marchese, S., & Giacomozzi, C. (2008). HELLODOC: A European experience on tele-rehabilitation. Preface. Annali dell'Istituto Superiore di Sanità, 44(2), 123–124. PMID: 18660561

Seron, P., Oliveros, M. J., Gutierrez-Arias, R., Fuentes-Aspe, R., Torres-Castro, R. C., Merino-Osorio, C., Nahuelhual, P., Inostroza, J., Jalil, Y., Solano, R., Marzuca-Nassr, G. N., Aguilera-Eguía, R., Lavados-Romo, P., Soto-Rodríguez, F. J., Sabelle, C., Villarroel-Silva, G., Gomolán, P., Huaiquilaf, S., & Sanchez, P. (2021). Effectiveness of telerehabilitation in physical therapy: A rapid overview. Physical Therapy, 101(6), pzab053. https://doi.org/10.1093/ptj/pzab053

Suso-Martí, L., La Touche, R., Herranz-Gómez, A., Angulo-Díaz-Parreño, S., Paris-Alemany, A., & Cuenca-Martínez, F. (2021). Effectiveness of telerehabilitation in physical therapist practice: An umbrella and mapping review with meta-meta-analysis. Physical Therapy, 101(5), pzab075. https://doi.org/10.1093/ptj/pzab075

World Physiotherapy. (2021). Physiotherapist education framework. Retrieved from https://world.physio/sites/default/files/2021-07/Physiotherapist-education-framework-FINAL.pdf

AQUACULTURE IN MOROCCO: CHALLENGES, SUSTAINABILITY, AND FUTURE PROSPECTS FOR THE BLUE ECONOMY

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ABSTRACT

The primary objective of this study was to examine the influence of dietary lipid content in two types of tilapi feeds (Ff and Fv) on lipid metabolism, morphometric characteristics, and the physical and organoleptic quality of tilapia fillets. The evaluation was conducted using a combination of instrumental analyses and sensory assessments to obtain a comprehensive understanding of how feed composition affects fish growth, body composition, and flesh quality.

This study focused on comparing the effects of different lipid levels on the biochemical composition of tilapia, including lipid content, protein levels, and energy utilization. The results showed that Feed B produced superior morphometric performance, with higher values for the viscerosomatic index (VSI) and hepatosomatic index (HSI), as well as improved filleting yield (FY) and evisceration yield (EY).

Keywords : morphometric performance ; lipid ; hepatosomatic index ; viscerosomatic index

INTRODUCTION

The benefits of fish consumption for public health are increasingly recognized. Numerous studies highlight the link between fish consumption and a reduced risk of cardiovascular diseases. The fatty acid composition of fish flesh generally reflects that of the feed (Watanabe, 1982). The high content of n-3 polyunsaturated fatty acids in fish oils contributes significantly to the value of fish flesh (Nettelon, 1991). Since the first research by Lee and Putman (1973), the use of feeds with very high lipid content has become a common practice in aquaculture (Hillestad and Johnsen, 1994; Hillestad et al., 1998; Refstie et al., 2001). While this can save proteins or reduce nitrogen emissions, its effects on nutritional and organoleptic quality are often debated.

Fish are the main source of long-chain omega-3 polyunsaturated fatty acids (PUFAs) in the human diet. The concentration of fatty acids (FAs) increases with the lipid content of the flesh. Significant

differences exist in muscle lipid content (from less than 1 g to more than 15 g / 100 g of flesh) between species (Regost et al., 1999).

These differences are not related to the origin of wild-caught or farmed fish but to the ability of the species' muscle tissue to store fat. For the same species, muscle lipid content can vary throughout the year depending on the physiological state of the fish and the amount of available feed. The largest variations are observed in fatty wild-caught species (Médale, 2009), while variations in farmed fish are less pronounced. The fatty acid composition of lipids in fish flesh depends almost exclusively on the diet; it reflects the lipid composition of the aquatic trophic chain for wild fish, and the feed components (mainly oils) for farmed fish (Regost et al., 1999).

II. Materials and Methods

The experiment was conducted to evaluate the effects of two types of fish vegetable oil feed and feed fish oil (Feedf and Fv) with different lipid levels on tilapia growth, morphometric parameters, and flesh quality. Juvenile tilapia (Oreochromis niloticus) of uniform size (average weight: 50 g) with 50 fish per tank.

The tanks were supplied with aerated freshwater at a constant temperature of 28 ± 1 °C, with dissolved oxygen maintained above 8 mg/L. Fish were acclimated for one week before the experiment and fed manually twice daily (08:00 and 16:00) at 3% of their body weight, adjusted every two weeks based on biomass measurements.

The experimental period lasted **6 weeks**, during which fish were monitored for growth performance, morphometric indices, and feed utilization.

1. Feed Composition

Two extruded feeds were formulated with different lipid sources: Feed $_F$ contained oil fish whereas Feed $_V$ contained lipids derived from vegetable oil. Both feeds provided a balanced protein supply from fish meal and plant ingredients, supplemented with vitamins and minerals to meet the nutritional requirements of tilapia.

2. Growth and Morphometric Measurements

Every two weeks, 20 fish per tank were randomly sampled after 24 hours of fasting to measure:

Measurements were conducted using a digital scale (±0.01 g) and calipers (±0.1 mm).

Table 1: Morphometric parameters studied for the three samples A, B and C.

Morphometric parameters	
Hepatosomatic index (HSI,%)	= Liver Weight (g) * 100 / Body Weight
Viscerosomatic index (VSI,%)	= Weight of viscera (g) * 100 / Body weight
Evisceration yield (E.Y)	= Weight of eviscerated fish / weight of total fish

Results:

Table 2: Variations in morphometric parameters for fish samples

	Oil Fish	Oil Vegetale
VSI %	**8,44 ±1,16**	**7,76 ±0,75**
HSI%	**1,39 ±0,31**	**1,26 ±0,31**
EY	**90,17±1,19**	**82,58±7,33**

The monitoring of morphometric parameters showed that fish fed with FeedF had a higher viscerosomatic index (VSI = 8.44% ± 1.16) compared to fish fed with Feed v. In contrast, the hepatosomatic index (HSI) was lower in Feed B (HSI = 1.26 ± 0.31) than in Feed A (HSI = 1.39 ± 0.31).

Discussion

Tilapia flesh is a high-protein food of significant biological value, rich in minerals such as phosphorus and iodine, and vitamins including vitamin D. It also contains a substantial amount of long-chain polyunsaturated fatty acids (n-3 series), such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are beneficial for human health, helping to reduce blood cholesterol and cardiovascular risk.

Filleting efficiency depends on the species and size of the fish and typically ranges between 40 and 70% for species commonly used in aquaculture (Bencze, 2001). In this study, the highest filleting yield was observed in tilapia fed Feed $_V$**,** reaching FY = 66.79 ± 3.41%**,** compared to Feed $_F$ **(**FY = 65.56 ± 1.72%**).** During fillet production, the main wastes include viscera, heads, skeletons, skin, fins, and subcutaneous fat. In tilapia, the edible portion often represents less than half of the live weight, with lipids stored primarily in the viscera but also in the muscle (Rechignat et al., 1995). Therefore, lipids play an important role both in processing efficiency and in the quality of tilapia flesh (Fauconneau et al., 1993).

Our results show that **Feedv**, despite its moderate dietary lipid content (24%), resulted in tilapia fillets with higher muscle lipid content and improved filleting yield. The viscerosomatic index (VSI = 7.76 ± 0.75) was lower for Feed $_V$ compared to Feed $_F$, suggesting that lipids from Feed $_V$ are more effectively deposited in the muscle, which contributes to higher filleting efficiency. These findings indicate an inverse relationship between VSI and filleting yield in tilapia: the lower the VSI, the higher the fillet yield.

REFERENCES

1. Baker, R. & Gunther, C. (2004). The role of carotenoids in consumer choice and the likely benefits from their inclusion into products for human consumption. Trends in Food Science & Technology, 15(10), 484–488.

2. Bencze, L.G., Crampton, V.O., Williams, P.D. (2001). The effect of feed pigment type on flesh pigment deposition and colour in farmed fish. Aquaculture Research, 32(2), 103–111.

3. Cosgrove, J.P., Church, D.F. (1987). The kinetics of the autoxidation of polyunsaturated fatty acids. Lipids, 22(5), 29–304.

4. Fauconneau, B., Corraze, G., Lebail, P.Y., Vernier, L.M. (1990). Les lipides de dépôt chez les poissons d'élevage: contrôle cellulaire, métabolique et hormonal. INRA Prod. Anim., 3, 369–381.

5. Nettelon, J. (1991). Fish oils and human health. Nutrition Reviews, 49(6), 187–193.

6. K. Ouaissa , A. kritihi, A. Maychal , M. Hasnaoui. Evolution of Fish Farm Feeding Strategies in Aquaculture. Egyptian Journal of Aquatic Biology & Fisheries. Vol. 28(5): 321 – 329 (2024). https://doi.org10.21608/ejabf.2024.378876

7. Rechignat, H., Arzel, J., Viau, M., Gandemer, G., Guillaume, J. (1995). Nature des lipides alimentaires et composition lipidique de la truite commune élevée en eau douce ou en mer. N.S.T., 13, 79–84.

8. Sheehan, E.M., O'Connor, T.P., Sheehy, P.J.A., Buckley, D.J., Fitzgerald, R. (1996). Effect of dietary fat intake on the quality of raw and smoked salmon. Irish Journal of Agricultural and Food Research, 35, 37–50.

9. Watanabe, T. (1982). Lipid nutrition in fish. Comparative Biochemistry and Physiology, 73B, 3–15.

LANDSCAPE MANAGEMENT OF NATURAL AND CULTURAL HERITAGE, MEDIEVAL ARCHAEOLOGICAL SITES IN BULGARIA

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ABSTRACT

The Kabiyuk study area is in Northeast Bulgaria, 10 km from the town of Shoumen. The area is unique in that it encompasses three different types of sites: archaeological sites, natural protected areas, and Stud farm Kabiuk. The early medieval archaeological site “Kabiyuk” located here is one of the non-capital royal residences (Auls) of the First Bulgarian Kingdom. It was announced as a National Historical and Archaeological Reserve in 2011 and covers an area of 5.7 sq. km. Within the study area are also located the earliest stud farm in Bulgaria - Stud "Kabiuk", founded in 1864; the only Balkan Museum of Horse, founded in 1984; and the Museum of Battenberg, the first ruler of the Bulgarian Third Kingdom. The study area also includes two natural protected zones - the protected site “The Mound” and the Natura 2000 site. This diversity makes the region very suitable for natural and cultural tourism. This paper presents an analysis of the landscape management and design for the natural and cultural heritage of the Kabiyuk Mound and its surroundings, and evaluates its tourist potential. The evaluation method is based on remote sensing data and products, as well as geoinformation technologies. It combines information on heritage sites and landmarks, land cover of the study area, a digital elevation model, satellite imagery, available e natural features, and heritage. The transport accessibility and presence of tourist infrastructure, the overall evaluation of the regional location, and the distance from other heritage sites are the main focus of the proposed evaluation method.

Keywords: cultural and natural heritage, remote sensing, tourism, GIS, landscape management.

INTRODUCTION

What is landscape? "Landscape" means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors”, according to the Council of Europe Landscape Convention (Council of Europe, 2000). We all live in some landscapes, since the landscape as such is an area with no clear borders, it is very difficult to tell when the next area with a different landscape starts. Landscapes may be divided by the administrative borders of regions within a country, but they are very often cross-border, located between regions or between two or more countries. On the other hand, every region may be seen as consisting of separate

landscapes, smaller in size. This makes every landscape unique in size and specifics. These areas and their borders are defined by our perception of natural and cultural conditions in them. Moreover, each of them requires a careful, attentive approach to ensure its sustainability and prosperity. All this justifies the need for what is defined as landscape policy, landscape protection, and landscape management. "Landscape management" means action, from a perspective of sustainable development, to ensure the regular upkeep of a landscape, so as to guide and harmonize changes which are brought about by social, economic and environmental processes" (Council of Europe, 2000).

Landscape management in scientific literature covers a broad spectrum of topics, including cultural heritage management, the conservation of natural and cultural heritage, ecosystem restoration, sustainable landscape management, and others (Grunewald et al., 2014; Mann et al., 2018; You et al., 2025; Lupp et al., 2013; Iglesias et al., 2025).

This paper presents an analysis of the landscape of the natural and cultural heritage of Kabiyuk Mound and its surroundings. The study area is Kabyuik and its surroundings, located in the Shoumen district in Northeast Bulgaria, standing 10 km northeast of Shumen town (Fig. 1).

Shoumen district covers an area of 3390 sq km and has a population of over 180,000 people (in 2011). It includes many protected areas – natural sites, parks, reserves, Natura 2000 sites, and a rich cultural heritage. Nonetheless, despite the great diversity of heritage sites, the total area of the district covered by natural heritage sites is only 26%, which is relatively small compared to other districts (Stamenova and Stamenov, 2021).

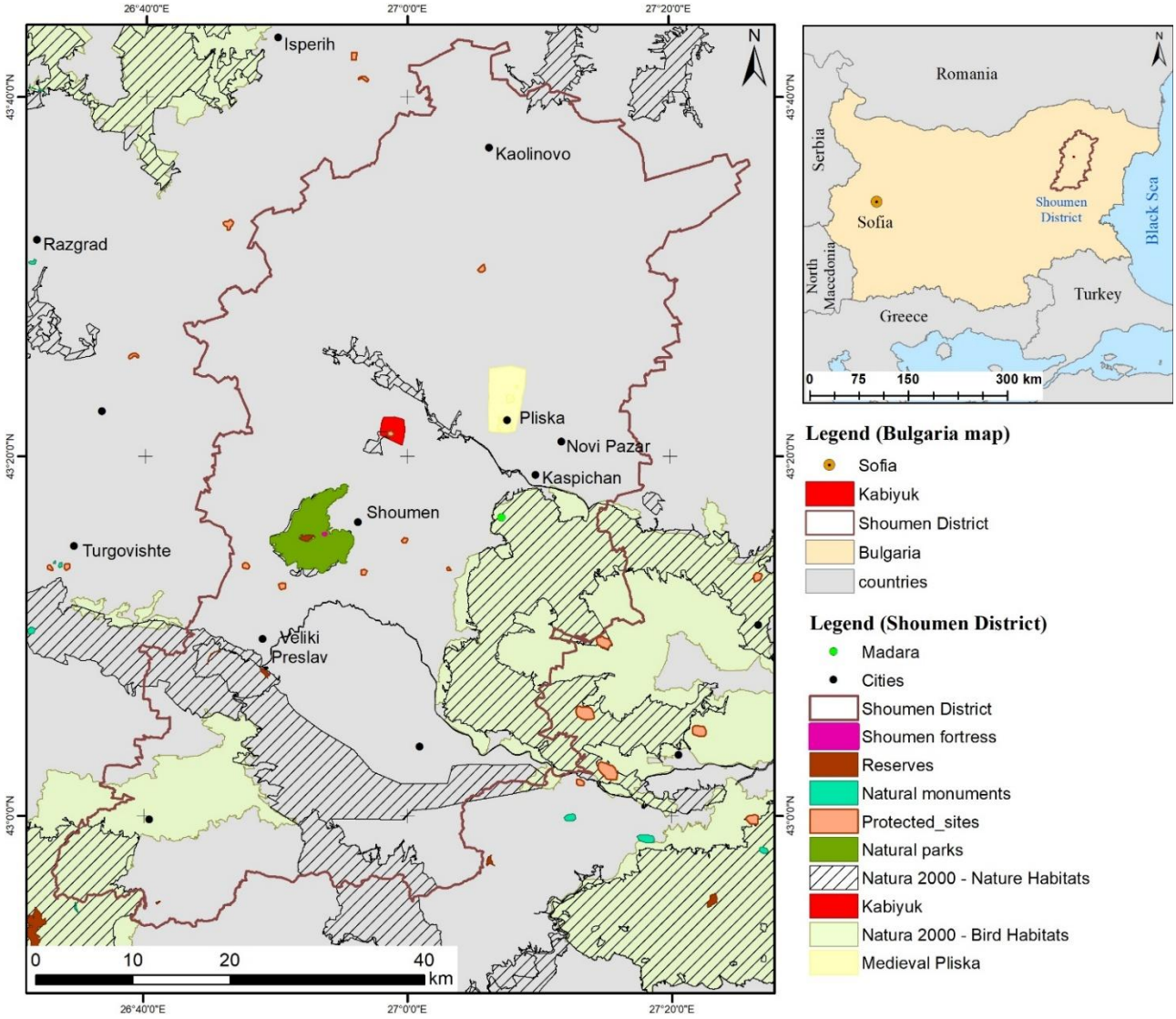


Figure 1. Cultural heritage and natural protected areas of Shoumen District

MATERIALS AND METHODS

The landscape management method is based on remote sensing data and products, and geoinformation technologies. It combines information on heritage sites and landmarks, the study area's land cover, available natural features, and heritage. The transport accessibility and presence of tourist infrastructure, the overall evaluation of the regional location, and the distance from other heritage sites (Fig. 2).

For the implementation of the method, six parameters have been elaborated and presented in Fig. 2. These parameters are considered initial and do not represent the full range of possible parameters that can be applied to fulfill the task. The size of the area for landscape management is of the first importance, because no real management can be done without knowing the size of the area to be managed. Dominant land cover types are crucial in providing information about what we have in this area, and the consequent conclusions. The locations of every object of importance for landscape management are important to know, and their distribution in the area indicates their relative positions to each other. The importance of transport infrastructure is also a key parameter, and whether it is available and what kind it is provides important information for planning travel in the area. The same applies to information on distances to the major cities and towns in the area.

Materials used for the method include the Corine Land Cover product; other land cover products may also be used. High- and very-high-resolution satellite imagery, such as Sentinel-2, SPOT-6, and WorldView-3, is suitable for landscape analysis and management. DEMs of different spatial resolutions may also be applied.

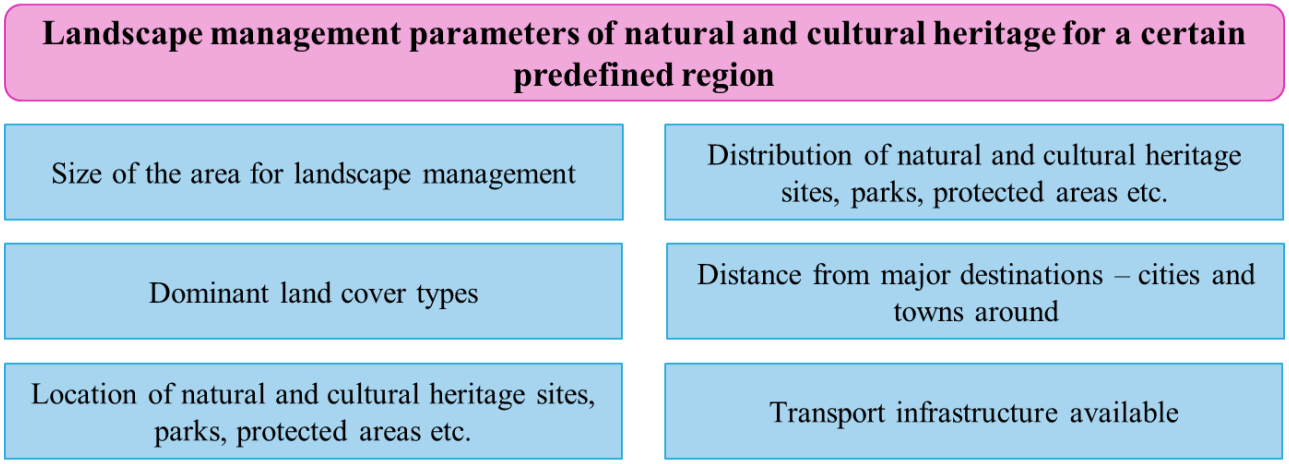


Figure 2. Landscape management parameters of natural and cultural heritage for a certain predefined region

RESULTS AND DISCUSSION

The land cover of the Shoumen region is generally monotonous, though comprising 19 CORINE land cover classes (Fig. 3-4). As seen on the map, most classes cover small areas scattered across the region. The most prevailing land cover class is 211 (non-irrigated arable land), 57%, followed by class 311 (broad-leaved forest), 11.6%, on the plateaus of the area. Third place is for class 243 (Land principally occupied by agriculture with significant areas of natural vegetation, 7%. Natural areas outside the protected areas are the riparian zones of small rivers, which are almost evenly distributed across the region and are classified as class 243 (Fig. 4).

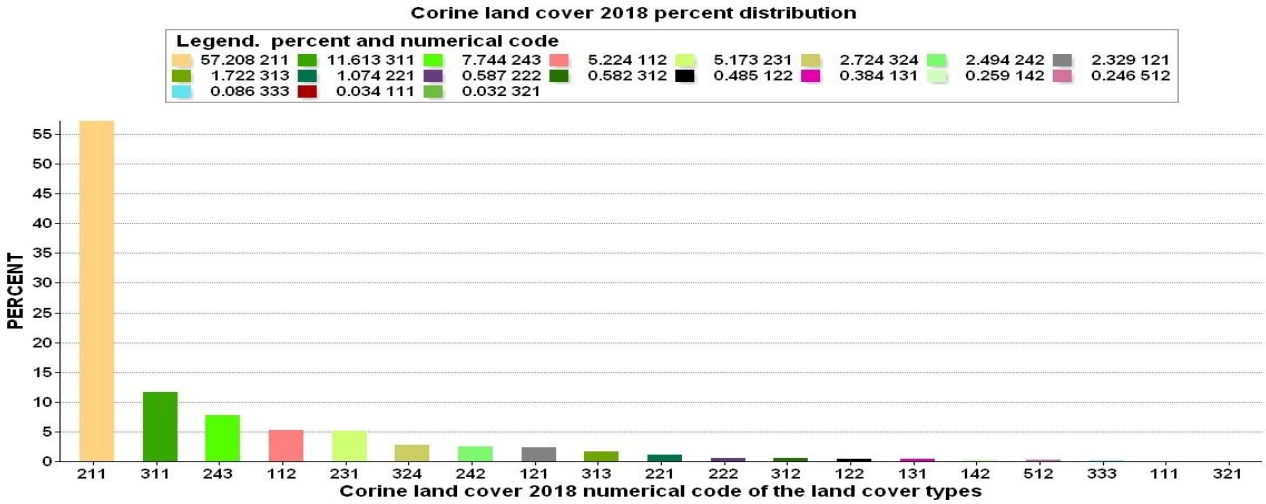


Figure 3. Distribution of the Corine land cover classes for 2018 for the Shoumen area

The distribution and locations of natural and cultural heritage sites in the Shoumen area are shown in Fig. 1 and Fig. 5. The area is rich in cultural heritage, with two national historical and archaeological reserves (NHAR) of sites from the First Bulgarian Kingdom – the NHAR Kabiyuk

and NHAR Pliska. Previous work on these sites has focused on their non-destructive study and conservation of cultural heritage (Stamenov, 2019; Stamenov and Stamenova, 2016, 2021, 2025; Stamenov and Naydenova, 2013-2014). Other significant historical sites include Shoumen Fortress and the Madara Rider. The Madara Rider is an early medieval rock relief representing a horseman, carved into a 100-m-high cliff of the Madara Plateau, east of Shoumen. The monument was listed as a UNESCO World Heritage site in 1979, covering an area of 1.2 ha and a buffer zone of 534.34 ha (UNESCO World Heritage Committee, 1979).

The natural heritage is represented by the Shumen Plateau Nature Park, declared a protected area on February 5, 1980, by Order No. 79 of the Committee for the Protection of the Natural Environment under the Council of Ministers and promulgated in the State Gazette No. 21/1980, and the Reserve "Bukaka" located within it. Other protected areas include the protected site “The Mound” and the Natura 2000 protected zone under the habitats and birds’ directives.

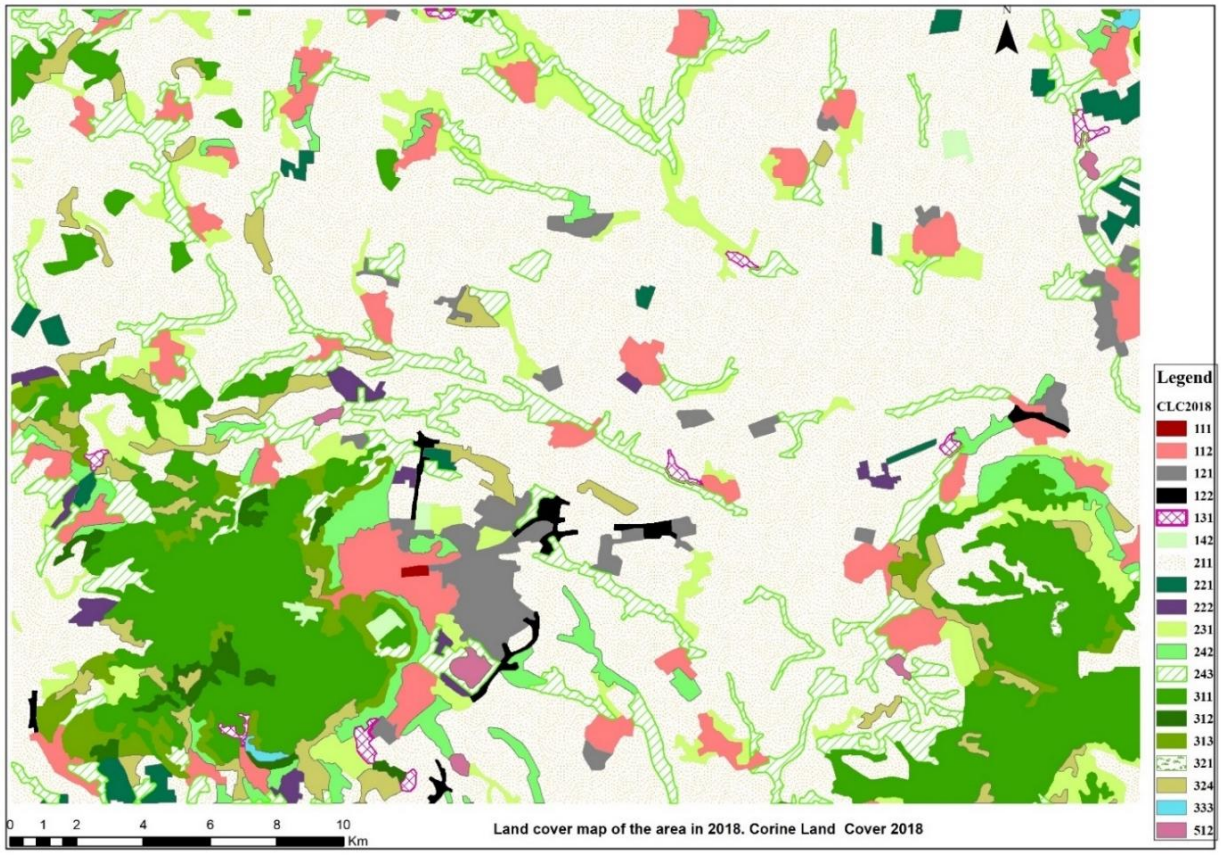


Figure 4. Map of the land cover of the Shoumen area

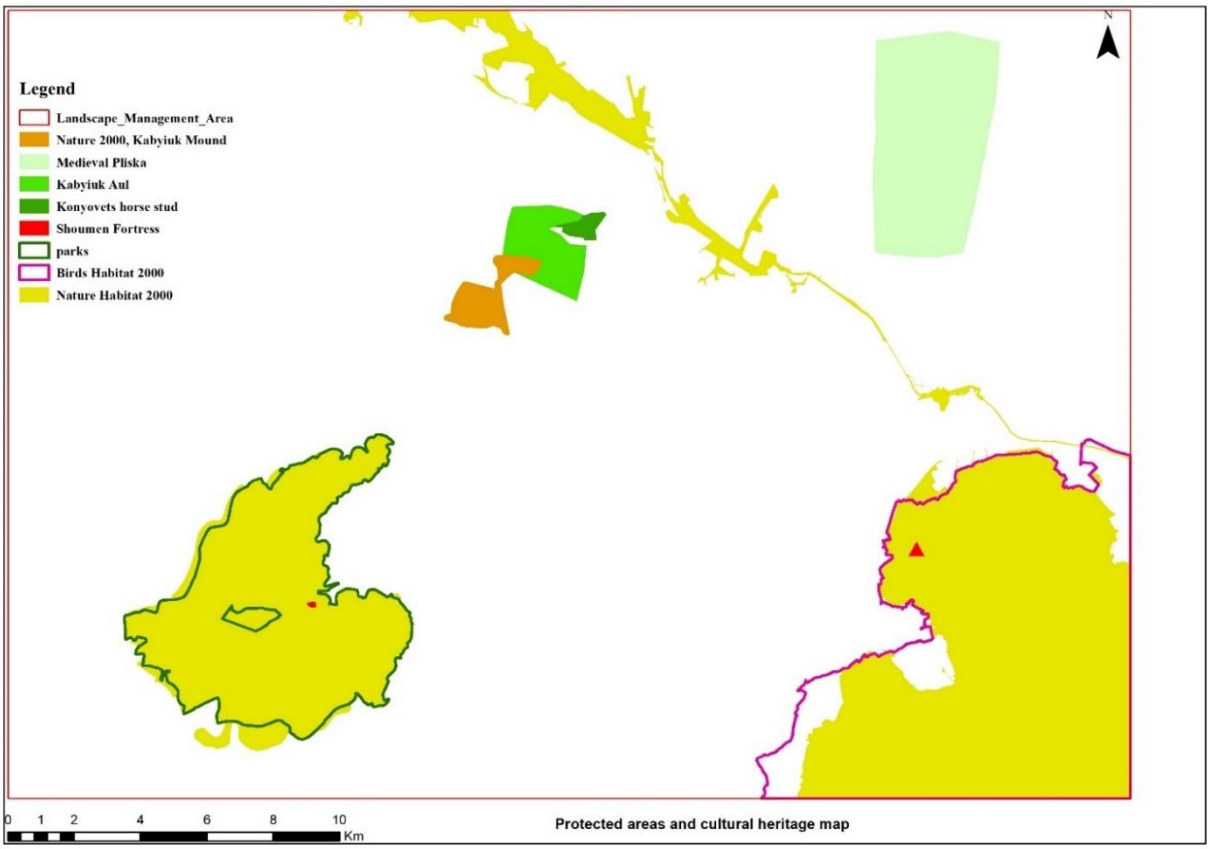


Figure 5. Protected areas and cultural heritage in the Shoumen area.

The region of Kabiyuk is a great example of a combination of cultural and natural heritage. It includes three protected areas: an archaeological reserve, a protected site, and a Natura 2000 site (Fig. 6). Here are also located the National Kabiyuk Stud Farm and two museums - the only Museum of Horses in the Balkans, founded in 1984, and the Museum of Battenberg, the first ruler of liberated Bulgaria.



Figure 6. Cultural and natural heritage of Kabiyuk area

The Mound "Kabiyuk"

The protected territory of the mound "Kabiyuk" was designated a Natural Monument in 1973 and reclassified as a Protected Site in 2003. The mound Kabiyuk is a small hill with an altitude of 336 m (according to DSM acquired by UAV in 2013, the elevation is 374 m) (Fig. 7). The protected site covers 47.5 ha and is home to over 200 herbaceous shrub species. "The Mound" is designated a protected area because it is the best-preserved site with steppe vegetation in Bulgaria (Stamenov and Stamenova, 2016). Typical species include Adonis vernalis (Fig.8), Stipa species, Pulsatilla vernalis, Anemone sylvestris (Fig. 8), Achillea clypeolata (Balkan endemic species), Caragana frutex (Fig. 8), and others. Caragana frutex, a critically endangered species in Bulgaria, whose most significant habitat is at the Mound Kabiyuk (Stamenov and Stamenova, 2016).



Figure 7. Photo of Kabiyuk mound



Figure 8. Vegetation species - Caragana frutex, Adonis vernalis, Anemone sylvestris

The mound Kabiyuk falls within Natura 2000 protected sites under the Habitats Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Site Code BG0000602), with an area of 286.87 ha, adopted by the Council of Ministers by Decision №122/02.03.2007 (Fig. 6). The site is one of the most important territories for the preservation of steppe bushes (Caragana frutex, Amygdalus nana), Subcontinental peri-Pannonic scrub, etc. There are many rare species, including Anemone sylvestris (Fig. 8), Peucedanum ruthenicum, and Centaurea marshaliana, and the Echium russicum population is among the largest in Bulgaria (Stamenov and Stamenova, 2016). There is also an old, thin oak forest on the site's territory.

National Historical and Archaeological Reserve (NHAR) "Kabiyuk"

Kabiyuk was announced as a National Historical and Archaeological Reserve in 2011. With the amendment to the Law on Cultural Heritage, in its appendix, Kabiyuk was added under No. 32 with the name "Early Medieval Village of Kabiyuk" as an archaeological reserve situated on the territory of two municipalities - Shumen and Hitrino, Shoumen District (State Gazette, issue 54 of July 15, 2011). It is one of the main early medieval archaeological sites connected to the First Bulgarian Kingdom, whose earthen rampart is the second largest after the fortification of the First Bulgarian Capital – Pliska. It covers an area of 5.7 sq. km. The investigation of the early medieval Bulgarian culture in Northeastern Bulgaria began at the end of the 19th century and the beginning of the 20th century, when the first field observations and excavations were made by K. Shkorpil. As a result, several important archaeological sites are found, among them is Kabiyuk. After its discovery, the site was explored sporadically, and only individual structures were examined over the years (Stamenov and Stamenova, 2016; Stamenov and Naydenova, 2013, 2014).

Stud Farm KABIYUK

Konyovets is a village entirely related to the Stud farm Kabiyuk. There are almost no private houses in the village, and the local population works in the Kabiyuk stud. According to the 2011 census, the population of Konyovets is 353. Kabiyuk is the earliest stud farm in Bulgaria, founded in 1864 by Midhat Pasha, the Governor of the Danube Province, as a military stud farm for the Turkish army. Since 1894, the farm has been known as Kabiyuk National Stud Farm, Stallion and Stud Depot, and has remained active to the present day (Stamenov and Stamenova, 2016). There are also two museums at the stud farm – the museum of Battenberg, the first ruler of liberated Bulgaria, and the Museum of Horse, the only one in the Balkan Peninsula.

The protected natural and cultural heritage sites in the Kabiyuk area are in proximity to the other heritage site of the Shoumen district. The average straight-line distance to most sites, including the first Bulgarian capital Pliska, the Madara Plateau, the Madara Rider, and the Shoumen Plateau, is about 13 km (Table 1).

Table 1. Straight line distance of the Kabiyuk site to other natural and cultural heritage sites

Distance from Kabiyuk Mound to:	km
NHAR "Pliska"	13
Madara plateau, and a cultural heritage site	15
Shoumen Plateau and the Bulgaria 1300 monument	12
Shoumen fortress	12
Nature reserve "Bukaka"	13
Veliki Preslav archaeological site	25

CONCLUSION

Natural and cultural heritage are important parts of every country's territory. Natural heritage and protected areas are part of the sustainable equilibrium of the country, preserving its natural status

and biodiversity, which are essential for a healthy and prosperous human society. Cultural heritage, on the other hand, keeps historical memory, a linkage between modernity and the past.

Managing and planning a country's territory and its constituent regions is directly related to managing and planning the landscape and depends on its specific characteristics. Landscape management and planning are part of this and begin with careful analysis of the area of interest and the landscape management method.

REFERENCES

Council of Europe, 2000. Council of Europe Landscape Convention *(ETS No. 176)*. https://www.coe.int/en/web/conventions/full-list?module=treaty-detail&treatynum=176

Grunewald K, Syrbe RU, Bastian, O 2014. Landscape management accounting as a tool for indicating the need of action for ecosystem maintenance and restoration – Exemplified for Saxony. Ecological Indicators, 37: 241–251.

Iglesias MC, Hermoso V, Azevedo JC, Campos JC, Salgado-Rojas J, Sil Â and Regos A 2025. Integrating multiple landscape management strategies to optimise conservation under climate and planning scenarios: a case study in the Iberian Peninsula. *Ecosystem Services* 74, 101742,

Lupp G, Konold W, Bastian O 2013. Landscape management and landscape changes towards more naturalness and wilderness: Effects on scenic qualities—The case of the Müritz National Park in Germany. Journal for Nature Conservation 21(1): 10–21.

Mann C, Garcia-Martin M, Raymond CM, Shaw BJ, Plieninger T 2018. The potential for integrated landscape management to fulfil Europe's commitments to the Sustainable Development Goals. Landscape and Urban Planning, 177: 75–82.

Stamenov S 2019. Prostranstven model i khronologichen analiz na srednovekovniya grad Pliska na bazata na aerokosmicheski i nazemni danni [Spatial model and chronological analysis of the medieval city of Pliska based on aerospace and ground data]. Sofia: Marin Drinov Publishing House of BAS. ISBN 978-954-322-980-2.

Stamenov S, Naydenova V 2013. GNSS role in planning and conductance of terrain archaeological survey: Technical aspects and methodology. In Proceedings of the 2013 Digital Heritage International Congress, IEEE, vol.1, pp. 235–238.

Stamenov S, Naydenova V 2014. Storing, processing and visualization of archaeological information using GIS: A case study – Kabiuk archaeological site. In Proceedings of the Second European SCGIS Conference "Conservation of Natural and Cultural Heritage for Sustainable Development: GIS-Based Approach" ISSN 1314-7749, SRTI-BAS, pp. 62–68.

Stamenov S, Stamenova V 2016. Kabiyuk Project: Exploration and conservation of archaeological site using remote sensing methods and GIS technologies. In Proceedings of the Third European SCGIS Conference "Geoinformation Technologies for Natural and Cultural Heritage Conservation", ISSN 1314-7749, SRTI-BAS, pp. 183–191.

Stamenov S, Stamenova V 2021. Geoinformation technologies for conservation of cultural heritage. In Digital Heritage, Progress in Cultural Documentation, Preservation and Protection (Lecture Notes in Computer Science, Vol. 12642), Springer, pp. 535–542. ISBN 978-3-030-73042-0; ISSN 0302-9743.

Stamenov S, Stamenova V 2025. Cultural heritage at risk: Analyzing a flood at a cultural heritage site. In Proceedings Book of the UMTEB-XVII International Scientific Research Congress, ISBN 979-8-89695-081-3, New York: Liberty Publishing House, pp. 389–398.

Stamenova V, Stamenov S 2021. Protected Areas in Bulgaria [Poster]. Esri User Conference 2021. https://mapgallery.esri.com/submission-detail/29450

You W, Xu H, Duan J, Zhou Y, Li J, He D, Kizos T 2025. Assessing spatial differences of perceptions of cultural ecosystem services for coastal cultural landscape management: A case study from rural and urban areas in Quanzhou, China. Journal of Environmental Management, *395*, 127674.

UNESCO World Heritage Committee, 1979. Decision 3 COM XII.46: Consideration of nominations to the World Heritage List. UNESCO.

EXOSOME-RELATED NON-CODING RNAS AND ATHEROSCLEROSIS

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ABSTRACT

Exosomes carrying non-coding RNAs (ncRNAs) represent a critical mechanism of intercellular communication in atherosclerosis development and progression. Current research demonstrates that exosomal ncRNAs, including microRNAs, long non-coding RNAs, and circular RNAs, significantly influence key atherosclerotic processes through regulation of gene expression, cellular function, and inflammatory responses. Atherosclerosis remains the leading cause of cardiovascular disease-related mortality globally, accounting for approximately one-fifth of all deaths worldwide. The disease involves complex interactions between multiple cell types including endothelial cells, vascular smooth muscle cells, and macrophages.

Keywords: Exosome, non-coding RNAs, Atherosclerosis

INTRODUCTION

Atherosclerosis remains the leading cause of cardiovascular disease-related mortality globally, accounting for approximately one-fifth of all deaths worldwide (Xinjie Lu et al., 2017)(Mengmeng Lu et al., 2019). The disease involves complex interactions between multiple cell types including endothelial cells, vascular smooth muscle cells, and macrophages (Ya-Ting Chen et al., 2020).

Exosomes are nano-sized extracellular vesicles (30-150 nm) that serve as important mediators of cell-to-cell communication by transporting bioactive molecules including proteins, lipids, and various RNA species (M. Alidadi et al., 2023)(Dongdong Zheng et al., 2021). These vesicles have emerged as crucial players in atherosclerosis pathogenesis through their ability to transfer regulatory molecules between cells (Jeongyeon Heo et al., 2022).

Types of Exosomal Non-Coding RNAs in Atherosclerosis

Research has identified three primary categories of ncRNAs transported by exosomes that influence atherosclerosis:

1. MicroRNAs (miRNAs): Small ~22-nucleotide sequences that regulate gene expression post-transcriptionally (B. Aryal et al., 2014)(Dongdong Zheng et al., 2021)

2. Long non-coding RNAs (lncRNAs): Longer RNA molecules that regulate gene expression through diverse mechanisms (Tian Zhou et al., 2016)(Hui Xu et al., 2021)

3. Circular RNAs (circRNAs): Circular RNA molecules involved in gene regulation (F. Fasolo et al., 2019)(Chen Li et al., 2021)

Mechanisms of Action

Exosomal ncRNAs influence atherosclerosis through multiple pathways:

Cellular Communication: Exosomes enable crosstalk between sub-endothelial cells, affecting endothelial dysfunction, foam cell formation, and vascular smooth muscle cell proliferation and migration (M. Alidadi et al., 2023)(Hongyun Wang et al., 2020).

Inflammatory Regulation: ncRNAs modulate inflammatory responses, with studies showing regulation of macrophage activation and endothelial cell function (B. Aryal et al., 2019)(Yuchan Yuan et al., 2020).

Apoptosis Control: Specific examples include lncRNA GAS5, which regulates apoptosis of both macrophages and vascular endothelial cells through exosomal transfer (Lei Chen et al., 2017).

Lipid Metabolism: Exosomal ncRNAs influence cholesterol metabolism and lipoprotein processing (A. Reiss et al., 2018)(B. Aryal et al., 2014).

Clinical Implications

Exosomal ncRNAs show promise as biomarkers for atherosclerosis diagnosis and progression monitoring (Mengmeng Lu et al., 2019)(Jia Liu et al., 2020). Plasma exosomal miRNAs such as miR-30e and miR-92a have been identified as potential diagnostic markers (Hongyun Wang et al., 2020).

The regulatory role of exosomal ncRNAs presents opportunities for therapeutic intervention (M. Alidadi et al., 2023)(Jeongyeon Heo et al., 2022). Studies suggest that modulating specific ncRNAs could provide novel treatment strategies for atherosclerosis (F. Fasolo et al., 2019).

Several significant gaps remain in our understanding:

1. Mechanistic Understanding: The precise molecular mechanisms of ncRNA regulation and function during atherogenesis remain largely unknown (B. Aryal et al., 2014).

2. Species Conservation: Long non-coding RNAs show poor genetic conservation between species, requiring extensive work to elucidate their specific roles in vascular biology (B. Aryal et al., 2019).

3. Clinical Translation: While promising in preclinical studies, the translation of exosomal ncRNA research to clinical applications remains limited (Chen Wang et al., 2021).

Conclusions

Exosome-related non-coding RNAs represent a rapidly evolving field with significant implications for understanding and treating atherosclerosis. The evidence demonstrates that exosomal ncRNAs serve as critical mediators of intercellular communication in atherosclerosis, influencing key pathological processes including inflammation, cellular dysfunction, and lipid metabolism (M. Alidadi et al., 2023)(Chen Wang et al., 2021).

While current research shows promising potential for diagnostic and therapeutic applications, significant work remains to fully elucidate the mechanisms involved and translate findings to clinical practice. The field would benefit from standardized methodologies, larger clinical studies,

and deeper mechanistic understanding of ncRNA function in atherosclerosis progression (Yuting Cui et al., 2022)(C. J. de Giusti et al., 2019; M. Alidadi et al., 2023)(Chen Wang et al., 2021).).

The convergence of exosome biology and non-coding RNA research offers unprecedented opportunities to develop novel approaches for atherosclerosis prevention, diagnosis, and treatment, potentially transforming cardiovascular medicine in the coming decades.

REFERENCE:

- Alidadi, M., Hjazi, A., Ahmad, I., Mahmoudi, R., Sarrafha, M., Hosseini-Fard, S. R., & Ebrahimzade, M. (2023). Exosomal non-coding RNAs: emerging therapeutic targets in atherosclerosis. Biochemical pharmacology, 212, 115572.
- Wang, C., Li, Z., Liu, Y., & Yuan, L. (2021). Exosomes in atherosclerosis: performers, bystanders, biomarkers, and therapeutic targets. Theranostics, 11(8), 3996.
- Lu, X. (2017). The role of exosomes and exosome-derived microRNAs in atherosclerosis. Current pharmaceutical design, 23(40), 6182-6193.
- Lu, M., Yuan, S., Li, S., Li, L., Liu, M., & Wan, S. (2019). The exosome-derived biomarker in atherosclerosis and its clinical application. Journal of cardiovascular translational research, 12(1), 68-74.
- Chen, Y. T., Yuan, H. X., Ou, Z. J., & Ou, J. S. (2020). Microparticles (exosomes) and atherosclerosis. Current atherosclerosis reports, 22(6), 23.
- Zheng, D., Huo, M., Li, B., Wang, W., Piao, H., Wang, Y., ... & Liu, K. (2021). The role of exosomes and exosomal microRNA in cardiovascular disease. *Frontiers in cell and developmental biology*, *8*, 616161.
- Heo, J., & Kang, H. (2022). Exosome-based treatment for atherosclerosis. International journal of molecular sciences, 23(2), 1002.
- Aryal, B., Rotllan, N., & Fernández-Hernando, C. (2014). Noncoding RNAs and atherosclerosis. Current atherosclerosis reports, 16(5), 407.
- Zhou, T., Ding, J. W., Wang, X. A., & Zheng, X. X. (2016). Long noncoding RNAs and atherosclerosis. Atherosclerosis, 248, 51-61.
- Xu, H., Ni, Y. Q., & Liu, Y. S. (2021). Mechanisms of action of MiRNAs and LncRNAs in extracellular vesicle in atherosclerosis. Frontiers in Cardiovascular Medicine, 8, 733985.
- Fasolo, F., Di Gregoli, K., Maegdefessel, L., & Johnson, J. L. (2019). Non-coding RNAs in cardiovascular cell biology and atherosclerosis. Cardiovascular research, 115(12), 1732-1756.
- Li, C., Ni, Y. Q., Xu, H., Xiang, Q. Y., Zhao, Y., Zhan, J. K., ... & Liu, Y. S. (2021). Roles and mechanisms of exosomal non-coding RNAs in human health and diseases. Signal transduction and targeted therapy, 6(1), 383.
- Wang, H., Xie, Y., Salvador, A. M., Zhang, Z., Chen, K., Li, G., & Xiao, J. (2020). Exosomes: multifaceted messengers in atherosclerosis. Current Atherosclerosis Reports, 22(10), 57.
- Chen, L., Yang, W., Guo, Y., Chen, W., Zheng, P., Zeng, J., & Tong, W. (2017). Exosomal lncRNA GAS5 regulates the apoptosis of macrophages and vascular endothelial cells in atherosclerosis. PloS one, 12(9), e0185406.
- Reiss, A. B., Vernice, N. A., Siegart, N. M., De Leon, J., & Kasselman, L. J. (2017). Exosomes in cholesterol metabolism and atherosclerosis. Cardiovascular & Haematological Disorders-Drug Targets (Formerly Current Drug Targets-Cardiovascular & Hematological Disorders), 17(3), 185-194.
- Liu, J., Wu, J., Li, L., Li, T., & Wang, J. (2020). The role of exosomal non-coding RNAs in coronary artery disease. Frontiers in Pharmacology, 11, 603104.

- Kumar, S., Williams, D., Sur, S., Wang, J. Y., & Jo, H. (2019). Role of flow-sensitive microRNAs and long noncoding RNAs in vascular dysfunction and atherosclerosis. Vascular pharmacology, 114, 76-92.
- Cui, Y., Zhou, Y., Gan, N., Xiang, Q., Xia, M., Liao, W., & Tang, Z. (2022). The role of extracellular non-coding RNAs in atherosclerosis. Journal of Cardiovascular Translational Research, 15(3), 477-491.
- De Giusti, C. J., Santalla, M., & Das, S. (2019). Exosomal non-coding RNAs (Exo-ncRNAs) in cardiovascular health. Journal of molecular and cellular cardiology, 137, 143-151.

EXOSOMES IN IDIOPATHIC PULMONARY FIBROSIS

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ABSTRACT

Idiopathic pulmonary fibrosis (IPF) represents a progressive, life-threatening lung disease with limited therapeutic options and poor prognosis. Exosomes are critical mediators in idiopathic pulmonary fibrosis (IPF), serving both diagnostic and potential therapeutic roles through complex intercellular communication mechanisms. Multiple studies provide strong evidence for exosomes' significance; exosomes can influence inflammatory, immune, and extracellular matrix processes in pulmonary fibrosis. Exosomes carry microRNAs, proteins, and lipids that directly modulate fibroblast behavior and tissue architecture.

Exosomal non-coding RNAs regulate key pathways like TGF-β and Wnt/β-catenin, critically influencing IPF progression. The evidence spans multiple molecular mechanisms, with researchers identifying both pro-fibrotic and anti-fibrotic exosomal effects, suggesting complex regulatory potential for future therapeutic interventions.

Recent research has identified exosomes—nanoscale extracellular vesicles—as critical mediators in IPF pathogenesis, offering promising avenues for diagnosis, prognosis, and treatment.

Keywords: Exosomes, Idiopathic Pulmonary Fibrosis, Treatment

PATHOGENIC ROLE OF EXOSOMES IN IPF

Cellular Communication and Disease Progression

Exosomes serve as crucial intercellular communicators in IPF, facilitating pathogenic processes through transport of bioactive molecules (M. C. Negrete-García et al., 2022). (R. J. Nija et al., 2025) demonstrates that these vesicles carry microRNAs, proteins, and lipids that directly influence fibroblast behavior, immune signaling, and tissue architecture, driving key pathogenic pathways including TGF-β, WNT/β-catenin, PI3K/AKT, and YAP/TAZ signaling. A. Martín-Medina et al. (2018) found significantly increased extracellular vesicles in bronchoalveolar lavage fluid from IPF patients, with these vesicles carrying WNT5A protein that promotes fibroblast proliferation. This study provides direct evidence that exosomes contribute to disease pathogenesis by transporting pro-fibrotic signals.

Oxidative Stress and Inflammatory Processes

Zaiyan Wang et al., (2024) identifies oxidative stress as a pivotal hallmark of IPF inflammation, with exosomes playing dual roles as both mediators of oxidative damage and potential carriers for

antioxidant therapies. Exosomal cargo can promote epithelial-mesenchymal transition (EMT), fibroblast-to-myofibroblast transformation, and contribute to immunoregulatory dysfunction (Linshen Xie et al., 2020).

EXOSOMAL CARGO AND MOLECULAR MECHANISMS

MicroRNA Profiles and Regulation

Research provides comprehensive analysis of exosomal non-coding RNAs in IPF, revealing complex regulatory networks. Pro-fibrotic long non-coding RNAs like LINC00470 and PVT1 contrast with inhibitory RNAs such as lnc-DC and THRIL. Similarly, pro-fibrotic microRNAs (miR-486, miR-223) oppose anti-fibrotic miRNAs (miR-34a, miR-126), while some like miR-21 and miR-155 exhibit dual functions (Yajing Wei et al., 2025).Elevated miR-143-5p and miR-342-5p in IPF-derived exosomes, which target fatty acid synthesis pathways and contribute to alveolar epithelial cell injury and senescence. This study demonstrates how specific exosomal miRNAs can disrupt cellular metabolism in IPF (H. Hayek et al., 2023).

Protein and Lipid Components

Exosomes transport diverse bioactive molecules beyond nucleic acids, including proteins and lipids that maintain the fibrotic microenvironment. The deregulated release and altered cargo content during fibrogenesis directly contributes to disease progression (Alma Aurora Ramírez-Hernández et al., 2022).

DIAGNOSTIC AND BIOMARKER POTENTIAL

Serum and Plasma Biomarkers

Serum exosomes from IPF patients display distinct fibrotic miRNA profiles correlating with disease severity measures. Specifically, decreased anti-fibrotic miR-141 and increased fibrogenic miR-7 correlated with radiological and physiological disease burden, while miR-125b upregulation correlated with milder disease defined by GAP scores (P. Minnis et al., 2015).

Sputum-Derived Biomarkers

Sputum-derived exosomal miRNAs in IPF, discovering substantial dysregulation between patients and healthy subjects. Notably, miR-142-3p showed negative correlation with lung diffusion capacity, suggesting potential for monitoring disease severity (Makon-Sébastien NJOCK et al., 2018).

Multi-Source Biomarker Profiles

Exosomal miRNA profiles from both bronchoalveolar lavage fluid and lung tissue, identifying 55 differentially expressed miRNAs in lung tissue-derived exosomes from IPF patients compared to controls. This comprehensive approach demonstrates the potential for multi-source biomarker strategies (Gagandeep Kaur et al., 2021).

Systemic Biomarker Potential

Urine-derived exosomes from IPF patients carry pro-fibrotic cargo, suggesting systemic features of the disease. These urine exosomes expressed miRNAs consistent with lung tissue patterns and could induce fibrotic phenotypes in experimental models (S. Elliot et al., 2022).

THERAPEUTIC APPLICATIONS

Stem Cell-Derived Exosome Therapies

Researchers showed that inhalation of lung spheroid cell-secretome and exosomes could attenuate bleomycin- and silica-induced fibrosis by reestablishing normal alveolar structure and decreasing collagen accumulation. This study showed superior therapeutic benefits compared to mesenchymal stem cell-derived counterparts in some measures (P. Dinh et al., 2020). Human amnion epithelial cell-derived exosomes reduced lung inflammation when administered early and improved tissue-to-airspace ratio when given later in disease progression. These exosomes carried protein cargo enriched for MAPK signaling pathways and miRNAs targeting PI3K-Akt, Ras, Hippo, and TGFβ pathways (J. Tan et al., 2018).

Targeted Therapeutic Mechanisms

Induced pluripotent stem cell-derived exosomes could suppress M2-type macrophages through miR-302a-3p delivery, targeting TET1 and mitigating pulmonary fibrosis. This study illustrates how engineered exosomal therapies can target specific cellular populations involved in fibrosis (Yan Zhou et al., 2021).

CONCLUSIONS

The evidence demonstrates that exosomes play multifaceted roles in IPF, serving as both pathogenic mediators and therapeutic targets. Their potential as diagnostic biomarkers is supported by consistent findings across multiple biological samples, while therapeutic applications show promise in preclinical models. However, significant challenges remain in standardization, characterization, and clinical translation that must be addressed to fully realize the potential of exosome-based approaches in IPF management.

The field is rapidly evolving, with recent studies providing increasingly sophisticated understanding of exosomal mechanisms and therapeutic potential. Continued research focusing on standardization, clinical validation, and innovative engineering approaches will be essential for translating these findings into clinical benefits for IPF patients. Exosomes are critical mediators in idiopathic pulmonary fibrosis (IPF), serving both diagnostic and potential therapeutic roles through complex intercellular communication mechanisms. The evidence spans multiple molecular mechanisms, with researchers identifying both pro-fibrotic and anti-fibrotic exosomal effects, suggesting complex regulatory potential for future therapeutic interventions.

REFERENCES

- Yang, Y., Liu, Y., Chai, Y., Liu, K., Hu, W., Zhao, K., & Zhang, C. (2022). Exosomes in pathogenesis, diagnosis, and treatment of pulmonary fibrosis. Frontiers in Pharmacology, 13, 927653.
- Nija, R. J., & Nithya, T. G. (2025). Pulmonary fibrosis and exosomes: pathways to treatment. Molecular Biology Reports, 52(1), 749.
- Wei, Y., Hong, M., Zhu, H., & Li, F. (2025). Recent progress in exosomal non-coding RNAs research related to idiopathic pulmonary fibrosis. Frontiers in Genetics, 16, 1556495.
- Minnis, P., Kane, R., Anglin, R., Walsh, S., Worrel, J., Khan, F., & Keane, M. P. (2015). Serum exosomes from IPF patients display a fibrotic miRNA profile that correlates to clinical measures of disease severity.

- Yang, Y., Liu, Y., Chai, Y., Liu, K., Hu, W., Zhao, K., & Zhang, C. (2022). Exosomes in pathogenesis, diagnosis, and treatment of pulmonary fibrosis. Frontiers in Pharmacology, 13, 927653.
- Fujita, Y. (2022). Extracellular vesicles in idiopathic pulmonary fibrosis: pathogenesis and therapeutics. Inflammation and Regeneration, 42(1), 23.
- Yang, Y., Lv, M., Xu, Q., Wang, X., & Fang, Z. (2024). Extracellular Vesicles in Idiopathic Pulmonary Fibrosis: Pathogenesis, Biomarkers and Innovative Therapeutic Strategies. International Journal of Nanomedicine, 12593-12614.
- Negrete-García, M. C., de Jesús Ramos-Abundis, J., Alvarado-Vasquez, N., Montes-Martínez, E., Montaño, M., Ramos, C., & Sommer, B. (2022). Exosomal micro-RNAs as intercellular communicators in idiopathic pulmonary fibrosis. International Journal of Molecular Sciences, 23(19), 11047.
- Martin-Medina, A., Lehmann, M., Burgy, O., Hermann, S., Baarsma, H. A., Wagner, D. E., & Königshoff, M. (2018). Increased extracellular vesicles mediate WNT5A signaling in idiopathic pulmonary fibrosis. American journal of respiratory and critical care medicine, 198(12), 1527-1538.
- Wang, Z., Zhang, Y., & Li, X. (2024). Mitigation of oxidative stress in idiopathic pulmonary fibrosis through exosome-mediated therapies. International Journal of Nanomedicine, 6161-6176.
- Xie, L., & Zeng, Y. Therapeutic potential of exosomes in pulmonary fibrosis. Front Pharmacol. 2020; 11: 590972.
- Hayek, H., Rehbini, O., Kosmider, B., Brandt, T., Chatila, W., Marchetti, N., & Bahmed, K. (2024). The regulation of fatty acid synthase by exosomal miR-143-5p and miR-342-5p in idiopathic pulmonary fibrosis. American Journal of Respiratory Cell and Molecular Biology, 70(4), 259-282.
- Ramírez-Hernández, A. A., Velázquez-Enríquez, J. M., Santos-Álvarez, J. C., López-Martínez, A., Reyes-Jiménez, E., Carrasco-Torres, G., ... & Baltierrez-Hoyos, R. (2022). The role of extracellular vesicles in idiopathic pulmonary fibrosis progression: an approach on their therapeutics potential. Cells, 11(4), 630.
- Njock, M. S., Guiot, J., Henket, M. A., Nivelles, O., Thiry, M., Dequiedt, F., & Struman, I. (2019). Sputum exosomes: promising biomarkers for idiopathic pulmonary fibrosis. Thorax, 74(3), 309-312.
- Kaur, G., Maremanda, K. P., Campos, M., Chand, H. S., Li, F., Hirani, N., Haseeb, M. A., Li, D., & Rahman, I. (2021). Distinct Exosomal miRNA Profiles from BALF and Lung Tissue of COPD and IPF Patients. International journal of molecular sciences, 22(21), 11830. https://doi.org/10.3390/ijms222111830.
- Elliot, S., Catanuto, P., Pereira-Simon, S., Xia, X., Shahzeidi, S., Roberts, E., ... & Glassberg, M. K. (2022). Urine-derived exosomes from individuals with IPF carry pro-fibrotic cargo. Elife, 11, e79543.
- Dinh, P. U. C., Paudel, D., Brochu, H., Popowski, K. D., Gracieux, M. C., Cores, J., ... & Cheng, K. (2020). Inhalation of lung spheroid cell secretome and exosomes promotes lung repair in pulmonary fibrosis. Nature communications, 11(1), 1064.
- Tan, J. L., Lau, S. N., Leaw, B., Nguyen, H. P., Salamonsen, L. A., Saad, M. I., ... & Lim, R. (2018). Amnion epithelial cell-derived exosomes restrict lung injury and enhance endogenous lung repair. Stem cells translational medicine, 7(2), 180-196.
- Zhou, Y., Gao, Y., Zhang, W., Chen, Y., Jin, M., & Yang, Z. (2021). Exosomes derived from induced pluripotent stem cells suppresses M2-type macrophages during pulmonary fibrosis via miR-302a-3p/TET1 axis. International Immunopharmacology, 99, 108075.

GOVERNING THE MIND: PANOPTICON, AUTONOMY, AND PSYCHIATRIC NURSING

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ABSTRACT

The concept of governing individuals through subtle and continuous forms of surveillance has become a defining characteristic of modern institutional care. In psychiatric settings, the regulation of patients' behaviors, emotions, and thoughts often occurs through practices that extend beyond direct coercion, operating instead through observation, normalization, and internalized control. Drawing on Michel Foucault's concept of the Panopticon, this review examines how psychiatric nursing practices participate in the governance of the mind and how these practices affect patient autonomy. Psychiatric nursing plays a pivotal role in shaping daily life within psychiatric institutions through constant assessment, observation, documentation, and intervention. While these practices are primarily intended to ensure safety and therapeutic effectiveness, they may also function as mechanisms of power that influence patients' self-perception, decision-making, and capacity for autonomy. The continuous visibility of patients, combined with clinical evaluations and behavioral expectations, can lead to the internalization of institutional norms, encouraging self-regulation in accordance with dominant definitions of normality and health. This review explores the ethical tensions arising from the dual responsibility of psychiatric nurses to protect patients from harm while simultaneously respecting their autonomy and dignity. The analysis highlights how surveillance-based practices may unintentionally undermine patient autonomy by limiting opportunities for choice, privacy, and self-determination. At the same time, the paper acknowledges the complexity of psychiatric care, where autonomy must often be negotiated within contexts of risk, vulnerability, and legal constraints.

The review concludes that governing the mind through panoptic mechanisms is not an isolated or intentional act but an embedded feature of psychiatric care systems. By critically reflecting on the relationship between surveillance, power, and autonomy, psychiatric nurses can develop more ethically sensitive practices that support patient agency while maintaining safety. Such an approach may contribute to a more balanced model of psychiatric nursing that prioritizes autonomy, human rights, and recovery-oriented care alongside clinical responsibility.

Keywords: Panopticon, Patient Autonomy, Psychiatric Nursing, Power, Ethics.

Introduction

Inpatient psychiatric units are frequently described in policy documents as therapeutic environments designed to ensure safety and promote recovery. However, empirical research over the last decade indicates that these settings are simultaneously structured around intensive observation and risk management practices (Bowers et al., 2015; Molodynski et al., 2016). Observation levels, incident reporting systems, structured risk assessments, and multidisciplinary reviews are not peripheral components of care; they constitute its operational core. Within such environments, visibility is institutionalized.

The expansion of risk-based governance in mental health services has been widely documented (Szmukler, 2019). Clinical decision-making increasingly relies on formalized tools designed to predict harm, manage uncertainty, and justify intervention. Although these tools are implemented to protect patients and staff, they also reorganize professional attention around the anticipation of danger. As Molodynski et al. (2016) note, contemporary mental health systems operate within legal and ethical frameworks where the management of perceived risk often determines the limits of patient liberty.

At the same time, international mental health policy has shifted toward autonomy, participation, and rights-based care. The World Health Organization (2022) explicitly calls for the reduction of coercive practices and the strengthening of supported decision-making models. This policy orientation reflects broader commitments under the United Nations Convention on the Rights of Persons with Disabilities, which emphasizes equal recognition before the law and respect for individual will and preferences (Pritchard-Jones, 2019).). The coexistence of risk-intensive clinical environments and autonomy-oriented policy frameworks generates a structural tension within psychiatric institutions.

This tension becomes particularly visible in everyday nursing practice. Psychiatric nurses maintain continuous proximity to patients, monitor behavioral changes, administer medication, and document mental state fluctuations. Studies examining inpatient nursing environments show that nurses frequently navigate competing responsibilities: therapeutic engagement on the one hand, and enforcement of safety protocols on the other (Cleary et al., 2017). Decisions about enhanced observation, seclusion prevention strategies, or escalation procedures are often made under conditions of uncertainty, where the potential consequences of inaction are considered severe (Bowers et al., 2015).

Scholars analyzing contemporary psychiatry through a critical lens argue that surveillance in mental health settings is rarely experienced as overt coercion; rather, it is embedded within routine practices that appear clinically justified (McWade, 2016). When observation becomes continuous, behavioral expression may shift in response to anticipated interpretation. In this context, autonomy cannot be reduced to formal consent processes. Instead, it must be understood as a situated capacity shaped by institutional norms, documentation systems, and professional authority (Szmukler, 2019).

Recent debates in psychiatric ethics emphasize that autonomy and protection are not mutually exclusive but exist in a dynamic relationship (WHO, 2022). Nevertheless, evidence suggests that restrictive practices and constant monitoring can influence patients' experiences of dignity, privacy, and self-determination (Cusack et al., 2018). The ethical challenge, therefore, lies not in eliminating surveillance altogether—an unrealistic goal in acute psychiatric care—but in critically examining how surveillance practices are structured, justified, and experienced.

Understanding psychiatric nursing within this framework requires attention to both its protective function and its regulatory effects. The governance of behavior in inpatient units does not typically emerge from explicit intent to dominate; rather, it arises from cumulative procedural routines designed to ensure safety. Yet these routines shape the conditions under which autonomy is enacted. Recognizing this complexity is essential for developing nursing practices that align with contemporary commitments to recovery, human rights, and person-centered care (WHO, 2022).

Theoretical Framework: Panopticon, Disciplinary Power, and Modern Surveillance

Understanding modern institutions requires moving beyond a conception of power as merely prohibitive or coercive. Contemporary social theory increasingly conceptualizes power as a productive force—one that shapes conduct, generates norms, and forms subjectivities. Within this

framework, Michel Foucault's notion of disciplinary power provides a robust analytical lens for examining the mechanisms of surveillance operating in contemporary institutions.

Disciplinary power does not function primarily through direct repression; rather, it operates by rendering individuals continuously visible. Foucault's concept of the "panopticon" serves as a metaphor to explain this mechanism. The panopticon describes an arrangement in which surveillance may or may not be constant, yet the possibility of being observed is persistently felt. Under such conditions, individuals begin to regulate their own behavior not in response to overt coercion, but in anticipation of observation. Power thus shifts from an externally imposed force to an internalized mode of self-regulation (Bevir, 2017). Recent scholarship on healthcare institutions suggests that surveillance serves not only a protective function but also a norm-producing one. The growing prominence of risk-based management frameworks has made the continuous evaluation and documentation of behavior a structural requirement within health services (Molodynski, Rugkåsa, & Burns, 2016). Consequently, clinical practices assume not only a therapeutic character but also a regulatory dimension.

Psychiatry represents one of the domains in which this disciplinary logic becomes particularly visible. In psychiatric settings, the focus of evaluation extends beyond physical symptoms to encompass thoughts, emotions, intentions, and interpersonal behaviors. A patient's manner of speaking, silence, agitation, or level of cooperation generates clinical meaning. The production of such meaning is simultaneously a process of norm construction. Determinations regarding which behaviors are classified as "compliant," "risky," or "pathological" are shaped within institutional knowledge systems (Szmukler, 2019).

Contemporary mental health policies attempt to integrate these surveillance and norm-producing processes with discourses of human rights and autonomy. Reports issued by the World Health Organization emphasize the reduction of coercive practices and the strengthening of supported decision-making models in mental health services (World Health Organization, 2022). Nevertheless, in practice, the responsibility to manage risk remains central. As a result, psychiatric institutions operate within a dual structure in which visibility is intensified while autonomy discourse is simultaneously strengthened. Within this context, the concept of the panopticon can be applied not merely to architectural arrangements but to the broader regime of institutional visibility. In present-day psychiatric units, surveillance is no longer centralized; rather, it is enacted through observation forms, risk assessment scales, electronic health records, and multidisciplinary meetings (Bevir, 2017). The care provided in such settings does not typically function as an intentional mechanism of domination, but as a normalized structure of visibility embedded in institutional routines. This structure does more than monitor patient behavior; it also shapes the interpretive frameworks through which behavior is understood. In such an environment, an individual's self-perception cannot be considered entirely independent of institutional evaluation processes. This theoretical framework makes it possible to approach psychiatric nursing not only as a therapeutic care practice, but also as an active component of the institutional surveillance structure within which psychiatric care is delivered.

Structural Dimensions of Surveillance in Psychiatric Institutions

Inpatient psychiatric units are not merely clinical settings where treatment is delivered; they are highly structured institutional environments. Within these settings, ensuring safety, preventing crises, and managing risk constitute primary priorities. However, these priorities render continuous observation, documentation, and behavioral assessment integral components of everyday institutional practice.

Observation levels implemented in psychiatric units—such as routine observation, close observation, or one-to-one monitoring—directly affect patients' mobility and privacy. These measures are typically initiated in response to suicide risk, agitation, or the potential for self-harm or harm to others (Bowers et al., 2015). While designed to reduce risk, such systems simultaneously ensure that patients remain continuously visible. In this context, surveillance ceases to function as an exceptional intervention and instead becomes a routine element of care. In contemporary psychiatric institutions, surveillance extends beyond physical observation. Electronic health record systems, standardized risk assessment tools, shift reports, and multidisciplinary case conferences maintain the constant circulation of patient-related information. The documentation of behaviors is regarded as essential for justifying clinical decisions and distributing institutional responsibility. At the same time, this process contributes to the categorization of patients' experiences within predefined clinical frameworks (Molodynski, Rugkåsa, & Burns, 2016).

Risk-based governance has become increasingly prominent in mental health services in recent years. Within clinical practice, managing uncertainty is often approached through the identification and measurement of risk. This orientation encourages professionals to anticipate potential dangers and plan interventions accordingly (Szmukler, 2019). However, the discourse of risk also provides a normative framework that determines which behaviors are to be interpreted as dangerous. Consequently, risk assessment cannot be understood solely as a technical procedure; it also constitutes a value-laden decision-making process.

While the World Health Organization emphasizes the importance of rights-based transformation in mental health services and prioritizes the reduction of coercive practices (World Health Organization, 2022), the responsibility for ensuring safety within inpatient psychiatric units does not disappear. As a result, institutional visibility and surveillance remain structurally embedded. The simultaneous presence of autonomy discourse and security practices renders psychiatric institutions complex ethical environments. From a structural perspective, surveillance within psychiatric institutions cannot be attributed to a single authority figure. Rather, it operates in a dispersed manner through institutional procedures, clinical guidelines, and standardized forms. Power does not reside in a particular individual but becomes embedded in the functioning of the system itself. For this reason, surveillance in psychiatric settings should be understood less as overt oppression and more as a normalized organizational structure. Within this structural arrangement, patients' experiences are shaped not only by individual clinical interactions but also by the broader regime of institutional visibility. Continuous evaluation and documentation may influence how patients interpret and present their own behavior. Therefore, the protective and regulatory dimensions of institutional surveillance must be considered together.

The Dual Role in Psychiatric Nursing: Care and Surveillance

Psychiatric nursing stands out as the professional role that provides the greatest continuity within mental health services. Nurses remain in direct contact with patients for most of the day, administering medications, monitoring behavioral changes, responding to crises, and documenting clinical observations. This continuity positions nursing not only as a therapeutic relational practice but also as a sustaining force of institutional order.

In inpatient psychiatric settings, nurses carry the responsibility of ensuring patient safety while simultaneously supporting patient autonomy. These two responsibilities do not always progress in harmony. Particularly in situations involving suicide risk, agitation, or potential aggression, interventions implemented for protective purposes may restrict a patient's mobility and decision-making capacity (Bowers et al., 2015). At this point, nursing practice is required to establish a delicate balance between care and surveillance.

Nurses actively participate in decisions such as increasing observation levels, initiating one-to-one monitoring, or implementing specific restrictions. These decisions frequently generate ethical tension, as protective interventions may simultaneously produce limiting effects. The literature indicates that coercive practices can result in consequences such as loss of privacy, diminished self-worth, and erosion of trust among patients (Cusack et al., 2018). This dynamic further complicates the nurse's effort to sustain a therapeutic relationship.

Moreover, nursing practice does not produce surveillance solely through physical interventions. Daily observation notes, mental status assessments, and behavioral documentation play a decisive role in shaping the clinical narrative of the patient. The classification of a behavior as "compliant," "insightful," or "risky" can influence subsequent interventions and interdisciplinary team decisions. In this sense, the nurse is not merely an observer but also an active producer of clinical meaning.

The widespread adoption of risk-based practices places nurses in a position of continuously evaluating potential danger (Szmukler, 2019). This evaluative process is often conducted under conditions of uncertainty. Given that institutional and legal accountability may arise if harm occurs, a tendency to prioritize safety can become more pronounced. Consequently, practices of surveillance and restriction may be reproduced within the logic of the system, independent of individual intentions.

At the same time, contemporary mental health policies advocate for the strengthening of supported decision-making and recovery-oriented approaches in nursing practice (World Health Organization, 2022). This perspective requires positioning the patient not merely as an object of risk, but as a subject with agency. However, within a care relationship structured around continuous visibility, it may not always be easy for patients to freely express their subjective experiences.

For this reason, psychiatric nursing practice inherently embodies a dual character: on the one hand protective and supportive; on the other hand regulatory and restrictive. Rather than weakening the ethical position of nursing, this duality calls for a more conscious and critical reflexivity. In a context where care and surveillance are intertwined, the nurse's reflective stance becomes decisive in strengthening the patient's autonomy.

Conclusion: Rethinking Governance, Visibility, and Autonomy in Psychiatric Nursing

This paper has examined inpatient psychiatric care through the analytical lens of governance, disciplinary power, and institutional visibility. Drawing on contemporary debates in mental health policy and ethics, it has argued that surveillance within psychiatric settings cannot be understood solely as an exceptional or coercive intervention. Rather, surveillance is embedded within routine clinical procedures, risk assessment frameworks, documentation systems, and everyday nursing practices. In this sense, governance in psychiatric institutions operates less through overt domination and more through normalized structures of visibility.

The coexistence of risk-intensive environments and autonomy-oriented policy commitments creates a persistent structural tension. While international frameworks emphasize supported decision-making, dignity, and human rights, inpatient psychiatric units remain responsible for preventing harm and managing uncertainty. The institutionalization of observation levels, risk prediction tools, and multidisciplinary reviews reflects this responsibility. Yet these mechanisms do more than ensure safety; they also shape how behavior is interpreted, categorized, and responded to.

Within this environment, psychiatric nursing occupies a particularly complex position. Nurses are neither external observers nor detached implementers of institutional policy. Through continuous

proximity to patients, documentation practices, and participation in risk-related decisions, nursing practice becomes an active component of the governance structure. This dual positioning—therapeutic and regulatory—does not imply intentional control, but it does reveal how professional care is intertwined with mechanisms of surveillance.

Importantly, the governance of behavior in psychiatric settings does not emerge from individual motives to restrict autonomy. It develops cumulatively from procedural routines designed to minimize risk and distribute responsibility. However, these routines shape the conditions under which autonomy is exercised. When visibility becomes continuous and behavioral expression is constantly evaluated, autonomy cannot be reduced to formal consent or policy language. Instead, it must be understood as a situated and relational capacity, influenced by institutional norms and professional authority.

Recognizing this complexity does not require the elimination of surveillance—an unrealistic goal in acute psychiatric care. Rather, it calls for critical reflexivity within nursing practice and institutional structures. Ethical psychiatric nursing demands awareness of how protective intentions may simultaneously generate regulatory effects. Such awareness enables practitioners to remain attentive to patients' subjective experiences while fulfilling safety obligations.

Ultimately, governing the mind in psychiatric institutions is not simply a matter of clinical intervention; it is a process shaped by visibility regimes, risk discourses, and professional practices. Strengthening autonomy in this context requires more than policy reform. It requires ongoing reflection on how everyday routines contribute to the formation of self-regulating subjects and how nursing practice can support agency within, rather than despite, institutional constraints.

By situating psychiatric nursing within this broader framework of governance and disciplinary power, this paper contributes to contemporary discussions on recovery-oriented and rights-based mental health care. The challenge moving forward lies not in denying the necessity of safety, but in ensuring that safety practices remain critically examined, proportionate, and aligned with commitments to dignity and person-centered care.

REFERECES

Bevir, M. (2018). Governmentality after neoliberalism. In *Governmentality after neoliberalism* (pp. 1-15). Routledge.

Bowers, L., James, K., Quirk, A., Simpson, A., Stewart, D., & Hodsoll, J. (2015). Reducing conflict and containment rates on acute psychiatric wards: The Safewards cluster randomised controlled trial. *International journal of nursing studies*, *52*(9), 1412-1422.

Cleary, M., Horsfall, J., O'Hara-Aarons, M., & Hunt, G. E. (2013). Mental health nurses' views of recovery within an acute setting. *International Journal of Mental Health Nursing*, *22*(3), 205-212.

Cusack, P., McAndrew, S., Cusack, F., & Warne, T. (2016). Restraining good practice: reviewing evidence of the effects of restraint from the perspective of service users and mental health professionals in the United Kingdom (UK). *International Journal of Law and Psychiatry*, *46*, 20-26.

McWade, B. (2016). Recovery-as-policy as a form of neoliberal state making. *Intersectionalities: A Global Journal of Social Work Analysis, Research, Polity, and Practice*, *5*(3), 62-81.

Molodynski, A., Rugkåsa, J., & Burns, T. (2010). Coercion and compulsion in community mental health care. *British medical bulletin*, *95*(1), 105-119.

Molodynski, A., Rugkåsa, J., & Burns, T. (2010). Coercion and compulsion in community mental health care. *British medical bulletin*, *95*(1), 105-119.

Pritchard-Jones, L. (2019). Exploring the potential and the pitfalls of the United Nations Convention on the Rights of Persons with Disabilities and General Comment no. 1 for people with dementia. *International Journal of Law and Psychiatry*, *66*, 101467.

Szmukler, G. (2015). Compulsion and "coercion" in mental health care. *World Psychiatry*, *14*(3), 259.

World Health Organization. (2022). *World mental health report: Transforming mental health for all*. World Health Organization.

GROWTH, YIELD AND QUALITY OF WHEAT AND POST-HARVEST SOIL PROPERTIES AS INFLUENCED BY BIOGAS DIGESTATE FROM COW DUNG AND POULTRY MANURE

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ABSTRACT

A pot experiment was carried out to observe the influence of biogas digestate from cow dung and poultry manure; raw cow dung and raw poultry manure on growth, yield and quality of wheat in crop field of the Department of Soil Science, University of Chittagong, Bangladesh. The results showed that application of biogas digestate from cow dung and poultry manure as well as raw cow dung and raw poultry manure significantly influenced plant height, number of panicles plant^{-1}; stem and root biomass and grain yield. The highest grain yield was produced by addition of 50%RDN through urea along with 50%RDN through poultry manure digestate followed by 50%RDN through urea along with 50%RDN through cow dung digestate and 50%RDN through urea along with 50%RDN through raw poultry manure digestate. The increase of grain yield over control was 114%, 106% and 104% by T8, T7 and T10 treatments respectively. In combination with urea, poultry manure digestate and raw poultry manure was more favorable in increasing wheat yield than cow dung digestate and raw cow dung respectively. The supply of required total N (120kg ha^{-1}) through the integration of different organic amendments with urea produced higher N concentration in wheat than through their application alone. The nutrients availability in post-harvest soil was higher in poultry manure digestate and raw poultry manure treated pots than cow dung digestate and raw cow dung treated pots respectively indicating poultry manure was more effective in providing nutrients in available forms and hence producing quality crop yield of wheat.

Keywords: Digestate, cow dung, poultry manure, protein, wheat.

ASSESSMENT OF RADIATION DOSE LEVELS TO PRISON GUARDS DURING MYOCARDIAL PERFUSION SCINTIGRAPHY IN NUCLEAR MEDICINE UNITS

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ABSTRACT

In nuclear medicine, patients administered with radiopharmaceuticals are typically isolated before and after scintigraphy to reduce unnecessary exposure to others. However, in the case of prisoner patients, constant supervision by guards is required. This creates a conflict between ensuring the patient's medical care and maintaining radiation protection for non-medical personnel. This study aimed to evaluate the radiation dose levels to which prison guards are exposed during myocardial perfusion scintigraphy procedures.

Radiation dose rates were measured using a calibrated Geiger–Müller counter. Measurements were taken at three time intervals: immediately after injection, one hour later, and before the patient's discharge. The obtained data were analyzed to observe changes in dose rate depending on both distance and time after injection.

The results indicated that radiation dose rates decreased as both the time after injection and the distance from the patient increased. The highest dose was recorded at 25 cm immediately after injection, while the lowest was observed at 200 cm before discharge. Average radiation levels for guards remained well below the limits set by international and national radiation safety guidelines, even when the guards remained near the patient for approximately two hours.

This study demonstrates that prison guards supervising patients during myocardial perfusion scintigraphy are not exposed to hazardous levels of radiation. The findings confirm the adequacy of existing protection measures and highlight the importance of including non-medical personnel in occupational radiation safety assessments.

Keywords: radiation exposure, myocardial perfusion scintigraphy, prison guards, radiation protection

HEAVENLY CREATURES: HOW BYZANTINE PAINTERS DEPICTED MALE AND FEMALE BEAUTY

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ABSTRACT

Although not in the focus of Byzantine scholars, the depiction of physical beauty of the saintly images can not be excluded from the investigation of aesthetic categories of the medieval painting in the Orthodox East. It is well known that the manners of ideological conception and visual presentation of the holy portraiture in Byzantium were highly dependent on the religious dogma as well as church canons established as early as the Late Antique period. However, the sophisticated approach of representative Byzantine painters towards the specific and highly distinctive aesthetic configuration of different saintly categories has left a significant testimony to the ways of construction of the very decisive painterly code for the expression of their "attractive" physical appearance. In that regard and according to our typological categorization, the holy warriors due to their bravery and uncompromising nature, received the features of masculine and vigorous outlook (*energy and resolution*); the martyrs, who have proudly sacrificed themselves for the common religious cause, gained the physical characteristics of dignified and elegant pillars of the faith (*resolution and distinction*), the holy physicians appeared as symbols of corporeal and spiritual health (*distinction and generosity*), the bishops as members of the most respected church entourage were represented as noble and erudite leaders of the faithful (*generosity and maturity*), while the representatives of the hermitic category were given the look of ascetic tribunes in "silent" combat for the purity of faith (*maturity and purity*). On the other hand, the female saints, according to their hagiographies, were depicted in two different manners: as nuns and as wealthy and glamorous lady aristocrats. In the first case, they embody the humble and god-fearing female gender (*purity and grace*), while in the second, the images radiate with feminine graciousness and tender physical attractiveness (*grace and fashion*).

ICOR-BASED ASSESSMENT OF THE INVESTMENT–GDP PROPORTION IN AZERBAIJAN

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ABSTRACT

It should be noted that in recent years, the mainstream of economic science has somewhat moved away from the study of macroeconomic proportions. It is precisely as a result of the study of macroeconomic proportions that it is possible to identify the main determinants of economic development. One of the most classic forms of macroeconomic proportions is the investment-GDP proportion. An indicator called the Incremental Capital Output Ratio (ICOR) is used to measure this proportion. If the ICOR indicator is higher than 1, then investments have been used inefficiently. On the other hand, if the ICOR indicator is less than 1, then it can be said that investments have been used effectively. It should be noted that investments are one of the main factors characterizing economic development. Since Azerbaijan is a developing country, it is necessary to conduct a proportional analysis and assess the effectiveness of investments in this area. The research work is based on the quantitative method. The research work consists of two research questions. Results were obtained in accordance with both research questions. In order to check the correlation between the variables used in the macroeconomic proportional analysis, Spearman rank correlation was conducted between fixed capital investments in Azerbaijan and GDP, and a highly strong relationship was revealed. Then, the effectiveness of fixed capital investments in Azerbaijan was assessed through ICOR. The ICOR result was somewhat variable, as fluctuations in investment efficiency were observed over different periods. The practical significance of the research work lies in its ability to serve as a basis for indicative indicators when establishing long-term strategic development plans.

Keywords: macroeconomic proportions, Spearman rank correlation, ICOR, investment-GDP proportion, Azerbaijan

INTRODUCTION

In recent decades investment plays a vital role in the economies of countries as it has various effects on different aspects of the economy.

Investment is an increase in the number of capital goods, which is aimed at to escalate production efficiency of the economy. Investment is also believed to have a major effect on the real economic

growth rates in a country's economy which can be supported by the fact that in the 1980s the decline in the investment level showed positive correlation with the slowdown in the economic growth of several countries (Greene, J., & Villanueva, D. 1991). In addition, David Aschauer also saw a relationship between the decrease in the rate of public capital investment and productivity rates in the US in his calculations, in 1989 (Munnell, A. H., 1992). The reason for this relationship between economic growth and investment can be seen in terms of change that occurs in productive potential, aggregate demand, general price level and costs of economies as a result of change in investment.

Ensuring investment is crucial in the cases of countries, such as Azerbaijan. As Azerbaijan is considered to have a developing economy, injecting the right amount of investment to the economy can help to maintain sustained economic growth and achieve increase in the productive potential. However, conducting research on the efficiency of these investments and investigating the relationship between GDP and investment would help to provide a more clarified explanation about investment in the economy of Azerbaijan. So, the main questions of this research are presented below:

RQ1: Is there a relationship between investment and GDP in Azerbaijan?

RQ2: Is the investment put in Azerbaijan effective?

LITERATURE REVIEW

In previous years, several papers have analyzed the efficiency of investment with a use of the ICOR approach to determine the relationship between the investment and GDP or economic growth in various countries. For example, Jeton Mazllami has examined the relationship between ICOR level and GDP for the Republic of Croatia and Slovenia in 2023, and Anna Yulianita has examined the impact of investment efficiency on economic growth of Sumatera Island in 2019. Several articles on the analysis of the macroeconomic proportion in question are presented in the table below.

Table 1. The analysis of ICOR throughout the years in different countries and sectors

Author(s)	Research name	Main focus	Year
Ranadev Banerji	An Experiment with Incremental Capital-Output Ratio	To study whether developing countries experience fall in overall marginal ICOR.	1969
Nicholas V. Gianaris	International Differences in Capital-Output Ratios.	To analyze the balance of ICOR level through the years in different countries.	1970
U Tun Wai	Study of ICOR in developing countries.	To find out the link coalition between key variables and ICOR level.	1985
Hiroyuki Taguchi and Suphannada Lowhachai	A revisit to the incremental capital-output ratio: the case of Asian economies and Thailand.	To work out the relationship between ICOR and GDP per capita and GDP growth rate	2014
Anna Yulianita et al.	Analysis of Investment Efficiency by using ICOR Approach to Economic Growth in All Provinces of Sumatera Island.	To determine the impact of investment efficiency with ICOR on economic growth	2019
Jeton Mazllami	The Investments Efficiency Toward Economic Growth: ICOR of the Republic of Croatia and Slovenia - Comparative Analysis.	To find out the best ICOR level, the relationship between ICOR and GDP, and the effect of it on economic growth	2023

Source: (Mazllami, 2023; Yulianita, 2019; Taguchi and Lowhachai, 2014; WAI, 1985; Gianaris, 1970; Banerji, 1969).

Conducting ICOR analysis is an important direction for measuring the effectiveness of investments. It should be noted that the relatively small number of studies conducted in this direction by Azerbaijani researchers characterizes the creation of a literature gap in the field in question.

MATERIALS AND METHODS

In accordance with the existing research questions, quantitative research methods will be used in the study. GRETL 2025b and IBM SPSS Statistics 27 software will be used for the calculation of quantitative methods. The database of the study will be formed by the indicators of the State Statistical Committee of the Republic of Azerbaijan. The two main variables here are Gross Domestic Product (GDP) and fixed capital investments (INV).

First, within the framework of the first research question, the correlation method will be used to examine the relationship between two variables. In order to select the correct correlation method, it is first necessary to conduct normality tests on the variables.

Table 2. Normality test of variables

Tests for GDP	Result	p value	Tests for INV	Result	p value
Doornik-Hansen test	1.87335	0.391929	Doornik-Hansen test	6.2159	0.0446925
Shapiro-Wilk W	0.933205	0.114981	Shapiro-Wilk W	0.896542	0.018194
Lilliefors test	0.104798	~= 0.7	Lilliefors test	0.215472	~= 0.01
Jarque-Bera test	1.386	0.500074	Jarque-Bera test	2.25912	0.323175

Source: Authors' calculating

It should be noted that since the sample size is 24, the Shapiro-Wilk test will be considered here (Mishra et al., 2019). Although the test results show that GDP is normal, normality was not achieved in INV. For this reason, Spearman's rank correlation will be used here (Field, 2013). The formula for Spearman's rank correlation is as follows (Song and Park, 2020).

$$r_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \quad ((1)$$

Where, n is the total number of observations, and d_i indicates the significant difference between the ranked values of the two variables (Kumar and Abirami, 2018) The Spearman rank correlation coefficient varies between -1 and +1. If this coefficient approaches 0, then the relationship is weak, and if it approaches ±1, then the relationship is strong (Li et al., 2020)

Within the framework of the second research question, the ICOR method based on macroeconomic proportional analysis will be used to calculate the effectiveness of investments, the formula of which is as follows.

$$ICOR = \frac{\Delta K}{\Delta Y} \quad (2)$$

Where, ΔK denotes the change in Gross Fixed Capital Formation and ΔY denotes the change in GDP. If the ICOR coefficient is high (usually greater than 1), then the effectiveness of the investments is poorly evaluated. On the contrary, if the ICOR coefficient is small (usually less than 1), then the investments are effective (Amin et al., 2023).

RESULT AND DISCUSSION

It should be noted that since normality was not found in either of the variables, Spearman's rank correlation will be used here. The result of Spearman's rank correlation is as follows:

Table 3. Spearman's rank correlation matrix

			GDP	INV
Spearman's rho	GDP	Correlation Coefficient	1.000	.947**
		Sig. (2-tailed)	.	.000
		N	24	24
	INV	Correlation Coefficient	.947**	1.000
		Sig. (2-tailed)	.000	.
		N	24	24

**. Correlation is significant at the 0.01 level (2-tailed).
Source: Authors' calculating

Table 3 answers the first research question. Thus, if we interpret the correlation matrix, we see that there is a very strong correlation between GDP and fixed capital investment (Hair et al., 2017). In fact, this was expected because investment is an integral part of the calculation of GDP using the expenditure method. However, even if this is the case, it was necessary to test the said expectation. Finding this relationship creates the necessary conditions for conducting macroeconomic proportional analysis. It is for this reason that ICOR analysis can now be conducted to answer the second research question.

Table 4. Changes in fixed capital investment, GDP and ICOR in Azerbaijan

Years	I*	Y*	ΔI	ΔY	ICOR
2000	0,968	4718,1	-	-	-
2001	1,171	5315,6	1,209711	1,12664	1,073733
2002	2,107	6062,5	1,799317	1,140511	1,577641
2003	3,786	7146,5	1,796868	1,178804	1,524314
2004	4,923	8530,2	1,300317	1,193619	1,08939
2005	5,77	12522,5	1,17205	1,46802	0,798388
2006	6,234	18746,2	1,080416	1,497001	0,72172
2007	7,471	28360,5	1,198428	1,512867	0,792157
2008	9,944	40137,2	1,331013	1,41525	0,940479
2009	7,725	35601,5	0,77685	0,886995	0,875823
2010	9,906	42465,0	1,28233	1,192787	1,075071
2011	12,799	52082,0	1,292045	1,226469	1,053468
2012	15,407	54743,7	1,203766	1,051106	1,145237
2013	17,851	58182,0	1,158629	1,062807	1,090159
2014	17,619	59014,1	0,987004	1,014302	0,973087
2015	15,957	54380,0	0,90567	0,921475	0,982848
2016	15,773	60425,2	0,988469	1,111166	0,889578
2017	17,43	70337,8	1,105053	1,164047	0,949319
2018	17,245	80092,0	0,989386	1,138677	0,868891
2019	18,539	81896,2	1,075036	1,022527	1,051353
2020	17,226	72578,1	0,929176	0,886221	1,048471
2021	16,815	93203,2	0,976141	1,284178	0,760129
2022	17,878	133972,7	1,063217	1,437426	0,739668
2023	21,311	123128,4	1,192024	0,919056	1,297009

Source: Authors' calculating

* - million manat

The table shows that investments in the Azerbaijani economy have shown different effectiveness results in different years. There is no specific increase or decrease in the effectiveness of investments. However, an interesting point here is that there is a certain cyclicality. Although investments made between 2001-2004 were observed to be ineffective, effectiveness was observed in investments in 2005-2009. On the other hand, while inefficiency was observed in investments again in 2010-2013, effectiveness is again seen in investments in 2014-2018. This cyclicality was broken in 2019-2020. The main reason for this can be the COVID-19 pandemic. Volatility is also observed in the following post-pandemic years. Thus, although efficiency was observed in 2021-2022, inefficiency was again present in 2023. Here, when analyzing by year, it should be taken into account that changes over the years are taken into account. In fact, the effectiveness of investments in Azerbaijan in certain years can be considered a very good indicator. Thus, in the study conducted by Mazllami (2023) on Croatia and Slovenia, it is seen that investments made in both countries during the years 1996-2020 were ineffective. At the same time, in these countries the inefficiency indicator sometimes reaches the double-digit level, which differs from the results we obtained for Azerbaijan.

It is precisely macroeconomic proportional analysis that allows us to see the picture clearly. However, the important point here is to take into account the lags. Thus, an analysis that includes the investment lag is important to obtain more accurate information. This study is based on a somewhat classical macroeconomic proportional analysis. The main reason for doing this is that there is a literature gap in Azerbaijan regarding calculations using the ICOR method.

CONCLUSION

It should be noted that the analysis of macroeconomic proportions may be necessary in order to obtain very important research results. During the study, the investment-GDP proportion, which is based on the ICOR method and is considered a classical macroeconomic proportional analysis, was analyzed. Certain results were obtained within the framework of the research questions posed. Thus, based on Spearman's rank correlation, it was observed that there is a very strong correlation between investments in fixed capital and GDP in Azerbaijan. On the other hand, it was determined through ICOR that the effectiveness of investments in fixed capital in Azerbaijan is variable and somewhat cyclical. In future studies, it can be investigated why the investments are ineffective and the lag factor can be added to this, which can also act as important research questions.

REFERENCES

Amin, S. B., Taghizadeh-Hesary, F., Al Kabir, F., & Khan, F. 2023. Nexus between energy intensity and capital- output ratio: A holistic approach. Energy & Environment, 34(7): 2721-2739.

Banerji, R. 1969. An Experiment with Incremental Capital-Output Ratio *Weltwirtschaftliches Archiv*, 102: 274– 277.

Field, A. 2013. *Discovering statistics using IBM SPSS statistics*. 4th edition. Canada Sage Publications Limited.

Gianaris, N. V. 1970. International Differences in Capital-Output Ratios *The American Economic Review*, 60(3): 465–477.

Greene, J., & Villanueva, D. 1991. Private Investment in Developing Countries An Empirical Analysis. *Staff Papers (International Monetary Fund)*, 38(1): 33–58.

Hodgson, T. M., Breban, S. J., Ford, C. L., Streatfield, M. P., & Urwin, R. C. 2000. The concept of investment efficiency and its application to investment management structures *British Actuarial Journal*, 6(3): 451– 545.

Kumar, A., & Abirami, S. 2018. Aspect-based opinion ranking framework for product reviews using a Spearman's rank correlation coefficient method *Information Sciences*, 460: 23–41.

Li, H., Cao, Y., & Su, L. 2022. Pythagorean fuzzy multi-criteria decision-making approach based on Spearman rank correlation coefficient *Soft Computing*, 26(6): 3001–3012.

Mazllami, J. 2023. The Investments Efficiency Toward Economic Growth: ICOR of the Republic of Croatia and Slovenia-Comparative Analysis. *Journal of Economic & Social Studies (JECOSS)*, 8(1).

Mishra, P., Pandey, C. M., Singh, U., Gupta, A., Sahu, C., & Keshri, A. 2019. Descriptive statistics and normality tests for statistical data *Annals of Cardiac Anaesthesia*, 22(1): 67–72.

Munnell, A. H. 1992. Policy Watch Infrastructure Investment and Economic Growth *The Journal of Economic Perspectives*, 6(4): 189–198.

Song, H. Y., & Park, S. 2020. An analysis of correlation between personality and visiting place using Spearman's rank correlation coefficient *KSII Transactions on Internet and Information Systems (TIIS)*, 14(5): 1951–1966.

Taguchi, H., & Lowhachai, S. 2014. A revisit to the incremental capital-output ratio: the case of Asian economies and Thailand *International Journal of Economic Policy in Emerging Economies*, 7(1): 35– 54.

Wai, U. T. 1985. Study of ICOR in Developing Countries *Savings and Development*, 9(3): 225–263.

Yulianita, A., Marissa, F., Widyanata, F., Fitriyah, A., & Marcheline, M. 2019. Analysis of Investment Efficiency by using ICOR Approach to Economic Growth in All Provinces of Sumatera Island.

Hair, J. F., Wolfinbarger, M. F., Ortinau, D. J. & Bush, R. P. 2017. Essentials of Marketing Research Fourth Edition McGraw-Hill Education, 2 Penn Plaza, New York

STRUCTURAL ANALYSIS OF GRADED AND STANDART $AL_{\Delta X}GA_{1-\Delta X}N$ HEMT DEVICES BY WILLIAMSON-HALL METHOD

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ABSTRACT

It is well known that a fast response is a crucial property of crystal structures used in the design of optoelectronic devices. For this reason, in this study, $Al_{\Delta x}Ga_{1-\Delta x}N$ high electron mobility transistor (HEMT) grown by metal organic chemical vapor deposition technique (MOCVD) on double polished sapphire is investigated. These structures are durable to high temperature, pressure and voltage. Sapphire (Al_2O_3) is the most common wafer in growth of group-III nitrites. Graded AlGaN is one of the layers grown. Here Al ratio is at a detrmined Δx range. Other layer is in standart HEMT structure. Crystallite size and lattice strain are determined by using Williamson-Hall (W-H) method dependent on X-ray peak broadening analysis. Also, other physical parameters such as strain, stress and energy density are obtained by using different models dependent on W-H method. These models are, Uniform deformation model (UDM), Uniform deformation stress model (UDSM) and Uniform deformation energy density model (UDEDM). In accordance with these models, lattice broadening and relaxation are seen in graded AlGaN buffer layer. Crystallite size is formed by tiny particles. Grain size of graded layer is increasing and micro-strains shift to small values. From this point of view, it is understood that graded buffer layer makes differences in deformation properties. Strain value of graded AlGaN value is shifted from $2.1x10^{-3}$ to $1.05x10^{-3}$. For this reason HEMT structure should be optimised. Additionally, the spectral vibrations of the sapphire, GaN, and AlN layers were characterized using Raman spectroscopy.

Keywords: UDM, UDSM, UDEDM, XRD, HEMT, AlGaN, Sapphire, Williamson-Hall Analysis, Graded , Active Layer, Microstrain

DETERMINIG THE OCCUPATIONAL HEALTH LITERACY LEVEL OF NURSES WORKING IN THE INTENSVE CARE UNIT

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ABSTRACT

It is aimed to determine the level of occupational health literacy of nurses working in the intensive care unit, to learn their thoughts about occupational health and safety, to learn their ability to access OHS information, to understand, evaluate, use and communicate. This study, which was conducted using a quantitative research design, was carried out with the participation of 285 nurses working in intensive care units. In addition to the personal information form, the "Occupational Health Literacy Scale" was used. The data obtained from the study were analysed using SPSS 20 package programme. In the findings of the study, 51.6% of the nurses were aged 29 years and over, 52.3% were female, and 71.6% were married. Of the nurses working in the intensive care unit, 74.4% were bachelor's degree graduates, 66.3% were state hospital employees, 37.9% had a total of 6-11 years of professional experience, and 53% had more than 8 years of experience working in the intensive care unit. The proportion of nurses with an average monthly working time of 233 hours or more was 55.8%. Among the nurses working in the intensive care unit, 78.9% had not had a work accident before and 89.5% had no chronic disease. Among the important findings of the study, a significant difference was found between the age groups, marital status, total years of employment in the nursing profession and total years of employment in the intensive care unit. Occupational health and safety literacy levels of nurses working in the intensive care unit are extremely important in terms of preventing occupational accidents, occupational diseases and diseases arising from work environments in workplaces and preventing occupational accidents. For this reason, literacy levels related to OHS should be evaluated and determined intermittently

Keywords: Occupational health and safety, Occupational health literacy, Intensive care nurses

Özet

Yoğun bakım ünitesinde çalışan hemşirelerin iş sağlığı okuryazarlık düzeyini belirlemek, iş sağlığı ve güvenliği hakkındaki düşüncelerini öğrenmek, iş sağlığı ve güvenliği bilgilerine erişme, anlama, değerlendirme, kullanma ve iletişim kurma becerilerini öğrenmek amaçlanmıştır. Nicel araştırma tasarımı kullanılarak yapılan bu çalışma, yoğun bakım ünitelerinde çalışan 285 hemşirenin katılımıyla gerçekleştirilmiştir. Kişisel bilgi formuna ek olarak, "İş Sağlığı Okuryazarlığı Ölçeği" kullanılmıştır. Çalışmadan elde edilen veriler SPSS 20 paket programı kullanılarak analiz edilmiştir. Çalışmanın bulgularında, hemşirelerin %51,6'sı 29 yaş ve üzeri, %52,3'ü kadın ve %71,6'sı evli olduğu görülmüştür. Yoğun bakım ünitesinde çalışan hemşirelerin %74,4'ü lisans mezunu, %66,3'ü devlet hastanesi çalışanı, %37,9'u toplam 6-11 yıl mesleki deneyime sahip ve %53'ü yoğun bakım ünitesinde 8 yıldan fazla deneyime sahipti. Aylık ortalama çalışma süresi 233 saat ve üzeri olan hemşirelerin oranı %55,8 idi. Yoğun bakım ünitesinde çalışan hemşirelerin %78,9'u daha önce iş kazası geçirmemişti ve %89,5'i kronik hastalığı yoktu. Çalışmanın önemli bulguları arasında, yaş grupları, medeni durum, hemşirelik mesleğinde toplam çalışma süresi ve yoğun bakım ünitesinde toplam çalışma süresi arasında önemli bir fark olduğu tespit edilmiştir. Yoğun bakım ünitesinde çalışan hemşirelerin iş sağlığı ve güvenliği okuryazarlık düzeyleri, işyerlerinde iş kazalarının, meslek hastalıklarının ve çalışma ortamlarından kaynaklanan hastalıkların önlenmesi ve iş kazalarının önlenmesi açısından son derece önemlidir. Bu nedenle, İSG ile ilgili okuryazarlık düzeyleri aralıklı olarak değerlendirilmeli ve belirlenmelidir.

Anahtar Kelimeler: İş sağlığı ve güvenliği, iş sağlığı okuryazarlığı, yoğun bakım hemşireleri

Giriş

İş güvenliği kavramı insanlık tarihi kadar eski bir kavramdır. Gelişen teknolojiyle birlikte değişen üretim modelleri iş güvenliği kavramına gittikçe önem kazandırmıştır (Kantarcıoğlu vd., 2020).

Sağlık hizmetlerinin sunulduğu yataklı sağlık kuruluşları önemli risk ve tehlikeler taşıyan çalışma ortamlarının başında gelmektedir. Çalışma ortamlarında ki fiziksel, biyolojik, ergonomik, çevresel ve psikososyal risk ve tehlikelerle karşı karşıya kalan sağlık çalışanlarının iş performansları azalmakta, iş kazaları ve meslek hastalıklarının sayısını artırmaktadır. Bunun sonucunda hem sağlık çalışanları hemde hastaların güvenliği olumsuz yönde etkilenmektedir (Solmaz ve Solmaz 2017). İş kazası, meslek hastalığı veya hastalanmasından dolayı çalışanın işinden ayrı kalması hem kendisini hem kurumunu hem de bakmakla yükümlü olduğu ailesi ve ülke ekonomisini olumsuz yönde etkilemektedir (Bulut ve Ünal 2020). İş sağlığı ve güvenliği uygulamalarının yeterince uygulanmadığı durumlarda sağlık çalışanları ve ailelerini etkilemekte bu durum dolaylı ya da dolaysız yönden toplumu etkilemektedir. Maddi ve manevi kayıplar iş sağlığı ve güvenliğinin önemini göstermektedir (Aygün ve Özvurmaz 2020).

Sağlık çalışanlarının iş yerinde karşılaşabilecekleri risk faktörlerini bilmesi ve bu risklere karşı öncesinde önlemler alarak riskin en aza indirilmesi oldukça önem arz etmektedir (Kayabek ve Çevik 2022). Ülkemizde, 'İş Sağlığı Ve Güvenliği Hizmetleri Yönetmeliği'' ve ''Hasta ve Çalışan Güvenliğinin Sağlanmasına Dair Yönetmelik'' ile yataklı sağlık kuruluşlarında çalışan güvenliği komitelerinin kurulması, gerekli eğitimlerin verilmesi, sağlık taramalarının yapılması, koruyucu önlemlerin alınması, gerekli kayıtların tutulması ve sağlıkta şiddetin önüne geçilmesi için gerekli düzenlemeler yapılarak iş sağlığı güvenliği hizmetlerinin çalışması ve geliştirilmesi amaçlanmaktadır (Gürer 2018).

Sağlık çalışanları arasında hasta ve yakınlarıyla en fazla etkileşimde olan meslek grubunun başında hemşirelik gelmektedir. Dolayısıyla bu durum hemşirelerin önemini artırmakta onların bir çok tehlike ve risklerle karşı karşıya gelme olasılığını artırmaktadır (Gür vd., 2018). Son bir yılda hemşirelerin %31,3'ünün iş kazasına maruz kaldığı (Yüzügüllü vd., 2018), en sık kaza nedeninin

iğneyle yaralanma olduğu (Yöndem ve Çakmak 2022), %54,9'unun işten kaynaklı meslek hastalığı ve şikayetinin olduğu (Çakır ve Yüksel 2020) görülmektedir. Yataklı sağlık kuruluşlarının bünyesinde bulunan yoğun bakım üniteleri ileri düzeyde biyolojik, kimyasal, fiziksel ve psikolojik riskler içerdiği için hemşireler açısından yüksek risk ve tehlikeli çalışma ortamlarıdır (Orak 2020).

Toplumun tüm kesimleri için önemli bir kavram olan sağlık okuryazarlığı kavramı iş yerleri içinde oldukça önemli bir unsurdur. Sağlık okuryazarlığı kavramından yola çıkarılarak geliştirilmiş olan İş sağlığı okuryazarlığı kavramı iş sağlığı ve güvenliği bilgi ve hizmetlerini elde etme, iş sağlığı ve güvenliğine yönelik düşünceleri öğrenmek, erişebilmek, anlamak, değerlendirmek, kullanma ve iletme yeteneklerine sahip olma düzeyini ifade etmektedir (Wong 2012).

Bu çalışma, hemşirelerin iş sağlığı okuryazarlık düzeylerinin ölçülerek çalışma yaşamında, İSG ile ilgili önlem ve müdahaleleri çalışanların yeterince anlama ve uygulama becerileri, başka bir ifade ile çalışanların İSG ile ilgili okuryazarlık düzeyleri, çalışma ortamından kaynaklanan hastalıklardan korunma ve iş kazalarının önlenmesi açısından son derece önemlidir.

Yöntem

Çalışmanın Amacı

Yoğun bakım ünitesinde çalışan hemşirelerin iş sağlığı okuryazarlığı düzeylerini belirlemek, iş sağlığı ve güvenliğine yönelik düşüncelerini öğrenmek, İSG bilgilerine erişebilme anlama değerlendirme kullanma ve iletme yeteneklerinin öğrenilmesi amaçlanmaktadır.

Araştırmanın Tasarımı

Yoğun bakım ünitelerinde çalışan hemşirelerin iş sağlığı okuryazarlık düzeyinin belirlemek amacıyla yapılan tanımlayıcı kesitsel bir araştırmadır.

Örneklem

Bu çalışmanın evrenini aynı ilde bir kamu ve üniversite hastanesinin yoğun bakım ünitesinde görev yapmakta olan hemşireler dâhil edilmiştir. Çalışmanın örneklemi kolayda örnekleme yöntemi ile araştırma tarihleri içerisinde maksimum sayıya ulaşılmaya çalışıldığı için hemşirelerin gönüllü katılımı esas alınmıştır. Bu çalışmada örneklem dâhil etme kriterleri şu şekilde de belirlenmiştir; a. Yoğun bakım hemşiresi olmak b. En az 3 aydır yoğun bakımda çalışıyor olmak ve c. araştırmaya katılmaya gönüllü olmaktır. Verilerin 311 hemşireden toplanması amaçlanmış ancak 8 raporlu, 6 izinli ve 12 hemşirenin çalışmaya katılmayı istememesinden dolayı 285 hemşire çalışmaya dahil edilmiştir.

Veri Toplama Araçları

Bu çalışmada Yoğun Bakım Çalışanlarının İş Sağlığı okuryazarlık düzeyi bağımlı değişken, Hemşirelerin bireysel özellikleri (yaş, cinsiyet, medeni durum, eğitim durumu, meslekte çalışma yılı, çalıştığı birim vb.) bağımsız değişkenleridir.

İş Sağlığı Okuryazarlığı Ölçeği; Suthakorn ve ark tarafından geliştirilmiş Uskun ve ark. Tarafından Türkçeye uyarlanmıştır. çalışanların iş sağlığı ve güvenliği (İSG) ile ilgili bilgilere erişim sağlama yeteneğini, bu bilgileri anlama, değerlendirme, kullanma ve iletme becerilerini kişilerin kendi beyanlarıyla ölçen, 38 maddelik, 4 alt boyuttan oluşan 3'lü Likert tipi bir ölçektir. Ölçeğe verilen cevaplar için "en az uygun" için 1 puandan, "en uygun" için 3 puana kadar puan verilmekte ve toplam puan üzerinden değerlendirme yapılmaktadır. Ölçekten alınabilecek en düşük puan 38, en yüksek puan 114'tür. Alınan puanın yüksekliği iş sağlığı okuryazarlığının yüksek düzeyde olduğu anlamına gelmektedir. Ölçeğin maddeleri toplanabilir özelliktedir (Tukey additivity test, F=0,34; p=0,562).

Tüm maddelerin Cronbach alfa katsayısı 0,93; alt boyutların Cronbach alfa katsayıları İSG bilgilerine erişebilme yeteneği alt boyutu için 0,80; İSG bilgilerini anlama alt boyutu için 0,90; İSG bilgilerinin değerlendirilmesi için 0,90 ve İSG bilgilerini kullanma ve iletme için 0,83'tür (Uskun ve Güblü 2022).

Verilerin Toplanması

Veriler hemşirelere yüz yüze görüşme ve çevrimiçi yöntemlerle anket tekniği kullanılarak 1 Mart-20 Mart 2024 tarihleri arasında toplanmıştır. Anketin ilk sayfasında çalışmanın amaç ve kapsamı belirtilmiştir ve anketi 285 hemşire eksiksiz olarak doldurmuştur. Araştırmacılar, hemşirelerin kişisel bilgilerini içermeyen ve doldurulması yaklaşık 10 dakika süren anketi anonim olarak almıştır.

Etik Alınması

Bu çalışma için Selçuk Üniversitesi Sağlık Bilimleri Fakültesinden etik onay (Etik Karar No: 2024/85 Tarih: 31.01.2024 ve 2024/11 Sayılı) ve ölçek izinleri alınmıştır. Bu çalışmaya katılan tüm hemşireler bilgilendirilmiş onam vermiştir. Her katılımcı anketi yalnızca bir kez doldurmuş ve cevaplar araştırmacılara anonim olarak gönderilmiştir.

Bulgular ve Tartışma

Yoğun bakım ünitesinde çalışan hemşirelerin %51,6'sı 29 yaş ve üzerinde, % 52,3'ü kadın, %71,6'sı evlidir. Yoğun bakım ünitesinde çalışan hemşirelerin %74,4 ü lisans mezunu, %66,3'ü devlet hastanesi çalışanı, %37,9'unun toplam mesleki yılı 6-11 yıl aralığında ve %53'ünün yoğun bakım ünitesinde çalışma süresi 8 yılın üzerindedir. Aylık ortalama çalışma süresi 233 saat ve üzeri olan yoğun bakım ünitesinde çalışan hemşirelerin oranı %55,8'dir. Yoğun bakım ünitesinde çalışan hemşirelerin %97,2'si İSG eğitimi almış, %98,9'u kişisel koruyucu ekipman kullanmakta, % 78,9'u daha önce iş kazası geçirmemiş ve %89,5'unun kronik rahatsızlığı bulunmamaktadır.

Araştırmaya katılan yoğun bakım ünitesi hemşirelerinin yaş, cinsiyet, medeni durum, çalıştığı kurum, yoğun bakım ünitesinde çalışma süreleri, aylık çalışma saati, isg eğitim durumu, kişisel koruyucu ekipman kullanım durumu, iş kazası geçmişi, işin tehlike sınıfını bilme durumu ve kronik rahatsızlık durumu ile iş sağlığı okuryazarlık düzeyi erişebilme alt boyutu puan ortalamaları arasında anlamlı bir fark olup olmadığını belirlemek amacıyla yapılan bağımsız örneklem t testi analizi sonucu doğrultusunda grup ortalamaları arasında istatistiksel olarak anlamlı bir fark tespit edilememiştir ($p>0,05$).

Araştırmaya katılan yoğun bakım ünitesi hemşirelerinin cinsiyet, çalıştığı kurum, aylık çalışma saati, isg eğitim durumu, kişisel koruyucu ekipman kullanım durumu, iş kazası geçmişi, işin tehlike sınıfını bilme durumu ve kronik rahatsızlık durumu ile iş sağlığı okuryazarlık düzeyi anlama alt boyutu puan ortalamaları arasında anlamlı bir fark olup olmadığını belirlemek amacıyla yapılan bağımsız örneklem t testi analizi sonucu doğrultusunda grup ortalamaları arasında istatistiksel olarak anlamlı bir fark tespit edilememiştir Araştırmaya katılan yoğun bakım ünitesi hemşirelerinin yaş, medeni durum ve yoğun bakımda çalışma süresi ile iş sağlığı okuryazarlığı ölçeği anlama alt boyut grup ortalamaları arasında istatistiksel olarak anlamlı bir fark tespit edilmiştir ($p<0,05$) (Tablo IV). Bu sonuçlara göre yaş arttıkça iş sağlığı bilgilerini anlama düzeyinin arttığı, evli bireyler de iş sağlığı bilgilerini anlama düzeyinin arttığı ve ünitesinde çalışma yılı arttıkça iş sağlığı bilgilerini anlama düzeyinin arttığı söylenebilir.

Araştırmaya katılan yoğun bakım ünitesi hemşirelerinin eğitim durumları ile iş sağlığı okuryazarlık ölçeği anlama alt boyut puan ortalamaları arasında anlamlı bir fark olup olmadığını belirlemek amacıyla yapılan Anova testi analizi sonucu doğrultusunda grup ortalamaları arasında istatistiksel olarak anlamlı bir fark tespit edilememiştir ($p>0,05$).

Araştırmaya katılan yoğun bakım ünitesi hemşirelerinin hemşirelik mesleğinde toplam yıl ile iş sağlığı okuryazarlık düzeyi puan ortalamaları arasında anlamlı bir fark olup olmadığını belirlemek amacıyla yapılan Anova testi analizi sonucu doğrultusunda anlama alt boyut grup ortalamaları arasında istatistiksel olarak anlamlı bir fark tespit edilmiştir ($p<0,05$).

İstatistiksel olarak anlamlı fark bulunan anlama alt boyutu grubunda bu farkın hangi gruplardan kaynaklandığını bulmak için Post-Hoc testi uygulanmıştır. Hemşirelik mesleğinde toplam yıl gruplarına göre iş sağlığı okuryazarlık düzeyi arasında anlamlı farklılık göstermektedir. 1-5 yıl ile 11 yıl üzeri arasında fark vardır. 11 yıl ve üzeri grubun iş sağlığı okuryazarlık düzeyi daha yüksektir.

Araştırmaya katılan yoğun bakım ünitesi hemşirelerinin yaş, cinsiyet, medeni durum, çalıştığı kurum, yoğun bakım ünitesinde çalışma süreleri, aylık çalışma saati, isg eğitim durumu, kişisel koruyucu ekipman kullanım durumu, iş kazası geçmişi, işin tehlike sınıfını bilme durumu ve kronik rahatsızlık durumu ile iş sağlığı okuryazarlık düzeyi değerlendirme alt boyutu puan ortalamaları arasında anlamlı bir fark olup olmadığını belirlemek amacıyla yapılan bağımsız örneklem t testi analizi sonucu doğrultusunda grup ortalamaları arasında istatistiksel olarak anlamlı bir fark tespit edilememiştir ($p>0,05$).

Araştırmaya katılan yoğun bakım ünitesi hemşirelerinin eğitim durumları ve hemşirelik toplam hizmet süresi ile iş sağlığı okuryazarlık düzeyi değerlendirme alt boyutu puan ortalamaları arasında anlamlı bir fark olup olmadığını belirlemek amacıyla yapılan Anova testi analizi sonucu doğrultusunda grup ortalamaları arasında istatistiksel olarak anlamlı bir fark tespit edilememiştir ($p>0,05$).

Tartışma ve Sonuç

Yoğun bakım ünitelerinde görev yapan hemşireler ile yürütülen çalışmamızda, hemşirelerin sosyo-demografik özellikleri ile iş sağlığı okuryazarlık düzeyleri incelenmiştir.

Çalışmamızda ulaşılan yoğun bakım ünitesinde çalışan hemşirelerin %74,4'ünün lisans mezunu olduğu okuryazarlık düzeylerinin yüksek olduğu tespit edilmiştir. Çalışmamıza katılan 285 yoğun bakım ünitesi hemşirenin %55,8'inin aylık çalışma sürelerine bakıldığında 233 saat ve üzeri çalıştığı görülmüştür. Normal şartlarda bir çalışanın aylık çalışma saatinin ortalama 160-168 saat olduğu düşünülürse nöbet, vardiya ve mesai şeklinde çalışan hemşirelerin yoğun tempoda çalıştıkları tespit edilmiştir. Kişisel koruyucu ekipman kullanma oranının (%98,9) oldukça yüksek olduğu tespit edilmiştir. Bu durum yoğun bakım ünitesinde çalışan hemşirelerin iş sağlığı güvenliği önlemlerini alma hususunda çok hassas olduklarını göstermektedir. Araştırmada hemşirelerin %97,2'sinin iş sağlığı ve güvenliği eğitimi aldığı görülmektedir. Benzer başka bir çalışmada hemşirelerin %90'ının (Çelikalp vd., 2016) bu eğitimi aldıkları belirlenmiştir. Bunda 15.05.2013 tarihinde 28648 sayılı resmi gazete de yayınlanan '' Çalışanların İş Sağlığı Ve Güvenliği Eğitimlerinin Usul Ve Esasları Hakkında Yönetmelik'' le yapılan düzenlemelerin etkili olduğu anlaşılmaktadır. Çalışmamız da çalışanların %21,1'ini iş kazası geçirdiği belirlenmiştir (Tablo 1). Yapılan diğer çalışmalarda da aynı sonuçların elde edildiği görülmüştür (Aygün ve Özvurmaz 2020, Kaçan vd., 2023). Çalışmanın benzer koşullarda yapılmış olmasından dolayı sonucumuz literatür ile benzerlik göstermektedir. İş kazası geçirenlerin oranının yüksek olmasından dolayı çalışanın işinden ayrı kalması hem kendisini hem kurumunu hem de bakmakla yükümlü olduğu ailesi ve ülke ekonomisini olumsuz yönde etkilemektedir. Yoğun bakım ünitesinde risk ve tehlike düzeylerinin yüksek olmasında dolayı iş sağlığı ve güvenliği önlemlerinin artırılması ve iş kazası gerçekleşmeden risklerin ortadan kaldırılması gerekmektedir.

Araştırmada hemşirelerin bireysel özelliklerinin (yaş, cinsiyet, medeni durum, eğitim durumu, meslekte çalışma yılı, çalıştığı birim vb.) iş sağlığı okuryazarlığı ölçeğinin isg bilgilerine erişme,

isg bilgilerini değerlendirme, isg bilgilerini kullanma ve iletme alt boyutları ve toplam iş sağlığı okuryazarlığı toplam puanı üzerinde anlamlı etkisinin olmadığı görülmüştür. Anlama alt boyutunun ise yaş, medeni durum ve yoğun bakımda çalışma süresi ile iş sağlığı okuryazarlığı ölçeği anlama alt boyut grup ortalamaları arasında istatistiksel olarak anlamlı bir fark tespit edilmiş, yaş arttıkça iş sağlığı bilgilerini anlama düzeyinin arttığı, evli bireyler de iş sağlığı bilgilerini anlama düzeyinin arttığı ve ünitesinde çalışma yılı arttıkça iş sağlığı bilgilerini anlama düzeyinin arttığı söylenebilir. Bu durum evli bireylerin daha fazla sorumluluk hissetmesinden ve hane halkına bulaştırma riskinden dolayı daha özenli ve dikkatli olduğu düşünülebilir. Yapılan farklı çalışmalarda da benzer şekilde yaşın arttıkça iş sağlığı performansının arttığı evli ve çalışma yılının yukarı yönlü isg performansını etkilediği görülmüştür (Arslanoğlu vd., 2020, Terzi ve vd., 2019, Yıldız 2020).

Araştırmada meslekte çalışma süresi fazla olan ve yaşça daha büyük olan çalışanların iş sağlığı okuryazarlık düzeyinin daha yüksek olduğu görülmüştür. Meslekte çalışma süresi daha fazla ve yaşça daha büyük çalışanların mesleki tecrübelerinin daha fazla olması ve deneyimleri iş sağlığı ve güvenliği kavramının önemini daha iyi kavramaları nedeniyle iş sağlığı okuryazarlık düzeyinin daha yüksek olduğu söylenebilir.

Araştırma sonuçları araştırmaya katılan çalışanların değerlendirmeleriyle sınırlıdır. Araştırma sonuçlarının genellenebilmesi için araştırma kapsamının genişletilerek araştırmanın başka hastanelerde ve başka çalışanlar üzerinde de yapılması önerilmektedir.

Ülkemizde iş sağlığı okuryazarlığı kavramının gelişmesi ve çalışanların iş sağlığı güvenliği hakkında bilgi birikim ve deneyimlerin artması oldukça önemlidir. Yoğun bakım ünitesinde çalışan hemşirelerin iş sağlığı okuryazarlığı düzeylerini belirlemek, iş sağlığı ve güvenliğine yönelik düşüncelerini öğrenmek, İSG bilgilerine erişebilme, anlama, değerlendirme, kullanma ve iletme yeteneklerinin öğrenilmesi amaçlanmış ve iş sağlığı okuryazarlık düzeylerinin yüksek olduğu sonucuna ulaşılmıştır. Bu araştırmada, sağlık çalışanlarının tamamına yakınının iş sağlığı ve güvenliğine yönelik bilgilerinin bulunduğu, çalışma ortamlarındaki sağlık ve güvenliği tehdit eden riskleri büyük oranda fark edebildikleri görülmüştür. İş sağlığı ve güvenliği uygulamalarının yeteri kadar uygulanmaması ve yönetmeliklerin aktif olarak yerine getirilmemesi hem maddi hem manevi yönden büyük zararlar oluşturabilmektedir. İş kazaları neticesinde zarar gören kurumlar ülke ekonomisine de ciddi maddi kayıplar oluşturmaktadır. İş güvenliği tedbirlerinin uygulanması ve eğitimlerin sıklaştırılması bu zararların önlenmesi için çok basit uygulanabilir yöntemlerdir. İş sağlığı ve güvenliği uygulamaları mevzuat ve yönetmeliklerin yerine getirilmesinden çok iş yeri için geliştirici ve önleyici faaliyetler olarak benimsenmeli sağlık ve güvenliğimizi destekleyici bir araç olarak görülmelidir.

Yoğun bakım ünitesinde çalışan hemşirelerin iş sağlığı ve güvenliği eğitimine katılımının tam ve eksiksiz olması, eğitimlerin daha etkin ve pratikte uygulanabilir olarak verilmesi, hem görsel hem de işitsel duyulara etki edebilecek nitelikte olması, yapılan işe uygun, tehlike ve risklerin dikkate alınarak hazırlanıp verilmesi ve sürekliliği sağlanmalıdır. Kurum ve kuruluşlar tarafından belirli periyotlarda, hizmet içi iş sağlığı ve güvenliği eğitimleri güncellenerek verilmeye devam edilmelidir. Sosyal medya, broşür ve basılı materyaller iletişim araçları sık ve etkin kullanılarak sağlık çalışanlarının iş sağlığı okuryazarlık düzeylerinin artırılması bu konuda farkındalığın artırılması gerekmektedir. Sağlık çalışanlarının iş yerlerinde ki tehlike ve risk faktörleri konusunda bilgilendirilmeli ve kendi kendine de koruyucu önlemlerin etkin bir şekilde kullanabilmeleri sağlanmalıdır.

Sağlık çalışanlarının , İSG ile ilgili önlem ve müdahaleleri çalışanların yeterince anlama ve uygulama becerileri, başka bir ifade ile çalışanların İSG ile ilgili okuryazarlık düzeyleri, iş yerlerinde ki çalışma ortamlarından kaynaklanan iş kazası, meslek hastalığı ve hastalıklardan

korunma ve iş kazalarının önlenmesi açısından son derece önem arz etmektedir. Bu nedenle İSG ile ilgili okuryazarlık düzeyleri aralıklı olarak değerlendirilmeli ve belirlenmelidir.

Sağlık çalışanlarıyla iş sağlığı okuryazarlığına ilişkin benzer çalışmaların daha geniş katılımcı sayılarıyla ve Türkiye'deki kamu ve özel sektördeki sağlık çalışanlarını kapsayacak benzer çalışmaların yürütülmelidir. Sağlık çalışanlarına yönelik iş sağlığı okuryazarlık farkındalığı oluşturulmalı ve çalışanlarında bu konuda okuma ve araştırma yapmasına yönelik teşvikler edici faaliyetler oluşturulmaya çalışılmalıdır.

Kaynakça

Arslanoğlu A, Bektemür G, Yaşar S, 2020. İş sağlığı ve güvenliği uygulamaları performans değerlendirme: bir kamu hastanesi örneği, Sağlık Akademisyenleri Dergisi, 7, 121-24

Aygün G, Özvurmaz S ,2020. Sağlık çalışanlarının yaşadığı iş kazaları ve ilişkili faktörler, Medical Sciences, 15, 123-32

Bulut A, Ünal E, 2020. Bir kamu hastanesinde iş sağlığı ve güvenliği uygulamalarının değerlendirilmesi, Hacettepe Sağlık İdaresi Dergisi, 23, 1-22

Çakır M, Yüksel S, 2020. Bir devlet hastanesinde çalışan hemşirelerde iş kazası geçirme durumları, Akdeniz Tıp Dergisi, 6, 406-11.

Çelikkalp Ü, Varol G, Keloğlu G, Bilgiç S, 2016. Hemşirelerin çalışma ortamlarında iş güvenliği uygulamalarını değerlendirmesi, Taf Preventive Medicine Bulletin, 15, 408-13

Gür B, Yavuz Ş, Baba G, 2021. Yoğun bakım hemşirelerinin kişisel koruyucu donanım kullanımlarının değerlendirilmesi, Journal of Social and Humanities Sciences Research, 8, 2097-105

Gürer A, 2018. Sağlık hizmetlerinde çalışan güvenliği, Journal of Health Services and Education, 2, 9-14

Kaçan C, Özdemir A, Özdemir L, 2023. Hastanede çalışan sağlık çalışanlarının iş güvenliği düzeyi: eğitim araştırma hastanesi örneğii Balıkesir Sağlık Bilimleri Dergisi, 2, 579-85

Kantarcıoğlu H, Kantarcıoğlu A, Dinç H, 2020. Sağlık kurumlarında iş sağlığı ve güvenliği: kamu hastanelerinde risk değerlendirme yöntemlerine yönelik bir inceleme, Sağ Aka Derg, 7, 61-7.

Kayabek İ, Çevik C, 2022. Sağlık çalışanlarında iş yeri risk faktörleri ve korumaya ilişkin bir derleme, Ordu Üniversitesi Hemşirelik Çalışmaları Dergisi, 5, 258-68

Orak, 2020. Yoğun bakım hemşirelerinin çalışma ortamında iş sağlığı ve iş güvenliği durumlarının incelenmesi, Yüksek Lisans Tezi, Marmara Üniversitesi, Sağlık bilimleri Enstitüsü, İstanbul

Solmaz M, Solmaz T, 2017. Hastanelerde iş sağlığı ve güvenliği, Gümüşhane Üniversitesi Sağlık Bilimleri Dergisi, 6, 147-56

Terzi B, Polat Ş, Azizoğlu F, Ateş N, Güngörmüş E, İşsever H, 2019. Hemşirelerde iş güvenlğinin bazı değişkenler yönünden incelenmesi, Sdü Sağlık Bilimleri Dergisi, 10, 260-67

Uskun E, Güblü M, 2022. İş sağlığı okuryazarlığı ölçeği'nin Türkçe geçerlik ve güvenirliği, Turkiye Klinikleri J Med Sci, 42, 191-203

Yıldız A, 2020. Hastane iş güvenliği uygulamalarının sağlık çalışanlarının iş güvenliği performansına etkisi, Akademik Araştırmalar ve Çalışmalar Dergisi, 12, 566-78

Yöndem M, Çakmak A, 2022. Doktor ve hemşirelerin iş kazası riskleri ile iş sağlığı ve güvenliği eğitimlerinin incelenmesi, Batı Karadeniz Tıp Dergisi, 6, 194-202.

Yüzügüllü D, Aytaç N, Akbaba M, 2018. Bir üniversite hastanesinin yoğun bakım ünitesi hemşirelerinde yaşam kalitesi, iş kazaları ve vardiyalı çalışmanın etkileri, Sakarya Tıp Dergisi, 8, 99-107

Wong B. 2012 Building a health literate workplace. Workplace Health &Safety, 60, 363-69.

INTEGRATION OF LOG ANALYSIS AND ARTIFICIAL INTELLIGENCE METHODS IN CYBERSECURITY ANALYTICS

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ABSTRACT

This paper investigates the integration of artificial intelligence (AI) methods to enhance the efficiency of log analysis in cybersecurity analytics. Traditional log analysis faces challenges in processing large-scale data and timely detecting anomalies, often resulting in reactive security measures. To address these limitations, machine learning (Isolation Forest) and deep learning (Deep Auto-encoder) models are applied and evaluated. Integrating AI-driven log analysis and visualization platforms significantly enhances the effectiveness, pro-activity, and response speed of cybersecurity systems, offering a more robust defense compared to traditional methods.

Keywords: Cybersecurity Analytics, Log Analysis, Artificial Intelligence, Machine Learning, , Anomaly Detection, Real-time Monitoring

ASSOCIATIONS OF BURNOUT WITH ADVERSE PSYCHOSOCIAL FACTORS AT WORK IN AZERBAIJAN

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ABSTRACT

This study investigates the impact of adverse psychosocial workplace factors on physician burnout in Azerbaijan. Analyzing survey data from 200 physicians working in various clinics across the country, the research evaluates the interplay between job demands, autonomy, and social support. Results confirm a significant positive correlation between high job demands, particularly excessive workloads and elevated professional expectations, and emotional exhaustion. Conversely, job control and social support demonstrated strong inverse relationships with burnout symptoms. These findings underscore the critical need for healthcare organizations in Azerbaijan to reduce excessive workloads while fostering professional autonomy and supportive management practices to safeguard physician mental health.

Keywords: Burnout, Psychosocial Factors, Job Demands, Job Control, Social Support.

REHABILITATION APPROACHES FOR SHOULDER INJURIES IN OVERHEAD ATHLETES

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ABSTRACT

Background: Rehabilitation of overhead athletes requires a comprehensive approach that address not only the shoulder joint, but also the interaction between scapulothoracic complex and the kinetic chain. Evidence-based interventions emphasize the importance of integrating both upper and lower extremity training to optimize force transfer and functional performance during sport-specific movements for those athletes.

Design: This is a systematic review of different approaches used in rehabilitation of overhead athletes including only randomised controlled trials (RTCs).

Purpose: To summarize the existing literature on rehabilitation approaches for shoulder injuries in overhead athletes.

Methods: A systematic search was conducted on electronic databases, including PubMed, Scopus, Cochrane Library, Web of Science, and Google Scholar, for studies published over the last ten years (2015-2025). Two independent reviewers screened all identified studies based on eligibility criteria. Relevant data including participant characteristic, outcome measures, and intervention were extracted from studies included. This review followed a structured literature search to ensure transparent approach.

Results: The evidence for shoulder overhead athletes is of low to moderate quality. Some of the interventions included in the study supports traditional exercise programs, neuromuscular exercises, PNF, kinetic chain integration programs, and taping technique. Also, the evidence indicates that strengthening the core may support shoulder function.

Conclusion: The results of this review suggest that holistic rehabilitation of shoulder injuries in overhead athlete may be more effective, rather than local shoulder exercise. Core strengthening and neuromuscular exercise can support shoulder function and may reduce compensatory

movements. Future research should focus on well-designed high-quality RTCs with larger sample size and standardized protocol.

Key words: shoulder, rehabilitation, athletes, overhead

INTRODUCTION

Shoulder pain is one of the most common musculoskeletal conditions for athletes in overhead sports. In these sports, the shoulder joint is at high risk for overuse injuries because of the repetitive and explosive overhead movements that could lead to tissue damage (Potskhveria et al., 2025). Some of the most shoulder-demanding overhead sports are volleyball, basketball, tennis, and baseball, and all of them have been reported to cause shoulder injuries. The current evidence, highlights that, shoulder injuries in overhead sports can be serious and even career-threatening (Liaghat et al., 2022). The incidence and prevalence of shoulder injuries in overhead sports are related to training hours, sports-specific requirements, and the level of competition, whether amateur or elite (Asker et al., 2018). According to the latest evidence, the incidence varies from 0.2/1000 to 1.8/1000 hours. On the other hand, the prevalence varies from 5% to 36% (Hoppe et al., 2022). Furthermore, due to shoulder injuries, the time lost from sport-specific training in these athletes can range between 4 and 6 months. Therefore, it is important to create an efficient strategy for an athlete's health and long-term performance (Hoppe et al., 2022). Subacromial impingement syndrome (SIS) (Lau & Mukherjee, 2025), rotator cuff tendinopathy (Kwan et al., 2021), labral lesions (Michener et al., 2018b), and scapular dyskinesia (Burn et al., 2016) are common causes of shoulder pain in the athlete. For the multidisciplinary medical staff diagnosis and treatment of shoulder injuries in athletes can be difficult and sometimes challenging.

Therefore, the purpose of this narrative review was to update the clinical effectiveness of rehabilitation strategies for shoulder injuries in overhead athletes.

METHODOLOGY

This study was designed as a narrative review with a structured literature search aimed to update the approaches used for the rehabilitation of shoulder injuries in overhead athletes. Articles published over the last ten years are included in this narrative review. PubMed, Web of Science, Cochrane Library, Google Scholar, and Scopus were among the databases searched. Some of the keywords that were utilized in this search were "overhead", "athletes", "shoulder", "injuries", "rehabilitation", and "convectional therapy". Only articles published in English and available in full text were considered. Titles and ABSTRACTs were initially screened for relevance, and potentially eligible articles were assessed in full text. Data regarding study design from the included studies, participant characteristics, rehabilitation protocols, outcome measures, and main findings were collected and analyze using a qualitative approach.

Inclusion and exclusion criteria.

Studies were considered eligible if they: 1) included participants with a clinical diagnosis of shoulder injuries; 2) were randomized controlled trials; 3) had structured rehabilitation protocols of intervention; 4) participants in these studies were only overhead athletes over 16 years old. Exclusion criteria: 1) included non-overhead athlete populations; 2) quasi-experimental study, case reports, opinion papers, or narrative comments without empirical data; 3) studies without rehabilitation protocols; 4) studies that were not disponible in full text; 5) studies which were focused on surgical interventions without rehabilitation strategies; 6) studies excluded if they did not report measurable outcomes; 7) encompassed studies published in languages other than English.

The selected studies were critically appraised and synthesized to provide an evidence-based overview regarding the approaches to rehabilitation of shoulder injuries in overhead athletes.

RESULTS

A total of seven randomized controlled trials met the inclusion criteria and were in the final analysis. The studies included were focused on the effectiveness of different physiotherapy manual or exercise interventions in overhead athletes with different shoulder conditions. Some of the disorders were shoulder impingement syndrome, scapular dyskinesia, chronic shoulder pain, and glenohumeral internal rotation deficit. Also, the included studies look into a variety of rehabilitation approaches such as joint mobilization, stretching techniques, manual therapy, proprioceptive neuromuscular facilitation (PNF), dry needling, and kinesiology taping. Some of the outcome measures included shoulder range of motion, muscle strength, pain intensity, and functional performance. The current evidence regarding the strategies of rehabilitation for different shoulder injuries in this specific population is complex. Conservative management is preferred as an initial treatment strategy for athletes (Bolia et al., 2021). In a randomized controlled trial on overhead athletes with chronic shoulder pain, an anteroposterior mobilization technique in glenohumeral joint was applied in intervention group. The results of this study demonstrated significant improvement in shoulder ROM and reduction of pain levels compared to the control group (E et al., 2028). Similarly, in university-level overhead athletes, the effect of a posterior shoulder stretching program was investigated. After the intervention significant improvements in glenohumeral internal rotation deficit (GIRD) were noted (Chepeha et al., 2018). Likewise, the same results were observed in the study of Gharisia et al. (2021). Another RTCs with shoulder impingement syndrome examined the effect of resistance exercises combined with manual therapy. The results revealed significant increases in isometric shoulder strength. Also, in the intervention group, improvements in functional outcomes and reduction in pain intensity were noticed (Sharma et al., 2021). In the same way, Shih et al. (2018) examined the effects of kinesiology taping on scapular reposition accuracy, shoulder kinematics, and muscle activity in athletes with shoulder impingement syndrome. The results of this study showed positive effects on scapular positioning and neuromuscular control. As in the previous studies, positive effect has demonstrated dry needling combined with manual therapy in overhead athletes with scapular dyskinesia. The therapy in the intervention group was more effective in the reduction of pain and function of the shoulder compared to manual therapy alone (Kheradmandi et al., 2021). Improvement on shoulder function has also been described after a protocol of PNF technique. Proprioceptive Neuromuscular Facilitation (PNF) is a rehabilitation exercise approach that uses diagonal and spiral movement patterns combined with stretching and muscle contraction techniques. The aim of this therapeutic technique is to enhance flexibility, strength, and neuromuscular coordination (Higgins & Greer, 2025). The protocol of PNF was used in a sample of male basketball players with chronic shoulder injury (Alfen, 2025). After one week of intervention 3 times per week with PNF, the intervention group showed significant improvement in range of motion (ROM) extension, abduction, adduction, internal rotation, and external rotation ($p>0.05$), except for flexion compared to the control group.

Overall, the results of the studies included have demonstrated that physiotherapy rehabilitation intervention can reduce pain, improve shoulder range of motion, increase muscle strength, and enhance functional performance in overhead athletes with different shoulder conditions.

DISCUSSION

The present review demonstrates that the rehabilitation of shoulder injuries remains one of the most challenging things. The aim of this review was to bring into focus the current evidence about the effectiveness of strategies used in shoulder injuries. All interventions conducted in the studies involved in this review produced measurable improvement in outcomes such as pain, mobility, and functional outcomes. Improvements in pain were consistent in interventions like dry needling combined with manual therapy (Kheradmandi et al., 2021), joint mobilization (E et al., 2028), kinesiology taping (Shih et al. (2018)), stretching (Chepeha et al., 2018), and resistance exercise programs (Sharma et al., 2021). Those rehabilitation interventions enhance muscle activation and scapular positions and bring into focus the importance of mobility and motor control for those athletes. Similarly, manual therapy combined with resistance exercise has a positive effect on muscle strength and pain reduction level in athletes with impingement syndrome. On the other hand, the PNF technique can integrate neuromuscular facilitation with mobility in overhead athletes and may improve functional rehabilitation (Alfen, 2025). This technique can activate entire kinetic chain, enhance joint flexibility and motion, often exceeding static stretching (Higgins & Greer, 2025). The study investigating the effect of PNF in basketball player demonstrated positive improvements in shoulder ROM in almost all movement patterns. This technique may enhance neuromuscular coordination and facilitate joint mobility, which are very important for overhead athletes. The results of the RTCs included in this review are in line with previous literature. They highlight the positive effect of therapeutic intervention in mobility, neuromuscular control, and shoulder function on this population. In another study, DeCicco and Fisher reported that the PNF stretching improved shoulder external rotation (ER) in overhead athletes. Also, a recent systematic review and meta-analysis by Zhu et al. (2025) reported that PNF technique significantly reduces shoulder pain level, improves shoulder function and enhances daily life activity in patients with shoulder disorders. Similarly, other systematic reviews analyzing conservative treatment have shown that mobilization programs, manual therapy, stretching exercise combined with manual stabilization (Ceballos-Laita et al., 2024), and dry needling can improve glenohumeral internal rotation deficit (GIRD) (Jiménez-Del-Barrio et al., 2022) and overall shoulder mobility.

However, the current evidence highlights the need for future research, which should focus on high-quality trials to standardize the protocol of rehabilitation and long-term follow-up of the interventions for overhead athletes.

CONCLUSIONS

The evidence in this narrative review indicates that a structured exercise program in the rehabilitation of shoulder injuries in overhead athletes can be very effective. The intervention protocol in all of the RCTs revealed positive results in shoulder range of motion, pain level, muscle strength, and functional performance after intervention such as mobilization, stretching exercise, dry needling combined with manual therapy or with resistance exercise, or kinesiology taping. Moreover, the current evidence highlights the importance of the PNF technique on shoulder injuries in those athletes as a potential intervention that can minimize extra load in the shoulder complex. By applying this technique, the athletes may combine the stretching with neuromuscular activation through functional diagonal movement patterns. To conclude, these approaches may not only reduce the symptoms in these athletes but also may reduce the risk of injury and improve their performance.

REFERENCES

1. Alfen, Z. (2025). The effect of diagonal proprioceptive neuromuscular facilitation movement on shoulder joint range of motion in basketball players with chronic shoulder injuries. Indonesian Journal of Exercise Therapy and Rehabilitation, 1(3), 102–109.

2. Asker, M., Brooke, H. L., Waldén, M., Tranaeus, U., Johansson, F., Skillgate, E., & Holm, L. W. (2018). Risk factors for, and prevention of, shoulder injuries in overhead sports: a systematic review with best-evidence synthesis. *British Journal of Sports Medicine*, *52*(20), 1312–1319. https://doi.org/10.1136/bjsports-2017-098254

3. Bolia, I. K., Collon, K., Bogdanov, J., Lan, R., & Petrigliano, F. A. (2021). Management Options for Shoulder Impingement Syndrome in Athletes: Insights and Future Directions. *Open access journal of sports medicine*, *12*, 43–53. https://doi.org/10.2147/OAJSM.S281100

4. Burn, M. B., McCulloch, P. C., Lintner, D. M., Liberman, S. R., & Harris, J. D. (2016). Prevalence of scapular dyskinesis in overhead and nonoverhead athletes. *Orthopaedic Journal of Sports Medicine*, *4*(2), 2325967115627608. https://doi.org/10.1177/2325967115627608

5. Ceballos-Laita, L., Robles-Pérez, R., Carrasco-Uribarren, A., Cabanillas-Barea, S., Pérez-Guillén, S., Greidane, E., & Jiménez-del-Barrio, S. (2024). Is Stretching Effective for Reducing Glenohumeral Internal Rotation Deficit? A Systematic Review and Meta-Analysis. *Applied Sciences*, *14*(16), 7166. https://doi.org/10.3390/app14167166

6. Chepeha, J. C., Magee, D. J., Bouliane, M., Sheps, D., & Beaupre, L. (2018). Effectiveness of a Posterior Shoulder Stretching Program on University-Level Overhead Athletes: Randomized Controlled Trial. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine*, *28*(2), 146–152. https://doi.org/10.1097/JSM.0000000000000434

7. E, L., Pecos-Martín, D., Domenech-García, V., Herrero, P., & Gallego-Izquierdo, T. (2018). Effects of an anteroposterior mobilization of the glenohumeral joint in overhead athletes with chronic shoulder pain: A randomized controlled trial. *Musculoskeletal science & practice*, *38*, 91–98. https://doi.org/10.1016/j.msksp.2018.09.009

8. Eshghi, S., Zarei, M., Abbasi, H., & Alizadeh, S. (2022). The Effect of Shoulder Injury Prevention Program on Shoulder Isokinetic Strength in Young Male Volleyball Players. *Research in sports medicine (Print)*, *30*(2), 203–214. https://doi.org/10.1080/15438627.2020.1860050

9. Fenanlampir, A., Suryadi, H., & Prasetyo, E. (2024). Effects of PNF and static stretching on flexibility in physically active individuals: A systematic review. Indonesian Journal of Exercise Therapy and Rehabilitation, 2(1), 4558. https://journal.uny.ac.id/index.php/jolahraga/article/view/72373

10. Gharisia, O., Lohman, E., Daher, N., Eldridge, A., Shallan, A., & Jaber, H. (2021). Effect of a novel stretching technique on shoulder range of motion in overhead athletes with glenohumeral internal rotation deficits: a randomized controlled trial. *BMC musculoskeletal disorders*, *22*(1), 402. https://doi.org/10.1186/s12891-021-04292-8

11. Higgins, M., & Greer, C. (2025). Proprioceptive Neuromuscular Facilitation for the upper extremity and scapula: Review and update on Rehabilitation of shoulder Pathology. *International Journal of Sports Physical Therapy*, *20*(9), 1407–1419. https://doi.org/10.26603/001c.143176

12. Hoppe, M. W., Brochhagen, J., Tischer, T., Beitzel, K., Seil, R., & Grim, C. (2022). Risk factors and prevention strategies for shoulder injuries in overhead sports: an updated systematic review. *Journal of experimental orthopaedics*, *9*(1), 78. https://doi.org/10.1186/s40634-022-00493-9

https://journals.khatec.id/index.php/khater/article/view/102

13. Jiménez-Del-Barrio, S., Ceballos-Laita, L., Lorenzo-Muñoz, A., Mingo-Gómez, M. T., Rebollo-Salas, M., & Jiménez-Rejano, J. J. (2022). Efficacy of Conservative Therapy in Overhead Athletes with Glenohumeral Internal Rotation Deficit: A Systematic Review and Meta-Analysis. *Journal of clinical medicine*, *12*(1), 4. https://doi.org/10.3390/jcm12010004

14. Kheradmandi, A., Kamali, F., Ebrahimian, M., & Abbasi, L. (2021). Comparison between dry needling plus manual therapy with manual therapy alone on pain and function in overhead athletes with scapular dyskinesia: A randomized clinical trial. *Journal of bodywork and movement therapies*, *26*, 339–346. https://doi.org/10.1016/j.jbmt.2020.11.017

15. Kwan, C. K., Ko, M. C., Fu, S. C., Leong, H. T., Ling, S. K., Oh, J. H., & Yung, P. S. (2021). Are muscle weakness and stiffness risk factors of the development of rotator cuff tendinopathy in overhead athletes: a systematic review. *Therapeutic advances in chronic disease*, *12*, 20406223211026178. https://doi.org/10.1177/20406223211026178

16. Lau, R., & Mukherjee, S. (2025). The effects of an education and exercise-based injury prevention programme on knowledge, eccentric shoulder strength, shoulder range of motion, and thoracic range of motion among competitive youth volleyball athletes: a randomized controlled trial. *Research in sports medicine (Print)*, *33*(4), 458–474. https://doi.org/10.1080/15438627.2025.2475037

17. Liaghat, B., Pedersen, J. R., Husted, R. S., Pedersen, L. L., Thorborg, K., & Juhl, C. B. (2023). Diagnosis, prevention and treatment of common shoulder injuries in sport: grading the evidence - a statement paper commissioned by the Danish Society of Sports Physical Therapy (DSSF). *British journal of sports medicine*, *57*(7), 408–416. https://doi.org/10.1136/bjsports-2022-105674

18. Michener, L. A., Abrams, J. S., Bliven, K. C. H., Falsone, S., Laudner, K. G., McFarland, E. G., Tibone, J. E., Thigpen, C. A., & Uhl, T. L. (2018). National Athletic Trainers' Association Position Statement: Evaluation, Management, and Outcomes of and Return-to- Play Criteria for Overhead Athletes With Superior Labral Anterior-Posterior Injuries. *Journal of athletic training*, *53*(3), 209–229. https://doi.org/10.4085/1062-6050-59-16

19. Potskhveria, V., Maskhulia, L., Matiashvili, M., Akhalkatsi, V., Kvinikadze, I., & Pavliashvili, N. (2025). Prevalence and functional impact of shoulder soft tissue injuries in overhead athletes during in-season management. *Turkish Journal of Physical Medicine and Rehabilitation*, *71*(4), 445–456. https://doi.org/10.5606/tftrd.2025.16371

20. Sharma, S., Ghrouz, A. K., Hussain, M. E., Sharma, S., Aldabbas, M., & Ansari, S. (2021). Progressive Resistance Exercises plus Manual Therapy Is Effective in Improving Isometric Strength in Overhead Athletes with Shoulder Impingement Syndrome: A Randomized Controlled Trial. *BioMed research international*, *2021*, 9945775. https://doi.org/10.1155/2021/9945775

21. Shih, Y. F., Lee, Y. F., & Chen, W. Y. (2018). Effects of Kinesiology Taping on Scapular Reposition Accuracy, Kinematics, and Muscle Activity in Athletes With Shoulder Impingement Syndrome: A Randomized Controlled Study. *Journal of sport rehabilitation*, *27*(6), 560–569. https://doi.org/10.1123/jsr.2017-0043

22. Zhu, C., Huang, X., Yu, J., Feng, Y., & Zhou, H. (2025). The clinical efficacy of proprioceptive neuromuscular facilitation technique in the treatment of scapulohumeral periarthritis: A systematic review and meta-analysis. BMC Musculoskeletal Disorders, 26(1), 288. https://doi.org/10.1186/s12891-025-08303-w

LEAVING NO ONE BEHIND IN CBRN CRISIS MANAGEMENT: INCLUSIVE COMMUNICATION STRATEGIES FOR THE ELDERLY AND CHILD POPULATIONS

KBRN KRİZ YÖNETİMİNDE KİMSEYİ GERİDE BIRAKMAMAK: YAŞLILAR VE ÇOCUKLARA YÖNELİK KAPSAYICI İLETİŞİM STRATEJİLERİ

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ABSTRACT

Chemical, Biological, Radiological and Nuclear (CBRN) incidents are characterized by high uncertainty, invisible hazards, and the need for rapid protective actions. In such crises, outcomes are strongly influenced by whether people receive accurate instructions promptly and in a form they can understand and follow. However, contemporary risk and crisis communication systems often rely heavily on digital channels and "one-size-fits-all" messaging designed for the general population. This approach may unintentionally exclude two highly vulnerable groups: older adults with limited access to or familiarity with digital technologies, and children whose cognitive and emotional developmental stages require tailored language and framing.

This paper aims to propose inclusive communication strategies for older adults and children across the pre-incident, incident, and post-incident phases of CBRN crisis management. For older adults, the paper emphasizes trust-centered and low-tech delivery methods, including radio broadcasting, public address systems, community-based outreach, and face-to-face guidance through local networks. For children, it highlights the importance of fear-sensitive communication using visual materials, simple and concrete instructions, and age-appropriate, game-informed learning activities delivered through schools, caregivers, and child-friendly formats.

Methodologically, the study is grounded in a focused review of relevant literature on risk communication, inclusive emergency management, and vulnerable populations, complemented by a conceptual analysis of existing emergency communication practices. Building on these insights, the paper advances a target-audience-oriented, multi-channel "Inclusive CBRN Communication Model" that integrates accessibility principles, psychosocial considerations, and practical message design.

The paper argues that effective CBRN communication requires moving beyond uniform messaging and systematically adapting content, channels, and messengers to the needs of diverse

groups. Incorporating gerontological and pedagogical considerations into message development can reduce confusion, enhance compliance with protective actions (e.g., shelter-in-place, evacuation, and decontamination), and ultimately strengthen community resilience. The proposed framework supports the broader objective of "leaving no one behind" by embedding inclusivity as an operational requirement rather than an optional add-on in CBRN preparedness and response.

Keywords: CBRN, crisis communication, risk communication, older adults, children, inclusivity, emerken management.

ÖZET

Kimyasal, Biyolojik, Radyolojik ve Nükleer (KBRN) olaylar; yüksek belirsizlik, görünmez tehlikeler ve hızlı koruyucu eylemler gerektirmeleriyle karakterize edilmektedir. Bu tür krizlerde sonuçlar, insanların doğru talimatları zamanında alıp almadıkları ve bu talimatları anlayabilecekleri ve uygulayabilecekleri bir biçimde ulaşıp ulaşmadığı tarafından büyük ölçüde şekillenmektedir. Bununla birlikte, çağdaş risk ve kriz iletişimi sistemleri çoğu zaman dijital kanallara ve genel nüfus için tasarlanmış "herkese uyan tek tip" mesajlara aşırı biçimde dayanmaktadır. Bu yaklaşım, iki oldukça kırılgan grubu istemeden dışlayabilmektedir: dijital teknolojilere sınırlı erişimi olan ya da bu teknolojilere aşinalığı düşük yaşlı yetişkinler ile bilişsel ve duygusal gelişim evreleri nedeniyle özelleştirilmiş dil ve çerçeveleme gerektiren çocuklar.

Bu çalışma, KBRN kriz yönetiminin olay öncesi, olay sırası ve olay sonrası aşamalarında yaşlı yetişkinler ve çocuklara yönelik kapsayıcı iletişim stratejileri önermeyi amaçlamaktadır. aşlı bireyler için düşük teknoloji gerektiren ve güven temelli kanallar (radyo/TV, anons sistemleri, telefon, yüz yüze yönlendirme ve yerel ağlar) öne çıkmaktadır. Çocuklar açısından ise görsel materyaller, basit ve somut talimatlar ile okullar, bakım verenler ve çocuk dostu formatlar aracılığıyla sunulan, yaşa uygun ve oyun temelli öğrenme etkinlikleriyle desteklenen korku-duyarlı iletişimin önemini öne çıkarmaktadır.

Yöntemsel olarak çalışma; risk iletişimi, kapsayıcı acil durum yönetimi ve kırılgan gruplara ilişkin ilgili literatürün odaklanmış bir incelemesine dayanmakta, buna mevcut acil durum iletişimi uygulamalarının kavramsal bir analizi eşlik etmektedir. Bu içgörülerden hareketle çalışma, erişilebilirlik ilkelerini, psikososyal boyutları ve pratik mesaj tasarımını bütünleştiren, hedef kitle odaklı ve çok kanallı bir "Kapsayıcı KBRN İletişim Modeli" ileri sürmektedir.

Çalışma, etkili KBRN iletişiminin tek tip mesajlaşmanın ötesine geçmeyi ve içeriğin, kanalların ve mesajı ileten aktörlerin farklı grupların ihtiyaçlarına sistematik biçimde uyarlanmasını gerektirdiğini savunmaktadır. Mesaj geliştirme süreçlerine gerontolojik ve pedagojik hususların dâhil edilmesi; kafa karışıklığını azaltabilir, koruyucu eylemlere uyumu artırabilir (örneğin bulunduğu yerde sığınma, tahliye ve dekontaminasyon) ve sonuç olarak toplumsal dayanıklılığı güçlendirebilir. Önerilen çerçeve, kapsayıcılığı KBRN hazırlık ve müdahalesinde isteğe bağlı bir ek unsur yerine operasyonel bir gereklilik olarak yerleştirerek "kimseyi geride bırakmama" yönündeki daha geniş hedefi desteklemektedir.

Anahtar Kelimeler: KBRN, kriz iletişimi, risk iletişimi, yaşlı yetişkinler, çocuklar, kapsayıcılık, acil durum yönetimi.

GİRİŞ

Kimyasal, biyolojik, radyolojik ve nükleer (KBRN) olayları yüksek belirsizlik, görünmez tehditler ve kısa sürede koruyucu karar alma gerekliliği nedeniyle risk ve kriz iletişimini müdahalenin merkezine yerleştirmektedir. Bu tür olaylarda bireylerin güvenliğini belirleyen unsurlardan biri,

kamu otoriteleri tarafından iletilen uyarı ve yönlendirmelerin ne kadar hızlı, açık, güvenilir ve uygulanabilir olduğudur. Bununla birlikte, KBRN olaylarından etkilenen topluluklar homojen değildir. Yaş, sağlık durumu, bilişsel kapasite, duyusal yeterlilik, hareket kabiliyeti ve dijital araçlara erişim gibi değişkenler, bireylerin risk mesajlarını alma, anlama ve davranışa dönüştürme kapasitelerini doğrudan etkilemektedir. Bu nedenle genel nüfusa yönelik standartlaştırılmış ve tek tip iletişim yaklaşımları özellikle kırılgan gruplar açısından yetersiz kalabilmektedir (Carbon ve diğerleri, 2022). Savunmasız kişiler ya da kırılgan gruplar toplumdaki diğer bireylere göre, felaketlerden korunmak veya felaketlerden kurtulmak için tüm nüfus adına alınan önlemlere rağmen, tehlikelerin yıkıcı etkilerine daha yatkın olan özelliklere ve koşullara sahip kişilerdir (Vink ve Takeuchi, 2013).

Afet ve acil durum literatürü, kırılgan grupların özel gereksinimlerini dikkate almayan iletişim stratejilerinin bilgiye erişimde eşitsizlik yarattığını ve koruyucu davranışlara uyumu zayıflatabildiğini göstermektedir. Bu nedenle yalnızca tek bir kanala dayanan iletişim sistemleri yerine, yüz yüze iletişim, telefon, radyo, görsel materyaller ve dijital araçların birlikte kullanıldığı çok kanallı yaklaşımlara ihtiyaç duyulmaktadır (Beckjord ve diğerleri, 2008). Son yıllarda sosyal medya ve dijital platformlar kriz iletişiminde hız ve etkileşim sağlar. Bu kanallar, kurum–toplum arasında daha hızlı bilgi akışını destekleyebilir. Ayrıca şeffaf ve düzenli bilgi paylaşımının, kamu otoritelerine duyulan güveni artırabildiği ve verilen talimatlara uyumu olumlu yönde etkileyebildiği de vurgulanmaktadır (Ng ve Lean, 2012; Carbon ve diğerleri, 2022).

KBRN olaylarını diğer afet türlerinden ayıran en önemli özelliklerden biri, tehlikenin çoğu zaman doğrudan algılanamayan bir yapıya sahip olmasıdır. Kimyasal sızıntılar, biyolojik ajanlar, radyolojik yayılım ya da nükleer maruziyet gibi tehditler çoğu zaman gözle görülmez, anında doğrulanamaz ve teknik bilgi gerektiren açıklamalarla anlaşılabilir. Bu nedenle KBRN krizlerinde iletişim yalnızca bilgi verme işlevi görmez; aynı zamanda belirsizliği azaltma, güven oluşturma ve bireyleri uygun koruyucu eylemlere yönlendirme işlevi de üstlenir. Özellikle dekontaminasyon, tahliye, kapalı alanda kalma ya da koruyucu ekipman kullanımı gibi teknik yönlendirmeler, kriz anında bireyler açısından yüksek bilişsel yük yaratabilmektedir. Bu nedenle temel mesele yalnızca mesajın iletilmesi değil, mesajın anlaşılması, güvenilir bulunması ve uygulanabilir bir davranışa dönüşmesidir (Lindell ve Perry, 2012; Perko ve diğerleri, 2020).

Protective Action Decision Model (PADM), bireylerin kriz anlarında nasıl karar verdiğini açıklamada önemli bir kuramsal çerçeve sunmaktadır. PADM'ye göre bireyler, uyarıyı alır, mesaja dikkat verir ve mesajı anlar; ardından tehdidi ve eylem seçeneklerini değerlendirerek davranışa yönelir (Lindell ve Perry, 2012). KBRN olaylarında ise bu süreç çok daha hassas bir hâl almaktadır. Çünkü tehdidin çoğu zaman görünmez olması, kullanılan teknik dilin karmaşıklığı ve belirsizlik düzeyinin yüksekliği, verilen mesajların doğru biçimde algılanmasını ve yorumlanmasını zorlaştırmaktadır. Ayrıca yaşlı bireylerde duyusal gerileme, hareket kısıtlılığı, kronik hastalıklar ve dijital araçlara sınırlı erişim; çocuklarda ise bilişsel gelişimin henüz tamamlanmamış olması, soyut riskleri anlamada yaşanan güçlükler ve yetişkin desteğine duyulan ihtiyaç, karar alma sürecini doğrudan etkilemektedir (Liao ve Hu, 2025; Karakuş, 2024).

Bu çalışma, yaşlılar ve çocuklara yönelik kapsayıcı iletişim gereksinimlerini, KBRN kriz yönetiminin hazırlık, müdahale ve iyileşme aşamaları kapsamında ele almayı amaçlamaktadır. Çalışmanın çıkış noktası, mevcut risk ve kriz iletişimi uygulamalarının büyük ölçüde genel nüfusa yönelik standart mesajlara dayanması ve bu nedenle kırılgan grupların özel ihtiyaçlarını yeterince dikkate almamasıdır. Bu çerçevede, yaşlılar ve çocuklar için çok kanallı, erişilebilir ve hedef kitleye uyarlanmış bir iletişim yaklaşımının nasıl geliştirilebileceği tartışılmaktadır. Ayrıca KBRN bağlamında kapsayıcılığın yalnızca etik bir sorumluluk değil, aynı zamanda etkili kriz yönetimi açısından operasyonel bir zorunluluk olduğu vurgulanmaktadır.

MATERYAL VE METOT

Bu çalışma, KBRN krizlerinde yaşlılar ve çocuklara yönelik kapsayıcı iletişim gereksinimlerini inceleyen nitel bir literatür derlemesi ve kavramsal analiz çalışmasıdır. Çalışma kapsamında risk ve kriz iletişimi, kırılgan gruplar, afet hazırlığı ve çocuklara yönelik afet eğitimi konularında ilgili akademik yayınlar incelenmiştir. Çalışma kapsamında Google Scholar, ScienceDirect, Wiley Online Library ve erişilebilen tez kaynakları üzerinden risk iletişimi, kırılgan gruplar, yaşlı bireyler, çocuklar ve KBRN iletişimi konularına ilişkin yayınlar taranmıştır. Elde edilen bulgular hazırlık, müdahale ve iyileşme aşamaları çerçevesinde değerlendirilmiştir.

KBRN KRİZLERİNDE İLETİŞİMİN TEMEL GÜÇLÜKLERİ

Halka yönelik erken uyarı mesajlarının dağıtımı, kriz ve tehlike durumlarında can kayıplarını azaltmaya yönelik kritik bir iletişim mekanizmasıdır. Bu sistemde iki temel uyarı biçimi öne çıkmaktadır: ilki, genellikle siren veya yüksek ses yoluyla dikkat çekmeye yönelik genel uyarılar; ikincisi ise konum temelli olarak iletilen, SMS ya da Hücresel Yayın aracılığıyla gönderilen yazılı uyarı mesajlarıdır (Luht-Kallas ve diğerleri, 2023).

KBRN krizlerinde iletişim, diğer afet türlerine göre daha zor ve karmaşıktır. Bunun en önemli nedenlerinden biri, tehlikenin çoğu zaman doğrudan fark edilememesidir. Kimyasal sızıntılar, biyolojik ajanlar, radyolojik yayılım ya da nükleer maruziyet gibi durumlarda tehdit her zaman gözle görülmez. Bazen kokuyla da anlaşılamaz ve ilk anda etkileri açık biçimde ortaya çıkmayabilir. Bu nedenle insanlar riski kendi başlarına değerlendirmekte zorlanır. Böyle durumlarda resmî kurumlardan gelen doğru ve açık bilgi daha da önemli hâle gelir. Bu yüzden KBRN olaylarında iletişim sadece bilgi vermekle sınırlı değildir. Aynı zamanda belirsizliği azaltmayı, güven oluşturmayı ve insanları doğru koruyucu davranışlara yönlendirmeyi de içerir (Carbon ve diğerleri, 2022; Perko ve diğerleri, 2020).

KBRN olaylarında bir diğer temel güçlük, iletilmesi gereken bilginin çoğu zaman teknik ve uzmanlık gerektiren nitelikte olmasıdır. Dekontaminasyon, tahliye, kapalı alanda kalma, kişisel koruyucu ekipman kullanımı ya da radyolojik korunma gibi konular, kriz anında sadeleştirilmeden sunulduğunda toplum tarafından anlaşılması güç mesajlara dönüşebilmektedir. Bu tür teknik yönlendirmeler, özellikle stres altında bulunan bireylerde yüksek bilişsel yük yaratmakta ve doğru karar verme sürecini zorlaştırmaktadır. Koruyucu Eylem Karar Modeli'ne göre bireylerin bir uyarıyı davranışa dönüştürebilmesi için mesaja maruz kalması, dikkat göstermesi, mesajı anlaması, tehdidi ciddiye alması ve önerilen eylemi uygulanabilir bulması gerekmektedir (Lindell, 2012).

İletişim sürecini zorlaştıran bir diğer konu ise güvendir. KBRN krizlerinde halkın, bilgiyi veren kaynağa ne kadar güvendiği, mesajın etkisini doğrudan belirler. Eğer belirsizlikler açıkça paylaşılmazsa, mesajlar sık sık değişirse ya da kullanılan dil fazla teknik olursa, insanların resmî açıklamalara olan güveni azalabilir. Buna karşılık açık, düzenli ve şeffaf bir iletişim süreci hem riskin daha doğru anlaşılmasına hem de koruyucu talimatlara uyumun artmasına yardımcı olur (Ng ve Lean, 2012; Perko ve diğerleri, 2020). Özellikle nükleer ve radyolojik olaylarda, kesin olmayan bilgileri gizlemek yerine, mevcut durumu sınırlılıklarıyla birlikte paylaşmak daha etkili bir iletişim yöntemi olarak görülmektedir (Perko ve diğerleri, 2020).

Bunun yanında, kriz iletişiminin sadece dijital kanallar üzerinden yürütülmesi KBRN olaylarında tek başına yeterli değildir. Sosyal medya ve dijital platformlar bilgiye hızlı ulaşma, bilgiyi yayma ve geri bildirim alma açısından önemli kolaylıklar sağlar. Ancak bu kanallara herkes aynı ölçüde erişememektedir. Bu durum bazı gruplar için dışlayıcı sonuçlar ortaya çıkarabilmektedir. Yaşlı bireyler, dijital araçları kullanmada yaşadıkları zorluklar, duyusal kayıplar ve fiziksel sınırlılıklar nedeniyle standart mesajlardan yeterince yararlanamayabilir. Benzer şekilde çocuklar da

gelişimsel özellikleri ve yetişkin desteğine duydukları ihtiyaç nedeniyle bu mesajları aynı biçimde anlayıp uygulayamayabilir (Beckjord ve diğerleri, 2008; Carbon ve diğerleri, 2022).

Bu çerçevede elde edilen bulgular, KBRN kriz iletişiminde temel meselenin sadece bilginin hızlı bir şekilde paylaşılması olmadığını göstermektedir. Asıl önemli olan, mesajın hedef grubun özelliklerine uygun hazırlanması, güvenilir kanallar aracılığıyla iletilmesi ve insanların bunu uygulanabilir koruyucu davranışlara dönüştürebilmesidir. Bu ihtiyaç, özellikle yaşlılar ve çocuklar söz konusu olduğunda daha da belirgin hâle gelmektedir. Bu nedenle sonraki bölümlerde, her iki grubun KBRN krizlerindeki özel iletişim gereksinimleri ayrı ayrı ele alınacaktır.

YAŞLI BİREYLERİN İLETİŞİM GEREKSİNİMLERİ

Yaşlı bireyler, afet ve acil durumlarda daha kırılgan gruplar arasında yer almaktadır. Bunun başlıca nedenleri arasında yaşa bağlı fiziksel ve bilişsel değişiklikler ile sosyal destek yetersizliği bulunmaktadır. Görme ve işitme kayıpları, hareket kabiliyetinin azalması, kronik hastalıkların yaygın olması ve destek ağlarının sınırlı kalması, kriz anlarında bilgiye ulaşmayı ve uygun davranış geliştirmeyi zorlaştırmaktadır. Özellikle tahliye, dekontaminasyon ya da kapalı alanda kalma gibi hızlı karar verilmesi gereken KBRN senaryolarında bu durum daha da belirgin hâle gelmektedir. Bu nedenle yaşlı bireylere yönelik iletişim stratejileri sadece bilgi vermeye odaklanmamalı; aynı zamanda mesajın kolay algılanmasını, anlaşılmasını ve uygulanmasını destekleyecek biçimde hazırlanmalıdır (Beckjord ve diğerleri, 2008; Carbon ve diğerleri, 2022).

Afet hazırlığıyla ilgili çalışmalar da yaşlı bireylerin hazırlık düzeyinin sağlık durumu, fiziksel yeterlilik, sosyal destek ve önceden plan yapma alışkanlığı ile yakından ilişkili olduğunu göstermektedir. Genel sağlık durumu zayıf olan, birden fazla kronik hastalığı bulunan ya da hareket kısıtlılığı yaşayan yaşlı bireylerin, acil durumlara yönelik önceden plan yapma olasılığının daha düşük olduğu belirtilmektedir (Al-Rousan ve diğerleri, 2014). Benzer biçimde, yaşlı bireylerin afet hazırlık davranışlarını etkileyen unsurlar arasında fiziksel sınırlılıklar, bilgiye ulaşmada yaşanan güçlükler ve risk mesajlarını günlük yaşamla ilişkilendirme düzeyi öne çıkmaktadır (Liao ve Hu, 2025).

Yaşlı bireylerle iletişimde karşılaşılan temel sorunlardan biri, standart kriz mesajlarının çoğu zaman bu grubun algısal ve işlevsel özelliklerine uygun olmamasıdır. Teknik ifadeler, hızlı verilen bilgiler, küçük puntolu yazılar ya da yalnızca dijital kanallar üzerinden yapılan duyurular, yaşlı bireylerin mesaja ulaşmasını ve onu davranışa dönüştürmesini zorlaştırabilmektedir. Bu nedenle yaşlılara yönelik iletişimde sade bir dil kullanılması, kısa ve açık cümlelere yer verilmesi, mesajların gerektiğinde tekrar edilmesi ve birden fazla iletişim kanalının birlikte kullanılması önem taşımaktadır (Beckjord ve diğerleri, 2008; Carbon ve diğerleri, 2022).

KBRN olaylarında güven unsuru yaşlı bireyler için ayrı bir önem taşımaktadır. Görünmeyen ve teknik yönü ağır basan tehditler karşısında, yaşlı bireylerin bilgi kaynağına duyduğu güven, önerilen koruyucu davranışlara uyumu doğrudan etkileyebilmektedir. Bu nedenle yalnızca mesajın içeriği değil, nasıl sunulduğu da önemlidir. Güven veren, tutarlı, sade ve tekrar edilen açıklamalar, özellikle belirsizliğin yüksek olduğu durumlarda korku ve karışıklığı azaltarak daha uygun davranışların gelişmesine yardımcı olabilir (Carbon ve diğerleri, 2022).

Yaşlı bireylere yönelik kapsayıcı KBRN iletişiminin bazı temel ilkelere dayanması gerektiğini göstermektedir. Öncelikle iletişim tek bir kanalla sınırlandırılmamalıdır. Dijital araçlar, geleneksel medya ve yüz yüze destek yöntemleri birlikte kullanılmalıdır. Ayrıca mesajlar sade, açık, kısa ve doğrudan ne yapılması gerektiğini gösteren bir yapıda hazırlanmalıdır. İletişim yalnızca kriz anında değil, hazırlık aşamasında da planlanmalıdır. Tahliye planları, güvenli alan bilgileri, ilaç kullanımı ve bakım ihtiyaçları gibi konular yaşlı bireyler açısından önceden ele alınmalıdır. Bunun yanında, görme, işitme ve hareket kısıtlılıkları gibi durumlar dikkate alınarak erişilebilir bir

iletişim yaklaşımı benimsenmelidir. Bu nedenle yaşlı bireylere yönelik iletişim, genel mesajların biraz değiştirilmiş hâli olarak değil, ayrı ve hedef gruba özel bir planlama alanı olarak değerlendirilmelidir (Liao ve Hu, 2025; Dennis ve diğeleri, 2023; Lindell ve Perry, 2012).

ÇOCUKLARIN İLETİŞİM GEREKSİNİMLERİ

Çocuklar, afet ve acil durumlarda yetişkinlere göre daha fazla korunmaya ihtiyaç duyan kırılgan gruplar arasında yer almaktadır. Bunun temel nedenleri arasında bilişsel gelişimlerinin henüz tamamlanmamış olması, soyut ve görünmeyen tehditleri anlamakta zorlanmaları, duygusal olarak daha kolay etkilenmeleri ve büyük ölçüde bakım verenlerin yönlendirmesine ihtiyaç duymaları bulunmaktadır (Wisner ve diğerleri, 2004). KBRN olaylarında bu durum daha da belirgin hâle gelmektedir. Çünkü kimyasal, biyolojik, radyolojik ve nükleer tehditler çoğu zaman doğrudan görülemez. Bu nedenle çocukların tehlikeyi kendi deneyimleriyle anlaması daha zor olur. Bu da çocuklara yönelik iletişimin sadece bilgi vermekle sınırlı kalmaması gerektiğini göstermektedir. Aynı zamanda korkuyu azaltan, güven duygusunu koruyan ve yaşa uygun koruyucu davranışları destekleyen bir yaklaşım benimsenmelidir.

Çocukların KBRN tehdidi karşısında doğru davranış geliştirebilmesi, büyük ölçüde önceden verilen eğitimin niteliğine bağlıdır. Çocuklara yönelik afet ve risk iletişiminde yaşa uygun, sade, somut ve görsel olarak desteklenen içeriklerin daha etkili olduğu bilinmektedir. Özellikle animasyon destekli eğitimler, görsel materyaller ve oyun temelli öğrenme araçları, çocukların dikkatini sürdürmesine, karmaşık bilgileri daha iyi anlamasına ve öğrendiklerini hatırlamasına katkı sağlayabilmektedir. Bu nedenle çocuklara yönelik KBRN iletişimi yalnızca olay anında verilen uyarılarla sınırlı düşünülmemelidir. Bu iletişim, olay öncesi hazırlık sürecinde eğitim içerikleriyle de desteklenmelidir (Karakuş, 2024).

Okullar, bu hazırlık sürecinde en önemli kurumsal alanlardan biridir. Afet risk azaltma eğitiminin okulda verilmesi, çocukların sadece bilgi edinmesini değil, aynı zamanda riskleri tanımasını, güvenli davranış geliştirmesini ve aile içinde farkındalık oluşturmasını da desteklemektedir (Shah ve diğerleri, 2024). Benzer şekilde, çocukların afet öncesinde güvenli alanları, tahliye yollarını ve temel koruyucu davranışları öğrenmesi, kriz anında paniğin azalmasına ve daha kontrollü tepki verilmesine yardımcı olmaktadır. Morris ve Edwards'a (2008) göre çocukları afetlerden korumanın en etkili yollarından biri, olay yaşanmadan önce risk azaltma kültürünün geliştirilmesidir. Bu yaklaşım, çocukların sadece korunması gereken pasif bireyler olarak değil, aynı zamanda farkındalık süreçlerine katılabilen bireyler olarak da görülmesi gerektiğini ortaya koymaktadır.

Çocuklara yönelik iletişimde kullanılan dil ve mesaj yapısı da özel olarak düzenlenmelidir. Teknik terimler, uzun açıklamalar ve soyut risk anlatımları çocuklar için yeterince anlaşılır olmayabilir. Bu nedenle mesajların kısa, açık, somut ve doğrudan davranışa yönlendiren bir biçimde hazırlanması önemlidir. Örneğin "dekontaminasyon uygulanacaktır" gibi teknik bir ifade yerine, "üzerindeki zararlı maddeleri temizlemek için seni yıkayacağız" gibi daha sade bir anlatım çocuklar açısından daha anlaşılır olabilir. Bu tür bir yaklaşım, sadece anlamayı kolaylaştırmaz; aynı zamanda bilinmeyenden kaynaklanan korku ve direnç duygusunu da azaltabilir. Ronan ve diğerleri (2008) de çocuk ve aile dayanıklılığını artırmaya yönelik afet eğitimlerinin bilgi düzeyini yükselttiğini, korkuyu azalttığını ve daha gerçekçi bir risk algısının gelişmesine katkı sağladığını belirtmektedir. Çocukların iletişim sürecindeki rolü yalnızca bireysel korunma ile sınırlı değildir. Afet literatürü, çocukların aile içinde bilgi taşıyıcı, okul ortamında akran öğrenmesini destekleyici ve toplumsal farkındalık süreçlerinde etkili bireyler olabileceğini göstermektedir. Çocuklara yönelik KBRN iletişimi yalnızca "çocuğu bilgilendirme" yaklaşımıyla değil, aile ve okul çevresiyle birlikte ele alınması gerektiğini göstermektedir. Öğretmenler, ebeveynler ve bakım verenler, çocuklara iletilen mesajların en önemli aracılarından biridir. Bu nedenle çocuk odaklı

iletişim stratejileri geliştirilirken, yalnızca mesaj içeriği değil, mesajı destekleyecek yetişkin rehberliği de planlanmalıdır. (Nikku ve diğerleri, 2006).

Çocuklara yönelik kapsayıcı afet iletişiminin dört temel unsur üzerine kurulması gerekmektedir. İlk olarak iletişim, çocuğun yaşına ve gelişim düzeyine uygun olmalıdır. İkinci olarak mesajlar, görsel, uygulamalı ve mümkün olduğunca etkileşimli araçlarla desteklenmelidir. Üçüncü olarak hazırlık sürecinde okul temelli eğitimler, tatbikatlar ve çocuk dostu materyallerle güçlü bir öğrenme zemini oluşturulmalıdır. Son olarak çocuklara yönelik iletişim, aileyi ve bakım verenleri dışarıda bırakmayan bütüncül bir yaklaşımla planlanmalıdır (Shah ve diğerleri, 2024). Bu nedenle çocuklara yönelik KBRN iletişimi, genel afet mesajlarının sadece basitleştirilmiş bir biçimi olarak görülmemelidir. Aksine, pedagojik ilkelerle desteklenen ve hedef gruba özel olarak tasarlanan ayrı bir iletişim alanı olarak ele alınmalıdır.

KBRN'DE KAPSAYICI İLETİŞİM KANALLARI

KBRN krizlerinde etkili iletişim yalnızca doğru mesajın hazırlanmasına bağlı değildir. Mesajın doğru kanal üzerinden hedef gruba ulaştırılması da en az bunun kadar önemlidir. Bu nedenle iletişim kanalları seçilirken sadece riskin türü değil, hedef kitlenin yaşı, bilgiye erişim durumu, okuryazarlık düzeyi, duyusal yeterliliği ve teknoloji kullanımı gibi özellikleri de dikkate alınmalıdır. Kırılgan gruplara yönelik iletişimde yalnızca tek bir kanala dayanan sistemler çoğu zaman yeterli olmaz. Özellikle yaşlılar ve çocuklar açısından bu durum erişim sorunlarına yol açabilmektedir. Bu yüzden çok kanallı ve birbirini destekleyen iletişim yapılarının kullanılması, kapsayıcı KBRN iletişiminin temel unsurlarından biri olarak görülmektedir (Beckjord ve diğerleri, 2008; Carbon ve diğerleri, 2022).

Geleneksel iletişim araçları, özellikle yaşlı bireylere ulaşmada önemini hâlâ korumaktadır. Radyo, televizyon, telefonla bilgilendirme, kamu anons sistemleri ve yüz yüze yönlendirme gibi yöntemler, dijital araçları kullanmakta zorlanan ya da kriz anında çevrim içi bilgiye ulaşamayan kişiler için daha erişilebilir ve güven verici olabilmektedir. KBRN gibi görünmeyen ve belirsizliğin yüksek olduğu olaylarda, özellikle yerel yönetimler veya sağlık kurumları tarafından yapılan açık ve tekrar edilen açıklamalar, toplumda güven duygusunu güçlendirebilmektedir (Perko ve diğerleri, 2020; Carbon ve diğerleri, 2022).

Bununla birlikte dijital medya ve sosyal medya araçları da kriz iletişiminde önemli avantajlar sunmaktadır. Bu araçlar, bilginin hızlı yayılması, daha geniş kitlelere ulaşılması ve karşılıklı etkileşimin sağlanması açısından oldukça işlevseldir. Sosyal medya, kamu kurumlarının gelişmeleri kısa sürede paylaşmasına ve toplumun tepkilerini takip etmesine imkân vermektedir. Aynı zamanda kriz anlarında bireyler arasında bilgi paylaşımını kolaylaştırmakta, yardım çağrılarının yayılmasına katkı sağlamakta ve toplumsal dayanışmayı görünür hâle getirmektedir (Ng ve Lean, 2012; Jurgens ve Helsloot, 2018). Özellikle afet süreçlerinde yardım arayışına ilişkin bilgilerin sosyal medya üzerinden hızla yayılması, kırılgan grupların daha görünür olmasına ve destek mekanizmalarının daha hızlı devreye girmesine yardımcı olabilmektedir (Su ve diğerleri, 2025). Ancak tüm bu avantajlara rağmen dijital platformlar herkes için eşit ölçüde erişilebilir değildir. Bu nedenle sosyal medya, kapsayıcı iletişimin tek aracı olarak değil, diğer iletişim kanallarını destekleyen bir unsur olarak değerlendirilmelidir. KBRN olaylarında kısa mesaj servisleri ve mobil uyarı sistemleri de önemli iletişim araçları arasında yer almaktadır. Özellikle nükleer ve radyolojik acil durumlarda SMS tabanlı uyarılar, halka hızlı ve doğrudan ulaşmak için etkili bir yöntem olabilir. Ancak bu mesajların kısa, açık, sade ve doğrudan ne yapılması gerektiğini gösteren bir yapıda olması gerekir. Belirsizliklerin açıkça ifade edilmesi ve gerektiğinde insanları başka bilgi kaynaklarına yönlendiren açıklamaların eklenmesi de önemlidir (Perko ve diğerleri, 2020). Avrupa'daki uygulamalar ve eğitim çalışmaları da mobil uyarı sistemlerinin sadece teknik olarak iyi çalışmasının yeterli olmadığını göstermektedir. Mesaj

içeriğinin toplumun özelliklerine ve kültürel yapıya uygun biçimde hazırlanması da gereklidir (Perko ve diğerleri, 2020).

Çocuklara yönelik iletişimde ise kullanılan kanalların sadece bilgiye erişim sağlaması yeterli değildir. Aynı zamanda mesajın anlaşılmasını da kolaylaştırması gerekir. Bu nedenle çocuklara yönelik mesajların okul ortamında, öğretmen desteğiyle, bakım verenlerin katkısıyla, görsel materyallerle ve çocuk dostu anlatım biçimleriyle desteklenmesi önemlidir. Yaşlı bireylerde ise mesajın güvenilir bir kişi ya da kurum tarafından iletilmesi, yazılı ve sözlü olarak tekrar edilmesi ve mümkünse yüz yüze açıklamalarla desteklenmesi daha etkili olabilir. Bu nedenle kapsayıcı iletişim kanalları sadece teknik araçlardan oluşmaz. Aynı zamanda güven oluşturan sosyal iletişim yollarını da içermelidir (Beckjord ve diğerleri, 2008; Carbon ve diğerleri, 2022).

Bu bulgular, KBRN krizlerinde kapsayıcı iletişimin dijital ve geleneksel araçların birlikte değerlendirilmesini gerektirdiğini ortaya koymaktadır. Başka bir deyişle, bu araçlar birbirinin alternatifi olarak değil, birbirini destekleyen unsurlar olarak ele alınmalıdır. Etkili bir iletişim sisteminde sosyal medya, SMS ve çevrim içi duyurular gibi hızlı iletişim araçlarının; radyo, televizyon, telefon, yerel anons sistemleri ve yüz yüze bilgilendirme gibi daha erişilebilir yöntemlerle birlikte kullanılması önem taşımaktadır. Böyle bir yaklaşım, hem bilginin daha geniş kitlelere ulaşmasını kolaylaştırmakta hem de farklı yaş gruplarının ve kırılgan bireylerin koruyucu davranışlara uyumunu desteklemektedir. Bu nedenle KBRN kriz iletişiminde kanal seçimi yapılırken yalnızca teknolojik olanaklar değil, kapsayıcılık ve erişilebilirlik ilkeleri de göz önünde bulundurulmalıdır.

TARTIŞMA

Bu çalışmanın bulguları, KBRN krizlerinde etkili iletişimin yalnızca bilginin hızlı bir şekilde aktarılmasından ibaret olmadığını göstermektedir. KBRN olaylarının görünmeyen tehditler içermesi, yüksek düzeyde belirsizlik barındırması ve çoğu zaman teknik bilgiye dayanması, risk iletişimini sıradan bir bilgilendirme sürecinin ötesine taşımaktadır. Bu tür durumlarda iletişimin amacı sadece toplumu haberdar etmek değildir. Aynı zamanda belirsizliği azaltmak, güven duygusunu güçlendirmek ve bireyleri doğru koruyucu davranışlara yönlendirmek de büyük önem taşımaktadır. Bu nedenle yalnızca mesajın içeriği değil, mesajın kim tarafından verildiği, hangi kanal üzerinden iletildiği ve hangi gruba hitap ettiği de belirleyici olmaktadır (Carbon ve diğerleri, 2022; Perko ve diğerleri, 2020).

Çalışmada öne çıkan sonuçlardan biri de standart ve herkese aynı şekilde yöneltilen kriz mesajlarının, kırılgan gruplar açısından çoğu zaman yetersiz kalmasıdır. Yaşlı bireylerde görme ve işitme kayıpları, kronik hastalıklar, hareket kısıtlılığı ve dijital araçlara sınırlı erişim; çocuklarda ise bilişsel gelişimin henüz tamamlanmamış olması, soyut riskleri anlamada yaşanan güçlükler ve bakım verenlere duyulan ihtiyaç, aynı mesajın her grup tarafından aynı biçimde algılanmasını zorlaştırmaktadır (Beckjord ve diğerleri, 2008; Liao ve Hu, 2025; Karakuş, 2024).

Bu noktada Koruyucu Eylem Karar Modeli (PADM), elde edilen bulguları anlamlandırmak için yararlı bir kuramsal çerçeve sunmaktadır. Modele göre bireylerin koruyucu bir davranış geliştirebilmesi, yalnızca mesaja maruz kalmasına bağlı değildir. Mesajın anlaşılması, tehdidin ciddiye alınması, önerilen davranışın uygulanabilir bulunması ve bilgi kaynağına güven duyulması da bu süreçte belirleyici olmaktadır (Lindell ve Perry, 2012). KBRN olaylarında ise bu süreç daha hassas bir hâl almaktadır. Çünkü teknik dil, görünmeyen tehlike ve belirsizlik, özellikle kırılgan gruplar için süreci daha zorlaştırmakta ve bilişsel yükü artırmaktadır. Bu nedenle kapsayıcı iletişim yalnızca daha fazla iletişim kanalı kullanmak anlamına gelmemektedir. Aynı zamanda mesajın alıcının özelliklerine uygun biçimde sadeleştirilmesini, gerektiğinde tekrar edilmesini ve güvenilir kaynaklar aracılığıyla iletilmesini de gerekli kılmaktadır.

Bulgular, dijital iletişim araçlarının kriz yönetiminde önemli avantajlar sunduğunu, ancak tek başına yeterli olmadığını da göstermektedir. Sosyal medya ve mobil uyarı sistemleri, hız, görünürlük ve anlık bilgi paylaşımı açısından güçlü araçlardır. Ancak bu araçlar her toplumsal grup için aynı ölçüde erişilebilir değildir (Ng ve Lean, 2012; Jurgens ve Helsloot, 2018; Su ve diğerleri, 2025). Bu nedenle özellikle yaşlı bireyler açısından radyo, televizyon, telefon ve yüz yüze yönlendirme gibi geleneksel iletişim kanalları önemini sürdürmektedir. Çocuklar açısından ise okul, öğretmen, ebeveyn desteği ve görsel materyallerle güçlendirilen iletişim daha etkili sonuçlar verebilmektedir (Beckjord ve diğerleri, 2008; Carbon ve diğerleri, 2022). Bu durum, etkili KBRN iletişiminin dijital ve geleneksel kanalları birbirinin yerine geçen araçlar olarak değil, birbirini tamamlayan unsurlar olarak ele alması gerektiğini göstermektedir.

Bu çalışma, kapsayıcı KBRN iletişimini dört ilke altında toplar: hedef kitleye uygunluk, çok kanallılık, sade–eyleme dönük mesaj tasarımı ve güven. Yaşlı bireyler açısından erişilebilirlik, mesajların gerektiğinde tekrar edilmesi ve yerel destek ağlarının devreye girmesi öne çıkarken; çocuklar için yaşa uygun dil kullanımı, görsel destek, okul temelli hazırlık çalışmaları ve bakım verenlerin sürece eşlik etmesi daha belirleyici olmaktadır. Bu nedenle KBRN kriz yönetiminde kapsayıcı iletişim planları hazırlanırken yalnızca ne söyleneceğine odaklanmak yeterli değildir. Aynı zamanda mesajın kime, nasıl, hangi araçla ve hangi aşamada iletileceği de planlamanın temel bir parçası olarak ele alınmalıdır. Böyle bir yaklaşım, hazırlık, müdahale ve iyileşme süreçlerinin tamamında daha işlevsel ve daha dayanıklı bir toplumsal iletişim yapısının kurulmasına katkı sağlayabilir.

SONUÇ

KBRN krizlerinde etkili iletişim, yalnızca bilginin topluma hızlı bir şekilde ulaştırılmasından ibaret değildir. Görünmeyen tehditler, yüksek belirsizlik ve teknik bilgi yoğunluğu, bu tür olaylarda iletişimi koruyucu davranışların oluşmasını doğrudan etkileyen önemli bir unsur hâline getirmektedir. Bu çalışma da yaşlılar ve çocuklar gibi kırılgan grupların standart ve tek tip kriz mesajlarından aynı düzeyde yararlanamadığını göstermiştir. Bu nedenle kapsayıcı iletişim stratejilerinin, KBRN kriz yönetiminin temel unsurlarından biri olarak değerlendirilmesi gerekmektedir.

Bulgular, yaşlı bireyler için erişilebilirlik, tekrar edilen mesajlar, sade bir dil ve güvenilir bilgi kaynaklarının öne çıktığını göstermektedir. Çocuklar açısından ise yaşa uygun anlatım, görsel destek, okul temelli hazırlık ve bakım verenlerin rehberliği daha belirleyici görünmektedir. Bunun yanında, iletişim kanallarının seçimi de en az mesajın içeriği kadar önem taşımaktadır. Yalnızca dijital araçlara dayanan sistemler, kırılgan grupların bir kısmını dışarıda bırakabilmektedir. Bu nedenle sosyal medya, SMS ve çevrim içi platformlar; radyo, televizyon, telefon ve yüz yüze yönlendirme gibi daha geleneksel araçlarla birlikte kullanılmalıdır.

Sonuç olarak, KBRN kriz yönetiminde kapsayıcılık ikincil bir unsur değil, etkili bir müdahalenin temel koşullarından biridir. Yaşlılar ve çocuklar için hedef gruba uyarlanmış, çok kanallı, sade ve güven temelli iletişim planlarının geliştirilmesi, koruyucu davranışlara uyumu artırarak toplumsal dayanıklılığı güçlendirebilir. Bu nedenle KBRN'ye yönelik hazırlık ve müdahale planlarında iletişim stratejileri oluşturulurken, kırılgan grupların özellikleri mutlaka dikkate alınmalıdır.

KAYNAKÇA

Al-Rousan TM, Rubenstein LM, Wallace RB 2014. Preparedness for natural disasters among older US adults: a nationwide survey. American Journal of Public Health, 104(3): 506-511.

Beckjord E, Stern SA, Meredith LS, Shugarman LR, Chandra A, Tanielian T, Taylor SL, Parker AM 2008. Enhancing emergency preparedness, response, and recovery management for vulnerable populations: literature review. RAND Corporation, WR-581.
Carbon D, Arnold A, Görgen T, Wüller C 2022. Crisis communication in CBRNe preparedness and response: considering the needs of vulnerable people. International Journal of Disaster Risk Reduction, 79: 103187.
Dennis A, Weston D, Amlôt R, Arnold A, Carbon D, Carter H 2023. The role of pre-incident information and responder communication in effective management of casualties, including members of vulnerable groups, during a decontamination field exercise. *International Journal of Disaster Risk Reduction,* 94: 103806.
Jurgens M, Helsloot I 2018. The effect of social media on the dynamics of (self) resilience during disasters: a literature review. Journal of Contingencies and Crisis Management, 26(1): 79-88.
Karakuş E 2024. Çocukların kimyasal, biyolojik, radyolojik ve nükleer (KBRN) tehdit ve tehlikelerden korunmasına yönelik farkındalıklarını artırmada animasyon destekli eğitimin rolü. Yüksek lisans tezi, Namık Kemal Üniversitesi Sağlık Bilimleri Enstitüsü, Tekirdağ.
Liao KM, Hu YJ 2025. Factors influencing disaster preparedness behaviors of older adults. PLOS ONE, 20(2): e0315617.
Lindell, MK, Perry RW. (2012). The protective action decision model: Theoretical modifications and additional evidence. Risk Analysis, 32(4), 616–632.
Luht-Kallas K, Laanemaa E, Taukar M, Hatšaturjan A, Kapura J, Kibar T, Põld M 2023. Assessing the comprehensibility of SMS warnings: an example of crisis communication in the Estonian trilingual landscape. International Journal of Disaster Risk Reduction, 97: 104014.
Morris KAN, Edwards MT 2008. Disaster risk reduction and vulnerable populations in Jamaica: protecting children within the comprehensive disaster management framework. Children, Youth and Environments, 18(1): 389-407.
Ng K, Lean M 2012. The Fukushima nuclear crisis reemphasises the need for improved risk communication and better use of social media. Health Physics, 103(3): 307-310.
Nikku BR, Sah N, Karkara R, Ahmed S 2006. Child rights perspective in response to natural disasters in South Asia: a retrospective study. Save the Children Sweden.
Perko T, Benighaus L, Tomkiv Y, Wolf HV 2020. Guidance on communicating about uncertainties in nuclear emergency management. Radioprotection, 55(HS1): S169-S174.
Ronan KR, Crellin K, Johnston DM, Finnis K, Paton D, Becker J 2008. Promoting child and family resilience to disasters: effects, interventions, and prevention effectiveness. Children, Youth and Environments, 18(1): 332-353.
Shah AA, Khan NA, Ullah W, Khan A, Alotaibi BA, Ullah A, Amri A 2024. Disaster risk reduction education (DRRE) in elementary education of Pakistan: challenges and scaling up endeavours. International Journal of Disaster Risk Reduction, 114: 104962.
Su S, Zhou J, Zhong Z, Zhang J 2025. How help-seeking information spreads on social media during disasters: the role of vulnerable groups and information features. International Journal of Disaster Risk Reduction, 120: 105374.
Vink K, Takeuchi K 2013. International comparison of measures taken for vulnerable people in disaster risk management laws. International Journal of Disaster Risk Reduction, 4: 63-70.
Wisner B, Blaikie P, Cannon T, Davis I 2004. At risk: natural hazards, people's vulnerability, and disasters. 2nd ed. Routledge.

TEXT BEYOND WORDS: HOW MEANING IS CREATED THROUGH GAPS AND SILENCE IN CONTEMPORARY WRITING

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ABSTRACT

In contemporary writing, meaning is often perceived as residing solely in words and explicit statements. However, silence, gaps, pauses, and textual absences play an equally significant role in shaping interpretation and readerly understanding. This presentation examines how absence within a text function as an active site of meaning-making, rather than as a lack or deficiency. It points out how silence operates both as a deliberate literary strategy and as an interpretive space that encourages readers to participate in the construction of meaning beyond the literal surface of language.

Drawing on examples from contemporary literary and creative writing practices, the study argues that meaning in writing is not simply additive or fixed but relational and dynamic. It emerges through the interaction between what is present and what is withheld, between sound and silence, articulation and interpretation. Gaps, pauses, and omissions compel readers to slow down reflect, and engage more deeply with the text, allowing multiple interpretations to coexist. In this sense, silence becomes productive, shaping emotional response, aesthetic experience, and critical understanding.

By foregrounding the expressive potential of what remains unsaid, this paper offers a fresh perspective on contemporary textual practices and challenges word-centered approaches to interpretation. It suggests that absence is not a void but a meaningful structural element that actively contributes to narrative tension, thematic depth, and reader engagement.

The presentation ultimately encourages interdisciplinary discussion across literary theory, creative writing, and broader communicative practices. It provides an accessible framework for examining how unseen, unspoken, and implicit elements of texts influence meaning- making, thereby emphasizing the importance of silence and gaps in evolving interdisciplinary approaches to language and interpretation.

Keywords: Silence, Absence, Meaning-making, Reader Engagement, Interdisciplinary Studies.

A MACHINE LEARNING FRAMEWORK FOR ACCELERATING DISCOVERY IN HYDROGEN STORAGE MATERIALS

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ABSTRACT

The world energy transition and net zero emissions by 2050 are heavily dependent on hydrogen as a versatile high-density (120 MJ/kg gravimetric) clean energy carrier for decarbonising heavy industry, long-distance transport, aviation, steelmaking and seasonal renewable energy storage. Under ambitious net-zero pathways the global demand for hydrogen is forecasted to expand from around 100 million tonnes in 2024 to 500–600 million tonnes by 2050. Yet, no effective, safe, and cost-effective storage solutions are available which is one of the very big bottlenecks for scaling the hydrogen economy . Traditional storage techniques are not without limitations. High-pressure gaseous compression (350–700 bar) makes energy significant and expensive to compress (10–15% of stored energy lost) and use costly composite vessels while cryogenic liquefaction at 253°C consumes 30–40% of the hydrogen's lower heating value and has high boil-off losses (0.2–3% per day) The storage of solid state hydrogen represents a clear potential advance within this domain. Physisorption in MOFs (Metal Organic Framework) is based on ultra-high surfaces (>5000–7000 m^2/g), tunable pore sizes and fast kinetics, achieving gravimetric capacities of 7–10 wt% and volumetric capacities of 40–50 g/L at 77 K and moderate pressures . Chemisorption of metal hydrides—AB-type (LaNi), AB-type (TiFe) and Mg based systems—provides good volumetric density and has a significant effect on liquid phase separation but the latter can be hampered by the high desorption temperature, slow kinetics, and structural degradation. The main challenge is the huge chemical design space: millions of assumed MOF structures, and nearly infinite alloy compositions. Traditional trial-and-error-style experimental methods and high-fidelity computational approaches such as density functional theory (DFT) or Grand Canonical Monte Carlo (GCMC) are prohibitively time consuming. Machine learning (ML) has proven a potent accelerator. Recent Literature (2024–2026) presents solid results: explainable models (e.g. Bayesian regularized neural networks (BRANN), Least Squares Support Vector Machines (LSSVM), Extra Trees, and CatBoost) can achieve R^2 values of 0.9656–0.995 for hydrogen uptake in MOFs , tree-based ensembles (e.g. Random Forest, XGBoost) predict hydride content and binding enthalpy with $R^2 > 0.93$; hybrid deep learning approaches overcome small sample

constraints. Here the paper presents a complete, reproducible machine learning framework for accelerating materials screening and predicting gravimetric capacity (wt% H), and adsorption/binding energy (kJ/mol). It consists of a pipeline of heterogeneous dataset curation, preprocessing, feature engineering, model benchmarking (RF, SVR, MLP, XGBoost), and SHAP explainability. Results indicate great performance ($R^2 > 0.94–0.96$, MAE < 0.30 wt%)

and facilitate screening speedups of 10–10× over DFT/GCMC. Thus, this work presents a practical road map for AI-assisted rational design consistent with DOE targets.

Keywords: Hydrogen storage,Machine learning,Metal-organic frameworks,Metal hydrides, Gravimetric ca- pacity, Adsorption energy, Materials discovery, Random Forest,Support Vector Regression, Neural Networks, SHAP interpretability

INTRODUCTION

The pressing global imperative to achieve carbon neutrality by mid-century has made hydrogen (H) an important base of the clean energy transition [1]. Hydrogen, with its incredible gravimetric energy density (120 MJ/kg) and zero CO emissions at the point of consumption—fuel cells or combustion—can facilitate linking irregular renewable energy resources to reliable dispatchable power options and the decarbonization of tough-to-abate industries, enabling transitions to low CO applications in energy production and consumption [2]. However, the realization of this potential is profoundly constrained by the continuing problem of hydrogen storage [2]. For storage, the "storage trilemma" needs to be achieved simultaneously at high gravimetric/volumetric density, rapid kinetics and safety/reversibility [2]. The current benchmark technologies fail: with a high pressure for gas, energy intensive compression is required (10–15% loss) [2] and cryogenic liquid hydrogen suffers from 30–40% energy penalty and boil-off losses [2]. Advantages for solid-state storage also. In MOFs, 7–10 wt% gravimetric and >40–50 g/L volumetric capacity is achieved by physisorption at 77 K [3, 4]. Chemisorption in metal hydrides yields high volumetric density, while having high desorption temperature and degradation [5, 6]. The design field is large: there are millions of MOFs and alloy compositions [7]. The classic screening using DFT/GCMC is cost-intensive [8]. Machine learning speeds up discovery [9, 2], and the latest models generated R^2 0.9656–0.995 in MOFs [3, 8] and $R^2 > 0.93$ in hydrides [5]. This paper presents a full end-to-end ML structure with integrated datasets, feature engineering, model benchmarking and interpretability of SHAP model for MOFs and hydrides to speed-up their discovery.

METHODS AND MATERIALS

Dataset Curation and Harmonization

The proposed framework is built on the extensive selection and harmonisation across heterogeneous datasets for generalisation across physisorptive and chemisorptive hydrogen storage materials. The following sources were chosen for their reliability, size, and relevance:

- **QMOF database**: Approximately 20,000 metal-organic framework architectures for density functional theory (DFT)-calibrated structures with their optimised geometries, band gaps, formation energies, partial atomic charges [7].
- **CoRE MOF databases (2019 and 2021 releases)**: Approximately 14,000 experimentally realistic MOF structures with simulated adsorption isotherms, textural properties (BET surface area, total pore volume, void fraction, largest cavity diameter LCD, pore-limiting diameter PLD), and geometric descriptors [4].
- **Experimental MOF hydrogen uptake datasets**: Approximately 1,700–1,729 curated records

drawn from peer-reviewed literature, which include recorded gravimetric hydrogen capacity (wt% H) at heterogeneous temperatures (predominantly 77 K, with some ambient conditions) and pressures (max 100 bar), in addition to material properties including BET specific surface area, total pore volume, and composition [3].

- **Metal hydride datasets**: Information taken from the US Department of Energy (DOE), including 1,500–2,000 records in the public hydrogen storage materials database and updated literature on intermetallic hydrides (AB, AB, AB), magnesium-based alloys, alanates, borohydrides, and multi-principal-element systems. Gravimetric as well as volumetric capacity, formation enthalpy H, plateau pressure and cycling stability have all been reported [5, 6].

Target variables selected for modeling were:

- Gravimetric hydrogen storage capacity (wt% H at specified temperature and pressure, or usable swing capacity between charging and discharging conditions).
- Adsorption or binding energy (kJ/mol H), as a thermodynamic measure of interaction strength and reversibility.

All datasets were standardized to SI units, deduplicated by composition and structure identifiers, and underwent quality assurance checks to remove inconsistent or erroneous entries [9]. Data Preprocessing Pipeline

An exhaustive, multi-step preprocessing pipeline was deployed to guarantee high data quality, minimize noise, and ready the data for machine learning models:

1. **Outlier detection and exclusion**: Statistical z-score filtering (threshold > 3 deviation from the mean) and isolation forest algorithm which is especially well suited for high-dimensional data and does not assume Gaussian distribution [9] were used to identify and eliminate abnormal records.

2. **Imputation of missing values**: Structural and textural features (pore volume, void fraction, LCD, PLD, etc.) were imputed using K-nearest neighbors (KNN: k=5) based on Euclidean distance in feature space. Median imputation was applied for compositional and elemental descriptors to suppress bias due to means [9].

3. **Target variable transformation**: Gravimetric capacity (wt%) and adsorption energy (kJ/mol) showed right-skewed distributions. A log(1 + x) transformation was taken to stabilize variance and increase model convergence, in particular for regression models that can be sensitive to scale (SVR, MLP) [8].

4. **Feature scaling**: All input descriptors were normalized to the [0, 1] range through Min-Max scaling. This is important for distance-based algorithms (SVR, KNN imputation) and gradient-based optimizers (MLP, XGBoost) to achieve fair feature contributions that result in a faster process for convergence [5].

After pre-processing, a final unified dataset consisting of 15,000–20,000 high quality, harmonized samples can be employed for training, validation, and testing. Feature Engineering

Over 50 descriptors were developed to represent the multiple factors affecting the hydrogen storage performance in both MOFs and metal hydrides:

- **Elemental and compositional descriptors** (35+ features): Weighted means, standard deviations, lowest and highest atomic number (Z), period, group, Pauling electronegativity (),

electron affinity, atomic and ionic radii, valence electron number, first ionization energy and elemental density. Composite measures were developed using valence electron concentration (VEC), atomic radius mismatch parameters (), Pettifor electronegativity difference and composition-weighted thermodynamic proxies [6, 5].

- **Structural and textural descriptors** (10+ features, preferentially of MOFs): BET specific surface area (m^2/g), total pore volume (cm^3/g), micropore volume fraction, void fraction, largest cavity diameter (LCD, Å), pore-limiting diameter (PLD, Å), metal node type and count, organic linker length, and topology indicators [4, 3].
- **Operational and environmental conditions**: Temperature (K), pressure (bar), and in selected cases, gravi- metric or volumetric loading conditions at equilibrium [8].

In feature engineering, we adopted domain knowledge derived from recent literature to adjust descriptors to account for physical mechanisms (physisorption dominated by porosity, chemisorption by electronic structure) [9]. Feature Selection

Dimensionality reduction was carried out in three sequential steps to mitigate redundancy, minimize overfitting, and enhance model interpretability and efficacy of training:

1. **Correlation-based filtering**: Features with absolute Pearson correlation coefficient > 0.85 were identified and one member of each associated feature was discarded (kept the feature with higher mutual information to the target) [9].
2. **Mutual information ranking**: Each feature was ordered by its mutual information score to the target variable, focusing on the feature with the strongest non-linear dependency [8].
3. **Recursive Feature Elimination (RFE)**: Recursive elimination was used to extract the most informative features (top 20–30) with Random Forest as the base estimator. Finally, the final selected set included BET surface area, pore volume, pressure, temperature, void fraction, valence electron concentration (VEC), and atomic radius mismatch as dominant predictors [4, 5].

This multi-stage selection process led to retaining only the most physically relevant and predictive features.

Machine Learning Models and Training Protocol

Four families of regression models were chosen and tested rigorously to determine the best fit on gravimetric capacity and adsorption energy prediction:

1. **Random Forest (RF)**: 100–500 decision trees, with maximum depth set 10–30, minimum samples for each split 2–10, and bootstrap sampling. Optimized for noise-tolerance, overfitting resistance, and the integration of feature importance ranking [5].
2. **Support Vector Regression (SVR)**: -insensitive loss using radial basis function (RBF) kernel. Hyperpa- rameters C (regularization), (insensitivity margin), and (kernel width) were optimized with grid search and Bayesian optimization [9].
3. **Multi-Layer Perceptron (MLP)**: 3–6 hidden layers (64–512 neurons per layer) feed-forward neural network, ReLU activation, dropout regularization (rate 0.1–0.3), batch normalization, Adam optimizer (learning rate 1e-4–1e-3), and early stopping (patience 50 epochs) to prevent overfitting [8].
4. **XGBoost / Gradient Boosting**: Best-in-class gradient boosting trees with 100–1000 estimators, 0.01–0.3 learning rate, maximum depth 3–10, 0.6–1.0 subsample ratio, column sampling.

Tuned to maximize prediction accuracy and generalization [5, 6].

Training and evaluation protocol consisted of:

- Data partitioning: 80% training / 20% hold-out test data, stratified by target value to preserve distribution.
- Cross-validation: 5-fold stratified cross-validation across the training set.
- Hyperparameter tuning: Bayesian optimization (50–100 trials) using libraries such as scikit-optimize or Optuna in order to enhance the search.
- Performance metrics: coefficient of determination (R^2), mean absolute error (MAE), root mean squared error (RMSE), and mean absolute percentage error (MAPE).
- Interpretability: Kernel SHAP (SHapley Additive exPlanations) values calculated for global feature importance and local explanation of individual predictions [9].

All computations were done in Python using scikit-learn, XGBoost, TensorFlow/Keras, and SHAP libraries.

RESULTS

Predictive performance on the hold-out test set for gravimetric hydrogen capacity is presented in Table 1. XGBoost achieved the highest accuracy (R^2 = 0.952, MAE = 0.25 wt%, RMSE = 0.38 wt%), followed by the ensemble average of all models (R^2 = 0.958, MAE = 0.23 wt%). Random Forest provided excellent interpretability at only marginally lower performance [5].

Table 1: Model Performance Comparison for Gravimetric Capacity Prediction (wt%)

Model	R^2	MAE (wt%)	RMSE (wt%)	MAPE (%)
Random Forest	0.941	0.28	0.42	4.1
SVR (RBF kernel)	0.928	0.32	0.48	4.8
MLP (5 hidden layers)	0.935	0.30	0.45	4.4
XGBoost	0.952	0.25	0.38	3.7
Ensemble (average)	0.958	0.23	0.35	3.4

Adsorption/binding energy prediction followed similar trends, with MAE values ranging from 0.28 to 0.42 kJ/mol across models.

Feature importance (from Random Forest) and SHAP analysis (Figure 1) consistently identified BET surface area as the dominant predictor for MOFs (28.4% importance), followed by pore volume (19.7%), operating pressure (14.2%), and temperature (11.8%) [4, 3]. In hydride systems, valence electron concentration (VEC) and atomic radius mismatch were critical [5, 6] (see Table 2).

Inference time per candidate averaged less than 1 ms on standard hardware, enabling the virtual screening of 10–10 hypothetical structures or compositions in hours—representing a speedup of 10–10× compared to traditional DFT or GCMC calculations [8].

DISCUSSION

The developed framework demonstrates predictive accuracy comparable to or exceeding recent state-of-the-art results: R^2 values >0.94–0.96 are in line with Extra Trees (R^2 0.995), BRANN (R^2 0.9656), and CatBoost models reported for MOF uptake prediction [3, 8]. Tree-based ensembles

(particularly XGBoost) excelled due to their ability to model non-linear interactions and handle heterogeneous feature types without extensive preprocessing [5].

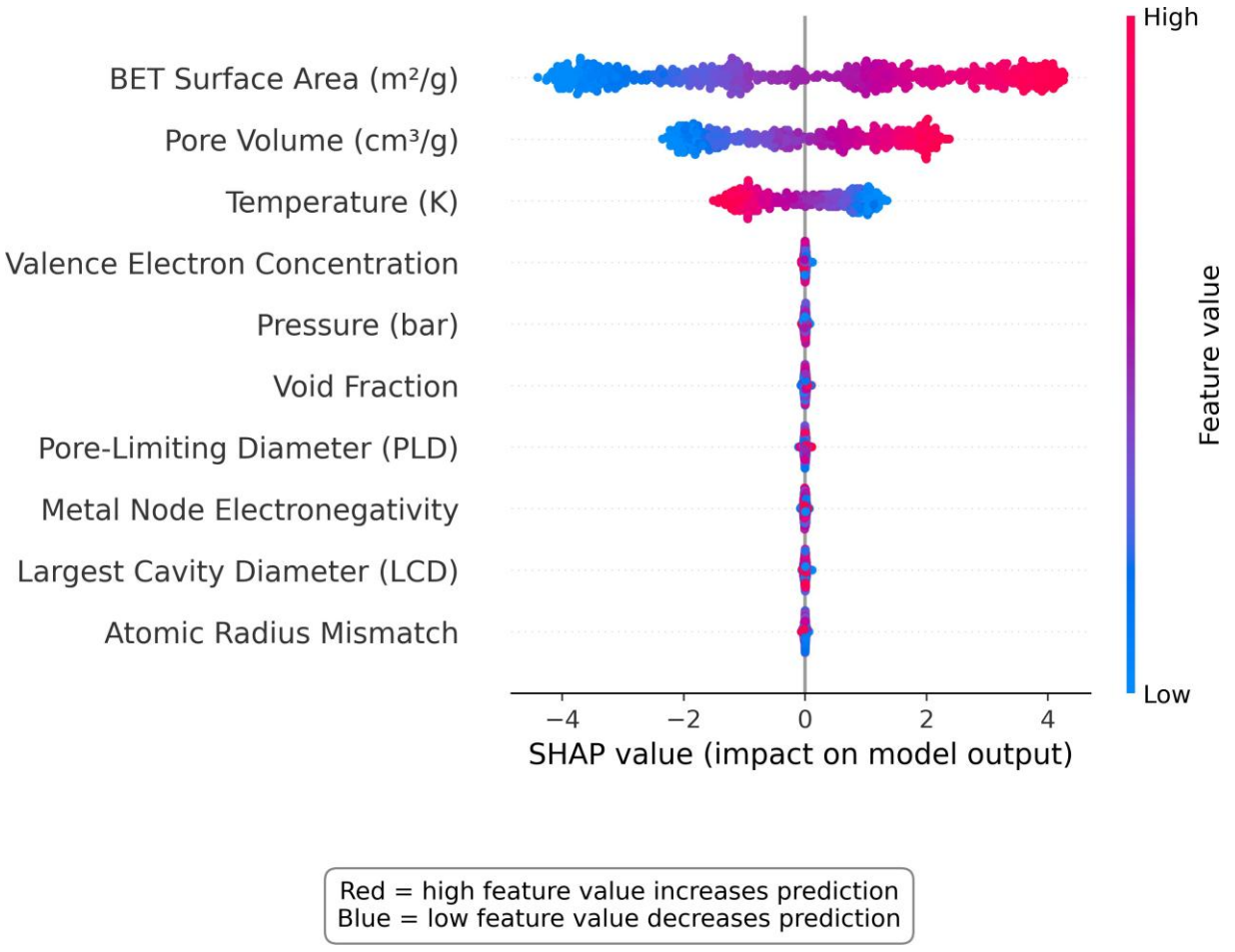


Figure 1: SHAP summary beeswarm plot illustrating feature impacts on predicted gravimetric hydrogen capacity (red = high value increases prediction; blue = decreases prediction).

Table 2: Top 10 Feature Importances from Random Forest Model (Gravimetric Capacity)

Feature	Importance (%)
BET Surface Area (m²/g)	28.4
Pore Volume (cm³/g)	19.7
Pressure (bar)	14.2
Temperature (K)	11.8
Void Fraction	7.5
Metal Node Electronegativity	5.3
Valence Electron Concentration (VEC)	4.1
Atomic Radius Mismatch	3.6
Largest Cavity Diameter (LCD, Å)	2.9
Pore-Limiting Diameter (PLD, Å)	2.5

SHAP interpretability analysis provided deep physical insights aligned with established mechanisms:

- In MOFs, textural properties (BET surface area, pore volume, void fraction) dominate physisorption, with positive SHAP contributions confirming that larger accessible surface area and pore volume directly enhance hydrogen uptake at cryogenic conditions, consistent with Dubinin–Astakhov and Langmuir isotherm models [4, 3].
- Operating conditions (pressure positive, temperature negative) reflect the exothermic nature of adsorption and temperature-dependent weakening of van der Waals forces [8].
- In metal hydrides, compositional descriptors such as valence electron concentration (optimal VEC 4.5–6) and low atomic radius mismatch emerge as key stabilizers of hydride phases, reducing formation enthalpy magnitude for improved reversibility and lowering kinetic barriers [5, 6].

These interpretable insights enable actionable design guidelines: for MOFs, prioritize structures with BET surface area >4000 m^2/g, pore volume >1.5 cm^3/g, and void fraction >0.7 while maintaining structural integrity; for hydrides, target alloys with balanced electronic structure (VEC 5) and minimized lattice strain (low) [9].

The framework's extreme computational acceleration (inference <1 ms per candidate) allows screening millions of candidates rapidly, focusing experimental efforts on top predictions and significantly reducing lab costs [8]. This efficiency is critical for meeting international hydrogen storage targets (US DOE 2025: 5.5 wt% usable gravimetric, 40 g/L volumetric) [2].

Limitations include:

- Training data bias toward experimentally successful or high-performing materials, potentially limiting general- ization to novel chemistries [9].
- Limited domain transferability between MOFs and hydrides without fine-tuning or transfer learning [5].
- Absence of built-in uncertainty quantification (addressable via Bayesian neural networks or ensemble variance) [8].
- Exclusion of dynamic properties (kinetics, cycling stability, thermal/mechanical degradation) [6].
- Incomplete encoding of synthesis feasibility, defect concentration, and linker flexibility [7].

Future directions include:

- Graph neural network (CGCNN, MACE, SchNet) integration for direct crystal graph learning [7].
- Active learning for intelligent query of expensive DFT/GCMC for high-uncertainty candidates [8].
- Multi-objective Pareto optimization to achieve the trade-offs of capacity, kinetics, cost, toxicity and cyclability [9].
- Closed-loop autonomous experimentation (prediction → robotic synthesis → characterization → retraining) [2].
- Modeling operando conditions (impurities, thermal excursions, cyclic stress) [6].
- Federated learning to exploit distributed experimental data without compromising privacy [9].
- Screening for uncertainty that emphasizes high-performance, low-uncertainty candidates [8].
- Extension to hybrid materials (MOF@hydride composites, supported nanoparticles) [4].
- Integrate life-cycle assessment (LCA) / techno-economic analysis (TEA) descriptors [2].
- Development of community adoption standards and open-source tools [9].

CONCLUSION

This research introduces a new robust, reproducible, and interpretable machine learning framework considerably helping to accelerate the discovery and optimization of solid-state hydrogen storage materials. Through curated datasets, advanced feature engineering, comparative modeling (RF, SVR, MLP, XGBoost), and SHAP explainability, the framework provides high-fidelity predictions of both gravimetric capacity and adsorption energy while exposing physical design rules [9, 2].

The dramatic computational speedup (10–10× compared to DFT/GCMC) makes it feasible to facilitate high- throughput virtual screening, greatly mitigating experimental trial-and-error and favoring promising candidates for synthesis and experimental testing [8].

In particular, this work lays out a feasible roadmap for AI-assisted materials identification for the development of a safe, efficient, high-density storage solution to promote the scalable, sustainable hydrogen economy and global net-zero emission potential in the realization of global low-carbon hydrogen economy objectives [1].

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REFERENCES

[1] International Energy Agency. 2025. Global Hydrogen Review 2025. IEA, Paris.

[2] Osman A.I. et al. 2024. Enhanced hydrogen storage efficiency with sorbents and machine learning: a review. Environmental Chemistry Letters, 22:1703–1740.

[3] Alatefi S. et al. 2025. Advancing hydrogen storage: Explainable machine learning models for predicting hydrogen uptake in metal-organic frameworks. Results in Surfaces and Interfaces, 19:100359.

[4] Borja N.K. et al. 2024. Prediction of Hydrogen Adsorption and Moduli of Metal–Organic Frameworks Using Machine Learning Strategies. Energies, 17(4):927.

[5] Allal Z. et al. 2026. Predicting Hydrogen Storage Capacity of Metal Hydrides Using Novel Imputation Techniques and Tree-Based Machine Learning Models. Computational Materials Science.

[6] Chandana K.S. et al. 2024. Machine learning insights into prediction of H gravimetric/volumetric capacity in Mg-based alloys. International Journal of Hydrogen Energy.

[7] Kim W.T. et al. 2024. Machine Learning-Assisted Design of Metal–Organic Frameworks for Hydrogen Storage. ChemRxiv.

[8] Qiu H. et al. 2024. Prediction of hydrogen storage in metal-organic frameworks using CatBoost-based approach. International Journal of Hydrogen Energy.

[9] Yamde A.A. et al. 2025. Machine learning approaches for the prediction of hydrogen uptake in metal- organic-frameworks: A comprehensive review. International Journal of Hydrogen Energy, 98:1131–1154.

[10] Maghsoudy S. et al. 2024. Connectionist technique estimates of hydrogen storage capacity on metal hydrides using hybrid GAPSO-LSSVM approach. Scientific Reports

SPY LITERATURE AS A PROPAGANDA DEVICE ACROSS THE EAST-WEST DIVIDE: A COMPARISON OF HUNGARIAN AND AMERICAN COLD WAR SPY NOVELS

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ABSTRACT

In this article, I explore how paperback spy novels of the Cold War Era either complicate or reinforce dominant political narratives in the United States and Hungary as spy heroes sacrifice their personhood in the interest of state ideologies. My examples of analysis are *Hód's Introduction* (1967) and *Hód's Mission* (1968) by Hungarian author Jenő Mattyasovszky, *Assignment Budapest* (1957) by Edward S. Aarons and *The Cold War Swap* (1966) by Ross Thomas, both American authors. Jenő Mattyasovszky's *Hód* novel series portrays violence as a mechanism of Western capitalist interests, while Communist spies protect egalitarian institutions through wit and resourcefulness. American author Edward S. Aarons shows prominent agents of the USSR committing violence out of inherent sadistic malice, whereas American spy heroes show restraint on high moral grounds. In Aarons' work, characters fighting for democratic ideals are highly sexualized, whereas villainous actors are both physically and morally unappealing. American author Ross Thomas completely departs from the uncompromising binaries of Mattyasovszky and Aarons with agents that appear to pledge an allegiance to nothing but survival or personal gain. While unhindered, sadistic violence is instinctual among enemy parties for Mattyasovszky and Aarons, Thomas's work portrays violence as something normalized, uncalculated and unprocessed in the world of intelligence. Rather than a symptom of a state system defined by moral decay, unprocessed violent behavior in the interest of survival is just another factor isolating intelligence agents from civilian normalcies in Thomas's *The Cold War Swap*. In observing the protagonists and antagonists of each novel, according to their propensity or resistance to violence and their access to their own personhood in the form of their sexuality (i.e., a winner among damsels in distress or a lone wolf agent with no personal ties), I will compare how each author portrays the spy agent as either a devoted servant of ideology or the cog of a state machine.

Keywords: spy literature, Cold War, political ideology, Hungarian crime literature, American spy literature

PECULIARITIES OF THE POETICS IN ETHEM BARAN'S SHORT STORY COLLECTION 'I FEEL LIKE CRYING WHENEVER I SEE YOUR BEAUTY'

'GÜZELLIĞINI GÖRDÜKÇE AĞLAYASIM GELIYOR' - THE ALIENATION, THE PROVINCE, AND THE MODERN PERSON

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ABSTRACT

Twenty-first-century Turkish prose is frequently defined by its preoccupation with the 'ordinary individual,' (küçük insan), their alienation, focusing on their inner world and the escalating tension between the self and the social order. Within this literary landscape, Ethem Baran's oeuvre stands out for it is profound engagement with the inferiority of marginalized figures and occupies a special place in contemporary literature. As the writer, who strongly and deeply explores his characters' souls, inner thoughts and personalities, he focuses on individuals living on the periphery of society and culture. Through them, he manages to depict both: the subjective world of the characters and the harsh reality surrounding them.

The article aims to analyze Ethem Baran's short story collection'Güzelliğini Gördükçe Ağlayasım Geliyor' ('I Feel Like Crying Whenever I See Your Beauty') as a cohesive narrative project. Guided by Virginia Woolf's epigraph regarding the search for the "true story", the study aims to identify the key similarities of the narrative techniques used, types of the characters, repetitive themes and topics, as well as ways of reflecting contemporary life, provincial space and the phenomenon of alienation. The article explores the function of space, particularly the district of Sincan in Ankara, which serves not merely as a topographical setting but as an ontological trap defined by repetition and waiting. Specifically, it examines how family (centered on the oppressive father figure), education, and the labour market operate as mechanisms of "symbolic violence" that strip individuals of their agency. Ultimately, the article concludes that Baran's work offers a vital critique of "institutional emptiness", capturing the moment where social forms persist but fail to provide meaning to the individual.

Keywords: alienation, father figure, authrority.

INTRODUCTION

Ethem Baran is one of the notable representatives of Turkish prose, especially in the short story genre. He was born in 1962 in Yozgat, Türkiye and got his MA degree in Ankara. Baran's literary activity started back then in the late 1970s: his stories, essays and critical articles were published in the leading Turkish literary journals multiple times, such as in 'Hisar' and 'Türk Edebiyatı'. Since the 1990s, Ethem Baran has been consistently associated with contemporary Turkish short story writing. His contribution to the development of the genre has been recognised with a number of prestigious awards: in 1994, he received the Turkish Writers' Union Award for his short story Kurutulmuş Gül Mevsimi; in 2005, he was awarded the Yunus Nadi Prize for his collection Dönüşsüz Yolculuklar Kitabı; and in 2025, he won the *Sait Faik Hikâye Armağanı Prize* for his

book ‘Döngel Dünya’. Ethem Baran’s bibliography includes not only different short story collections, but also novels, for instance, ‘Sonrası Ayrılık’, ‘Bozkırın Uzak Bahçeleri’, ‘Zira’, ‘Yarım’, ‘Emanet Gölgeler Defteri’.[1]

The works of Ethem Baran are regularly analysed by literary scholars in Turkish academic circles. Studies emphasise that his prose focuses on the inner life of his characters, their existential experiences and social disorientation. For example, an article devoted to the novel ‘Yarım’ interprets its main character as a figure embodying a crisis of self-awareness and an inability to perceive his own life holistically.[2]

Another academic work analysing the novel ‘Emanet Gölgeler Defteri’ emphasises the motif of alienation: the character is interpreted as a subject who has lost touch with himself and with society, which manifests itself in his inner turmoil and psychological isolation.[3]

A master's thesis completed at Ankara University examines Ethem Baran's stories as an artistic reflection of social realities and interpersonal relationships, with a particular focus on language and its role in constructing the artistic world.[4]

In literary criticism, Ethem Baran's language is regarded as a key element of his poetics. An analytical article published in the Turkish edition of Yeni Şafak emphasises that it is precisely his language that makes him a true storyteller and allows him to combine tradition with modernity: *‘It is the language that makes a storyteller authentic. Not to mention it would be an omission... He blends tradition and modernity in his stories.’* (“Bir öykücüyü sahih kılan dilidir. Ondan söz etmemek eksik bırakır … Gelenekle moderniteyi harmanlar öykülerinde.”) [5] This assessment is consistent with academic research, in which Baran's language is seen not only as a means of narration, but also as a way of expressing the psychological tension and internal fragmentation of his characters. Therefore, Ethem Baran is regarded in contemporary Turkish literature as a writer whose work focuses on analysing the inner world of individuals experiencing social and psychological disorientation. His prose is interpreted by critics as a form of artistic reflection on alienation, identity crisis, and the tension between the individual and social reality. Baran's stylistic originality, especially his language, is considered a key element of his poetics, allowing him to combine traditional and modern forms of narrative, such as shifting between the narrator, third person and the first person.[6] Making this specific move is just one of the details that keeps the reader consistently engaged.

MATERIALS AND METHODS

Determining an appropriate research model is essential for conducting a systematic literary examination. For this study, a qualitative research methodology was selected to facilitate a rich thematic exploration and structural analysis of the text. Qualitative research, by its nature, allows for a comprehensive exploration of complex, multi-layered concepts such as alienation, existential stagnation, and institutional critique within a literary framework.

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[1] https://edebistan.com/oykuculer-sozlugu/ethem-baran? (10.01.2026) ; https://www.ntv.com.tr/sanat/yazar-ethem-baran-sait-faik-hikaye-armaganinin-sahibi-oldu%2CkZJNLmfsX0WvJ4XPOiEiAQ (10.01.2026)

[2] Büşra Emine Bora, Ethem Baran’ın Yarim Romanında İdeleştiremeyen Varlık Olarak İnsan, **Ankara Üniversitesi Dil ve Tarih-Coğrafya Fakültesi Türkoloji Dergisi**, №.25, 2 (2021), p.64-76

[3] Büşra Emine Kurteş/Öznür Özdarıcı, Ethem Baran’ın Emanet Gölgeler Defteri Romanında Yabancılaşma, **RumeliDE Journal of Language and Literature Studies**, 2023, №.37, p.524-532

[4] Bahman Sidiq Hassan Hassan, **Ethem Baran'ın hikâyeleri üzerine bir inceleme**, Ankara Üniversitesi, Sosyal Bilimler Enstetüsü, 2016.

[5] https://www.yenisafak.com/hayat/yasadikca-kirleniyorum-ethem-baran-oykuculugu-3858453

[6] Bora, ibid., p.66.

Close textual analysis was employed as the primary research method. In literary studies and the broader humanities, textual analysis serves as a central methodology for systematically examining written works to extract meaning, identify patterns, and interpret cultural or social phenomena, as was done in this article. In this study, the primary text under investigation is Ethem Baran's short story collection, Güzelliğini Gördükçe Ağlayasım Geliyor. The analysis involves a rigorous reading of the text to isolate and evaluate information pertinent to the targeted phenomena, namely the depiction of the peripheral subject and spatial ontology.

Findings in this study are generated through the systematic categorization and interpretation of the primary text. Rather than quantifying data, the findings are structured thematically. The analysis deconstructs the narrative into key focal points such as the oppressive father figure, the ontological function of the Sincan district, and the use of intertextuality. These findings are supported by direct excerpts and quotes from the stories, which are then contextually analyzed to demonstrate how the author constructs a critique of modern societal institutions.

RESULTS

The textual analysis of Ethem Baran's Güzelliğini Gördükçe Ağlayasım Geliyor provides several important thematic and structural findings regarding the condition of the modern individual. The findings are divided into four main categories: existential alienation, gender dynamics, institutional critique, and spatial ontology.

The analysis reveals a profound exploration of the modern peripheral subject, whose existence is defined by existential alienation and a deeply fractured identity. This alienation is systematically reproduced by institutional emptiness, where schools, the labour market, and religious bodies function as mechanisms of symbolic violence and total control rather than support systems. The characters' lack of autonomy is further exacerbated by oppressive paternal authority which paralyzes male protagonists and relegates female characters to symbolic constrained roles. Physically, this entrapment is mirrored in the spatial ontology of the urban periphery, specifically the Sincan district, which acts as a claustrophobic boundary limiting both physical movement and self-realization. Baran reinforces this sense of confinement and cognitive dissonance through a chaotic inter-textual blending of religious texts, Western literature, and pop culture. Ultimately, in this landscape of institutional and patriarchal suppression, the characters' only subconscious resistance against total despair is their unrequited longing for people, objects or a bygone era.

DISCUSSION

Thematic unity of the collection: the phenomenon of alienation

It is fitting that the epigraph for the entire story collection is Virginia Woolf's quote:

"I have made up thousands of stories; I have filled innumerable notebooks with phrases to be used when I have found the true story, the one story to which all these phrases refer. But I have never yet found the story. And I begin to ask, Are there stories?" — Virginia Woolf, The Waves.[7]

This passage serves as a thematic anchor for the author's work. We are not merely the observers of the fictional stories; rather, those mirror the lived reality of many individuals. Ethem Baran captures and articulates the minutiae of our surroundings, the subtle details that many overlook or disregard. His attentiveness to nuances is what renders his stories so poignant and powerful.

[7] Ethem Baran, **'Güzelliğini Gördükçe Ağlayasım Geliyor'**, İletişim Yay, Istanbul, 2021, p.7.

The books comprises seven distinct stories called *Furkan, Nisa, Gözleri Dolana Dolana, Bay WC Sıcak Duş Emanet Alınır, Tıkır Tıkır, Her Yaz, Yedi Kaleminen Yazı Yazarım* and a dedication (*İtfah*). At first glance, they appear unconnected, as mostly all of them feature different characters and their own plots. However, a closed reading reveals that all the characters, without exception, do have a unifying thread: they all suffer from existential fatigue, a consequent sense of hopelessness, and profound social and spiritual isolation. They grapple with conflicts between the self and the family, society, and religious institutions, often trapped in a sense of time standing still.

This alienation is deeply internalized. It is not merely a sense of estrangement from others, but also from one's own self, a fragmentation reflected in their inner monologues. For instance, the protagonist of the story 'Furkan' constantly highlights his isolation and his inability to integrate into the prevailing economic and social order. He perceives his existence as a repetitive, burdensome cycle where every day is indistinguishable from the last.

Baran's depiction of the protagonist's anger is striking. The language the young man employs, his curses, stream of consciousness, and persistent rhetorical questioning serves as a mechanism to reveal the depths of his interior world and the limits of human endurance. Although he appears outwardly as a compliant student who follows the rules, the narrative exposes the desperation of his internal suffering. Ultimately, his suffering manifests in two distinct directions. The first is self-harm and self-destruction. The second is, surprisingly, something that transcends the self, his love for Nisa. Despite the overwhelming pressure, the thought of her serves as his sole mental support: '*I can't help loving my razor. At that time I see Nisa. She is proud of me. I tell her everything. With every cut I open myself to her. Can you see it, Nisa? But you are not answering. If only I could see my innerself.'* (*Seviyorum jiletimi ne yapayım. Nisa'yı görüyorum o sırada. Benimle gurur duyuyor. Anlatıyorum ona her şeyi. Her jilet darbesinde açıp içimi gösteriyorum. Görebiliyor musun Nisa? Bir şey demiyorsun da. Bir de ben görebilsem içimi).*[8] During his inner dialogues with her, albeit imaginary, the external world ceases to matter or even exist. Though, this act of self-harm isn't really understood by Furkan himself. He has doubts if it's his '*attempt to stay alive or to get used to taking his own life'.*[9] Although his love for Nisa is unrequited, it provides him with the resilience to survive. Subconsciously, this affection becomes his reason for being, even as he struggles to find meaning in life generally.

Unrequited longing is a recurring theme throughout the collection. For Nisa, it is her love for Mert; for Supi it is his love for Nüket (which we can infer was mutual); for the protagonist of 'Bay WC Sıcak Duş Emanet Alınır', it is his admiration for the writer he sought to meet. In 'Tıkır Tıkır', this longing transforms into nostalgia for the old-fashioned world, however in contrast, in 'Her Yaz' it is Kemal's love for Hülya. In 'Yedi Kaleminen Yazı Yazarım', it appears as the character's devotion to his expensive pens a clear symbol of the significance he attaches to his craft.

Undoubtedly, Ethem Baran succeeds in depicting the beauty and complexity of human life, capturing the delicate balance between existential despair and the search for small, simple anchors to cling to.

Depicting a modern person: male and female characters

As a rule, the male protagonists in Ethem Baran's narratives are young men unable to fully realize their potential due to various constraints. Most are either unemployed or engaged in labour they perceive as trivial. They grapple with deep-seated paternal conflicts, likely originating in early

[8] Baran, **ibid**, p.31.
[9] Baran, **ibid**, p.32.

childhood, which manifest as an Oedipus complex that plagues their existence. Their internal turmoil remains an 'inner outcry' that never translates into concrete action: '*..it felt like I could do something, but I like I was standing too far..'(sanki yapabileceğim bir şeyler varmış da ben uzak duruyormuşum gibi..)* [10]

The father figure, traditionally a symbol of stability and order, is here inextricably linked to abuse, suppression, and hypocrisy. In 'Furkan', for instance, the father is associated with weaponry, power, and aggression, revealing a connection between paternal authority and something truly despicable. The protagonist's rejection of his father's image serves as a potent signal of a fractured identity. While both parents undoubtedly play a crucial role in individual development, the father has historically served as the primary role model for the male child. Consequently, when the father withdraws his support, the son is spiritually broken, transforming into a furious adolescent starved of sympathy. A harsh detail we learn is that the father figure either hates their child or doesn't have feelings at all. So, when in story 'Nisa' we find out that Furkan wants his father dead, as readers this does not come as a surprise, but might cause slight feeling of sympathy for the protagonist. In the story called 'Gözleri Dolana Dolana' we can see how people don't want to take after their fathers: '*Their fathers were scoundrels too, in our opinion. Well, that sickening gait was inherited by their bastards from their fathers.' ('Bunların babaları da yavşaktı bize göre. Öyle ya, bu insanı hasta eden yürüyüş babalarından miras kalıyordu piçlerine'.)*[11]

Conversely, the female characters are equally devoid of fulfillment. Their presence in the narratives is fragmentary; they function primarily as objects of memory, longing, or unreachable desire rather than active subjects. The female figure is not a full participant in the plot but rather a symbol of lost intimacy and impossible salvation and this is evident in the story of Nisa, when she serves partially as a narrator, her narrative gaze is fixed on male figures: her father (an archetype of Baran's male characters), Mert, Oğuz, and Furkan. She rarely articulates desires independent of men; even her longing for Izmir does not seem entirely autonomous. Nisa's mother is similarly tragic. Despite her divorce, she remains trapped in the domestic sphere, forced to cohabit with her ex-husband, an infantilized figure: *'My father is still a child.' (Babam hâlâ aynı çocuk.)* '*This man slips to his childhood and doesn't want to come back.' (Adam çocukluğuna gidiyor ve geri dönmek istemiyor)*[12]*,* who does nothing, which makes his ex-wife furious all the time. Their daughter, who is the witness of this unfortunate relationship, cannot deal with her anger herself, so cope with it, she turns violent towards her mother.

There are instances of more complex dynamics, such as with Hülya. She attempts to carve out her own path by seeking a university scholarship, yet her autonomy is circumscribed by her parents' control. Accustomed to a comfortable life, she is ultimately powerless, as her parents have already brokered an arranged marriage for her, even though her mother claims it's her wish to marry that man. As readers it is made clear this is not the case as her parents selected a rich family to set up the marriage: '*We are pretty close with this family. We've been neighbours for years. They are very respectful. And their financial state is good. They own shops, houses, summer villas in Istanbul. My daughter will feel comfortable.' (Çok yakından tanıdığımız bir aile, yıllardır komşuyuz. Çok saygıdeğer insanlar. Durumları da iyi. İstanbul'da dükkânlar, evler, yazlıklar. Kızım rahat eder vallahi.)* '*Don't spill the bins; the father shouldn't hear it or he will kill the girl by slapping her, she has reached an agreement with that boy, though.' ('Laf aramızda; babası duymasın, yoksa dayaktan öldürür kızı vallahi, oğlanla kız önceden anlaştılar zaten…')*[13]

[10] Baran, **ibid**, p.64.
[11] Baran, **ibid**, p.57.
[12] Baran, **ibid**, p.46.
[13] Baran, **ibid**, p.84.

Although male characters appear to enjoy greater prominence and agency, this autonomy does not guarantee self-actualization. Ultimately, the narrative arrives at a universal truth: regardless of gender, the complexities of existence are inevitable. Life oscillates between desperation and inspiration exemplified by the protagonist in 'Bay WC Sıcak Duş Emanet Alınır,' who finds solace in imagining his stories being admired. Baran thus suggests that the coexistence of these opposing states is intrinsic to the human experience.

The reflection of modern life

Ironically, which is a crucial element of Ethem Baran's style, we observe a layered portrait of modern Turkish reality, where the youth are forced to exist in a society full of institutional pressure, economic instability, and ideological control. Social institutions, such as schools, the job market, and religious structures, are no longer supportive mechanisms, but structures that reproduce powerlessness and humiliation.

One of the central themes is the degradation of education as a social ladder. Formally, School fomally act as a gateway to the future, but in reality, it is turning into a mechanism of symbolic violence.

The image of the teacher here is not that of a mentor, but rather a repressive figure: he does not shape the individual, but rather cancels them out in advance. Thus, educational institutions do not prepare young people for the future, they socially disqualify them even before they begin their adult lives.

This loss of perspective is directly linked to the situation in the labour market. Vocational training turns out to be a simulation that does not lead to real qualifications. This leads to the working situation itself, which now becomes just an 'idea', which in a reality is full of red tape; moreover and more importantly, the characters are aware of not being needed in this system. Therefore, their intention to get employed seems to be more of a mockery: '*I don't have brain for that. Even if I do, it's not what they are looking for. I'm not the person they are looking for. In fact, they aren't looking for anybody. But we think they do. They just pretend. And so do we about finding a job. So*, *we are just tricking each other, isn't it great?!' (Vuracak başım yok. Varsa bile onların işine yaramaz. Aradıkları adam ben değilim. Aslında adam da aramıyorlar zaten. Biz öyle zannediyoruz. Arıyormuş gibi yapıyorlar. Biz de iş bulabilecekmişiz gibi yapıyoruz. Ne güzel kandırıyoruz birbirimizi değil mi?)*.[14]

Even religion, the most sacred and intimate thing in the world, is shown here as a tool of total control that regulates not only behavior but also the body, habits, and desires. Instead of being inspired by spiritual leaders, the young are taken under total control and forced to sacrifice their own leisure time. Their lives gradually become full of repetitive rituals. The absurd has its root in the total control of daily routine, where the students aren't allowed to make a decision about taking shower at the time they want to: *'Do we have to ask for your permission to have shower?*

Of course you do, there's limitation! Who do you think you are?'

(Senden izin mi alacağız banyo yapmak için?

Tabii izin alacaksın hadsiz! Sen kendini ne sanıyorsun!)[15]

Speaking of rituals, another good example is shown in the story 'Tıkır Tıkır'. Without questioning the actions of the authorities, people accept a new law which forces every man to have a walking

[14] Baran, **ibid**, p.19.
[15] Baran, **ibid**, p.31.

cane. It closely reflects reality: no matter how ridiculous the decisions are, the crowd will always follow.

A fundamental experience of temporal stagnation is presented: time passes, but life does not develop. The traditions and prejudices of the old world are always interfering with modern life, especially when it comes to arranged marriages and inaccessible education. In this context, the narrator's irony takes on an existential sharpness. His bitter, sarcastic tone is a form of resistance to a reality in which all institutions function as simulations of care.

Thus, in Ethem Baran's work, modern Turkey appears as a space of institutional emptiness: forms exist, but their content has been destroyed. It is precisely this gap between external normality and internal decay that creates the ironic and tragic tone characteristic of the collection, in which social criticism and personal pain become inseparable.

The provincial space and the ‘peripheral man’

Ethem Baran's image of the ‘peripheral person’ depicts a subject who is neither excluded nor fully included in society: he studies, works, and lives, but all these activities are devoid of transformational potential. His existence is reduced to survival rather than planning for the future, which embodies a paradox of visibility: he is physically present in the public sphere, yet socially invisible, functioning merely as a cog in a mechanism that operates independently of his desires.

Within the collection, the space of Ankara specifically its periphery, Sincan serves a dual function: it is both a topographical setting and an existential condition. Sincan represents the margins of the capital, a locus where life is defined by waiting, repetition, and social stasis. Unlike the city center, which symbolizes movement and possibility, Sincan acts as a container for unfulfilled dreams, trapping its inhabitants in a concrete labyrinth of uniformity.

This space offers no prospects for moving forward: houses are close together, routes are monotonous and life is confined to a few streets and rituals. The protagonist lists his world as a set of points between which he circulates endlessly. The picture does not change when it comes to other locations where the stories take place. For instance, almost every story features no more than two locations that are strongly connected, creating a binary world (for instance, the stifling home vs. the aimless street) with no "third space" for self-realization. The only exception is ‘Bay WC Sıcak Duş Emanet Alınır’, where we see three locations, all symbolizing different things: hope, desperation, and chaos.

Consequently, the urban periphery is not merely a geography but an ontology (a form of being), which structures the characters' consciousness, stripping them of the capacity to envision a ‘possible future,’ a deficit particularly visible in the realms of education and social mobility. The physical boundaries of the district eventually become the mental boundaries of the protagonist, limiting his imagination to the immediate and the mundane.

However, Ethem Baran's poetics are built on a dense layer of intertextual references, in which high literature, pop culture, and religious texts coexist in a single stream of consciousness. These elements do not create harmony; on the contrary, they demonstrate the inner fragmentation of the protagonist. References to Hemingway, Ahmet Kaya, Sagopa Kajmer, and religious texts (Risale-i Nur) serve not as ornamentation, but as a means to highlight the cognitive dissonance between culture, religion, and reality, mirroring the character’s peripheral existence. This eclectic mix reflects the fractured identity of modern Turkish youth, torn between the traditional values imposed by the family (represented by religious texts), the intellectual escapism offered by Western literature, and the raw, rhythmic expression of angst found in rap culture. The protagonist's mind

becomes a battleground where these opposing forces collide, yet none offer a definitive solution to his alienation.

CONCLUSION

In conclusion, the analysis of Ethem Baran's Güzelliğini Gördükçe Ağlayasım Geliyor reveals it to be a cohesive artistic project dedicated to exploring the existential condition of the 'ordinary individual' in modern Turkey. Despite the diversity of plots, the narratives are unified by recurring motifs of alienation, temporal stasis, and the coercive pressure of family, state, and religious institutions. The collection essentially reifies the sentiment of Virginia Woolf's epigraph: the reader encounters not merely separate tales, but variations of a singular, fundamental narrative, the erosion of meaning and the desperate search for anchors in a world where social institutions have abdicated their humanistic functions.

The central figure of this artistic world is the 'peripheral subject', a person on the margins of social visibility. They are formally included in social structures (school, the labour market, religious communities) but are, in fact, deprived of access to their resources. In this context, the image of Sincan and other marginal spaces in Ankara takes on ontological significance: the geographical periphery becomes a metaphor for an existence devoid of a future, movement, and the possibility of transformation. Spatial isolation reflects the mental and social stagnation of the characters, for whom the world is reduced to a few routes, rituals, and repetitive days.

The internal fragmentation of the characters is expressed in the unique linguistic and intertextual structure of Baran's prose. In his stories, religious texts, Western literature, and contemporary pop culture coexist in a single stream of consciousness, forming fractured reality, but rather intensifying the sense of internal conflict. These cultural layers do not integrate the subject but reflect its fragmentation: between tradition and modernity, faith and skepticism, intellectual aspiration and social helplessness. Thus, intertextuality here becomes not a decoration, but a key tool for psychological and sociocultural analysis.

The gender structure of Baran's world complements this picture of alienation. Male characters find themselves prisoners of a lost or violent paternal authority, which shapes their feelings of inferiority, anger, and inner paralysis. Female characters, although present in the narrative, appear more often as figures of memory, desire, or unattainable salvation rather than as autonomous subjects. However, this asymmetry does not mean that one gender has privilege; on the contrary, both men and women exist within a field of systemic constraints where personal fulfillment is almost impossible.

Unrequited love, nostalgia, and the desire for recognition function as 'small meanings' that prevent the characters from being entirely consumed by the existential void, at the same time serving as vital forms of resistance. It is within this delicate tension between despair and hope that the humanistic resonance of Baran's prose resides.

Ultimately, Ethem Baran establishes himself as a profound chronicler of the Turkish periphery, both spatially and psychologically. His work captures a specific historical moment: one where institutional forms persist despite the erosion of their content, leaving individuals to confront a fragmented reality in isolation. This exploration of the tension between surface 'normality' and internal disintegration defines the philosophical core of Güzelliğini Gördükçe Ağlayasım Geliyor, securing its place as a significant contribution to 21st-century Turkish literature.

REFERENCES

Baran E 2021. Güzelliğini gördükçe ağlayasım geliyor. İletişim Yayınları.

Bora BE 2021. Ethem Baran'ın Yarım romanında ideleştiremeyen varlık olarak insan. Ankara Üniversitesi Dil ve Tarih-Coğrafya Fakültesi Türkoloji Dergisi, 25(2): 64-76.

Edebistan, 2026. Ethem Baran: Hayatı ve eserleri, Edebistan Öykücüler Sözlüğü. Available at: https://edebistan.com/oykuculer-sozlugu/ethem-baran [08.03.26]

Gürbilek N 2005. Yer değiştiren gölge: Taşra ve modernlik. Metis Yayınları.

Hassan BSH 2016. Ethem Baran'ın hikâyeleri üzerine bir inceleme. Yayımlanmamış Yüksek Lisans Tezi, Ankara Üniversitesi Sosyal Bilimler Enstitüsü.

Kurteş BE, Özdarıcı Ö 2023. Ethem Baran'ın Emanet Gölgeler Defteri romanında yabancılaşma. RumeliDE Journal of Language and Literature Studies, 37: 524-532.

NTV Sanat, 2022. Yazar Ethem Baran Sait Faik Hikâye Armağanı'nın sahibi oldu. NTV. Available at: https://www.ntv.com.tr/sanat/yazar-ethem-baran-sait-faik-hikaye-armaganinin-sahibi-oldu [08.03.26]

TOWARD INTERPRETABLE EVALUATION OF STRUCTURAL VARIANT BENCHMARKING TOOLS

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ABSTRACT

Structural variants (SVs) are key contributors to genetic diversity and have also been proven to be associated with a wide range of diseases. Benchmarking tools are required to provide quantitative estimates of the accuracy of SV detection pipelines. These tools typically rely on one or more parameters to quantify concordance between caller predicted variants and truth sets in order to classify true positives. Examples of parameters include: reciprocal overlap, variant type, and breakpoint distance. While these parameters are essential in detecting SVs, the thresholds applied are usually developer- or user-defined and often heuristic. As a result, benchmarking outputs cannot be interpreted as absolute or universally comparable measures of detection accuracy.

A major challenge in current SV benchmarking practice arises from the fact that identical query and truth callsets can yield substantially different evaluation outcomes depending on the comparison framework and its parameterization. A threshold that classifies a variant as “matching” in one tool may yield very different results in another, and adjusting parameter settings can substantially alter performance metrics. Also, existing benchmarking tools do not systematically detect these effects within their use cases. Importantly, these effects are intrinsic to the comparison frameworks themselves rather than to the underlying caller performance. As a consequence, this inconsistency complicates interpretation of benchmarking results, reduces reproducibility, and prevents meaningful comparison of results across studies.

In this study, we systematically formed parameter grids of multiple benchmarking tools using HG002 whole genome sequencing data with its high confidence truth set from GIAB. We observed

striking trade-offs how variants are classified as true positives or false positives across tools, even when evaluating the same callset against the same truth set. Together, these observations emphasize that SV benchmarking metrics are highly sensitive to parameterization and matching logic**,** and that apparent confidence can vary substantially across frameworks even when identical data are evaluated.

To improve analysis of benchmarking processes and to enable justified comparisons, we need to treat benchmarking tools as active components of the evaluation pipeline. A clearer understanding of their comparison logic and parameter dependencies is essential for reproducible benchmarking and for the meaningful interpretation of SV performance results across studies. This highlights the need for evaluation methodologies that can contextualize reported concordance by considering not only apparent agreement, but also the conditions under which such agreement arises, particularly in the presence of framework-specific matching behavior.

Keywords: Structural variants, benchmarking, thresholds, reproducibility, comparison

LONE WORKERS' RISK PERCEPTION AND SOCIAL INTEREST: AN ADLERIAN PSYCHOLOGICAL PERSPECTIVE

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ABSTRACT

Lone working, increasingly prevalent in modern professional life, refers to a form of work in which individuals operate independently of corporate hierarchies and are either physically or operationally isolated. This study aims to analyse the psychological dynamics, motivations, and existential challenges faced by individuals who work alone, using the fundamental concepts of Alfred Adler's Individual Psychology theory.

The Adlerian approach considers humans as indivisible wholes (individuum) and, by nature, social beings. From this viewpoint, working alone is not merely a physical situation but a teleological (purposeful) choice shaped by an individual's lifestyle and level of social interest.

The concept of 'social isolation,' defined as a significant risk factor for lone workers in Occupational Health and Safety (OHS) policies, has been evaluated in the context of 'social interest,' which Adler considered a fundamental measure of psychological health. According to Adler, a lack of social interest can lead the individual into neurotic introversion, while institutional policies aim to manage the physical and mental risks of this isolation. Secondly, through the concepts of 'inferiority complex' and 'striving for superiority,' the study examines whether individuals experience solitary work as an escape mechanism or as a sign of competence. The study relates the 'dynamic risk assessment' ability developed by lone workers to address external dangers such as 'aggression and violence' to 'perception of reality' and healthy defence mechanisms in Adlerian psychology. Furthermore, the principle of 'separation of duties,' adopted to escape tensions in interpersonal relationships, is analysed as a process of liberation for lone workers, freeing them from the desire for approval.

Our study argues that working alone is not pathological isolation but can be a healthy means of constructing a 'creative self' as long as the individual integrates both physical security measures (risk assessment) and psychological resilience (social interest). Consequently, the article emphasises that it is vital for lone workers to maintain their psychological resilience through institutional support mechanisms and to keep alive their sense of contribution to society in the Adlerian sense.

KEYWORDS: Individual Psychology, Alfred Adler, Lone Workers, Social Interest, Risk Assessment, Occupational Health and Safety

INTRODUCTION

In today's working life, particularly in home healthcare services, remote industrial operations, information work conducted in digital environments, and social services, it is rapidly becoming widespread (Yavorska et al., 2024). The Health Service Executive (HSE) defines lone working as ‘any situation where a person works without close or direct supervision, without a colleague nearby, or outside of sight or hearing distance’ (HSE, 2022). Current occupational health and safety frameworks recognise social isolation as a significant hazard, particularly in remote or high-risk environments, where being separated from colleagues, family, and professional networks can exacerbate stress, fatigue, and mental health issues.

Individual Psychology, founded by Alfred Adler, views the human being as an indivisible whole and explains an individual's behaviour in terms of future-oriented goals (teleology) rather than past causes (Aslan & Sarı, 2025). From an Adlerian standpoint, these conditions are not merely environmental; they interact with the individual’s lifestyle, level of social interest, and creative self, shaping how isolation is perceived and metabolised psychologically (Adler,1956; Chen and et al.,2017). This article examines lone workers’ risk perception, motives, and coping patterns through Adlerian concepts—social interest, inferiority feelings, striving for superiority, lifestyle, and the creative self—integrated with contemporary OHS research on isolation, fatigue, and safety behaviour.

MATERIALS AND METHODS

Our study is a theoretical-conceptual work that combines Adlerian Individual Psychology with empirical OHS and loneliness literature on workers who are isolated, both physically and psychologically. Adler conceptualised the human being as an indivisible, meaning-creating whole, fundamentally oriented toward social embeddedness and contribution (Sabates ,2020). Social interest represents the individual’s felt sense of belonging to the human community and willingness to cooperate for the common good; it is a central criterion of psychological health and maturity (Koleva,2020). Core Adlerian constructs—inferiority feelings, compensation, striving for superiority, and lifestyle—describe how people respond to perceived deficits and challenges (Aytekin,2023). Feelings of inferiority are universal and potentially growth-promoting; they motivate efforts toward competence and contribution. When responses become rigid, self-protective, or self-aggrandising, an inferiority complex and a neurotic style of striving for superiority over others may emerge. The lifestyle is the relatively stable pattern of perceptions, goals, and interpersonal strategies through which individuals pursue significance and safety; it is formed early but remains open to creative revision (Chorna,2023).

For lone workers, the choice or acceptance of solitary roles can reflect very different lifestyles. In some cases, this way of working can take on a socially beneficial quality, allowing the individual to perform at a high level in independent roles while maintaining psychological ties with their

environment and preserving a sense of cooperation. However, in some individuals, it can manifest as defensive behaviours, such as avoiding interpersonal conflict, developing a hostile indifference towards their environment, or withdrawing due to feelings of social failure, indicating a lack of social interest (Tan, 2019).

Lone Working, Isolation, And OHS: Empirical Context

OHS studies address working alone and remote working models within a framework that focuses on unique psychosocial and structural risks. Research conducted on offshore activities, remote industrial sites, the construction sector, and home working practices highlights the increased risk posed by factors such as stress, chronic fatigue, and violent tendencies, as well as limited access to emergency assistance mechanisms (Bentley et al., 2023).

For example, it has been found that social isolation and loneliness experienced at remote energy facilities (oil and gas) lead to mental exhaustion, which in turn weakens compliance with occupational safety and active participation processes, thereby increasing the likelihood of accidents (Alroomi & Mohamed, 2022). Similarly, healthcare personnel working in remote areas complain of geographical and occupational isolation, as well as a lack of academic or professional support networks; this increases employees' emotional stress and deepens role conflicts (Adams et al., 2019). At the same time, organisational factors such as safety climate, structured workplace assessments, and integrated psychosocial risk management systems significantly influence both physical safety outcomes and psychological wellbeing (Dahler-Larsen et al.,2020). Positive safety climate and resilience-focused interventions are associated with lower stress and better safety performance while OHS management systems that explicitly address psychosocial risks can prompt more systematic preventive action (Suseno et al., 2025).

Dynamic Risk Assessment and Adlerian Perception of Reality

Lone workers typically engage in continual, dynamic risk assessment—moment-to-moment appraisal and management of external hazards (e.g., violence, accidents, environmental threats) in the absence of immediate team support. Adler described perception of reality as filtered through lifestyle and private logic: individuals do not simply register facts but interpret them according to their goals, convictions, and relational expectations. In a healthy lifestyle grounded in social interest, risk perception is reality-based and flexible. Workers acknowledge danger without catastrophising, seek appropriate help, follow procedures, and integrate organisational safety practices into a cooperative stance toward self- and co-worker protection . Here, the creative self functions to coordinate perceptual, cognitive, and emotional processes toward socially useful problem-solving (Bhushan & Malaviya, 2023). Conversely, a discouraged or antagonistic lifestyle may distort risk perception. Those with pronounced feelings of inferiority and low social interest may minimise hazards to prove toughness, or exaggerate them to justify withdrawal and victimhood. Such patterns can amplify fatigue, errors, and unsafe behaviours, particularly under conditions of physical or social isolation. By linking dynamic risk assessment to Adler’s notion of guiding fictions and private logic, lone workers’ safety-relevant decisions can be understood as expressions of deeper convictions about self-worth, trust in others, and anticipated cooperation or exploitation. Institutional safety policies that address only surface behaviours without engaging these underlying meaning structures may therefore be ineffective.

Psychological Meanings of Working Alone

The OHS discourse positions social isolation primarily as an external risk factor, such as lack of supervision, limited interaction, and difficulty accessing emergency assistance. In contrast, the Adlerian approach deepens this definition by sharply distinguishing objective loneliness from subjective disconnection. According to this perspective, the fundamental problem is not physical distance but rather a lack of community spirit and social interest. Therefore, even if an individual works alone physically, they can establish an internal connection with their professional networks and community; conversely, even if crowds surround them, they may become trapped in their 'private logic' and adopt a defensive or distant attitude towards the outside world.

Current empirical data on remote work show that being part of professional networks and collaborative processes reduces stress, strengthens psychological resilience, and prevents maladaptive coping methods (such as uncontrolled internet use) that attempt to fill the void left by real connections. These findings are fully consistent with Adler's thesis that a sense of belonging and contribution acts as a protective shield against neurotic withdrawal. On the other hand, in organisational structures where psychosocial risks are ignored or trauma is normalised, an individual's resilience may weaken, and their worldview may evolve into pessimism and cynicism. Van Heerden and Naicker (2025) emphasise that individual competency training alone is insufficient to increase the resilience of lone workers; it is imperative to establish structural norms and systems that institutionalise social care.

Implications For Policy and Practice

Risk analysis protocols prepared for lone workers should go beyond physical and ergonomic factors to include psychosocial risks such as loneliness, role ambiguity and inadequate support systems. These assessment processes should be presented not as a 'control' mechanism that keeps the individual under control, but as a collective effort aimed at protecting both the employee and social welfare; this approach is fully in line with the 'shared responsibility' ethic emphasised by Adler. Institutional tools such as mentoring programmes, peer advisory groups, and regular feedback systems enable employees to feel part of a value-producing community despite their physical isolation. Therefore, interventions should nurture social interest by prioritising mutual assistance and shared purpose rather than confining the individual to 'isolated autonomy' (Peddie et al., 2025).

Resilience training and psychological screening, when embedded in a respectful, stigma-reducing culture, can enhance confidence and reduce errors among workers in high-risk, isolated environments. These initiatives are most consistent with Individual Psychology when they are linked to themes of courage, cooperation, and contribution, rather than to perfectionistic self-optimisation. Organisations should treat autonomy and separation of duties not merely as efficiency tools but as ethical responsibilities. Lone roles need clear task boundaries, accessible support channels, and participation in organisational decision processes, particularly around. Such design acknowledges the worker as a co-author of organisational life, in line with Adler's emphasis on democratic relationships and social equality (McCluskey,2022). Academic studies related to the subject are listed in Table 1.

Table 1. Review of the relevant literature

Author(s) (Year)	Research Context	Objective	Methodology	Key Findings
Suseno et al. (2025)	Occupational Health and Safety (OHS), Resilience	To evaluate resilience-focused interventions within OHS systems	Empirical evaluation study	Resilience-oriented interventions reduce stress and improve safety performance; psychosocial risk integration strengthens preventive action.
Van Heerden & Naicker (2025)	Remote and Isolated Work	To examine the role of social support and organizational inclusion	Empirical study	Perceived social support buffers stress, enhances resilience, and reduces maladaptive coping among isolated workers.
Peddie et al. (2025)	OHS Policy and Practice	To develop institutional support mechanisms for lone workers	Applied / Policy-oriented research	Mutual support structures and shared purpose reduce psychosocial risks more effectively than individual coping strategies alone.
Aytekin (2023)	Adlerian Individual Psychology	To analyse core Adlerian constructs (inferiority, compensation, striving)	Theoretical analysis	Inferiority feelings are universal and potentially growth-promoting; rigid compensation leads to neurotic striving for superiority.
Chorna (2023)	Lifestyle Theory (Adlerian)	To examine the formation and flexibility of lifestyle	Conceptual / Theoretical	Lifestyle forms early but remains open to creative revision through the individual's creative self.
Bentley et al. (2023)	Lone and Remote Work, OHS	To identify psychosocial and organizational hazards of lone work	Empirical field studies	Lone work increases risks related to fatigue, stress, violence, and lack of immediate support.
Bhushan & Malaviya (2023)	Adlerian Perception and Self	To explain the role of the creative self in risk perception	Theoretical	Healthy lifestyles enable flexible, reality-based risk perception and socially useful problem-solving.
Alroomi & Mohamed (2022)	Oil and Gas Industry, Remote Work	To investigate links between isolation, fatigue, and safety behaviour	Quantitative empirical study	Social isolation increases mental fatigue, undermining safety compliance and participation, leading to higher injury risk.
McCluskey (2022)	Adlerian Organizational Ethics	To explore democratic relationships and social equality in organizations	Theoretical	Treating workers as co-authors of organizational life strengthens social interest and ethical responsibility.
Koleva (2020)	Social Interest (Adlerian Psychology)	To define social interest as a marker of psychological health	Theoretical / Literature-based	Social interest is a central indicator of psychological maturity and mental health.
Sabates (2020)	Adlerian Individual Psychology	To conceptualize the human being as a holistic, meaning-making entity	Conceptual / Theoretical	Humans are indivisible wholes fundamentally oriented toward social embeddedness and contribution.
Tan (2019)	Lone Working and Personality	To explore psychological meanings of working alone	Empirical psychosocial study	Lone working may reflect socially useful striving or avoidant, hostile disengagement depending on lifestyle orientation.
Adams et al. (2019)	Remote Health Workers	To examine experiences of professional and geographical isolation	Qualitative interview study	Isolation intensifies emotional burden, role conflict, and limits access to peer consultation and education.

RESULTS

Research shows that social isolation and loneliness predict mortality, health-risk behaviours, and psychological distress. Workplace loneliness is linked to poor job performance, low commitment, and burnout (Holt-Lunstad et al.,2015). In Adlerian terms, absence of social interest—felt belonging and contribution—turns physical solitude into psychologically harmful isolation (Wax et al., 2022).

In remote oil and gas work, loneliness increases mental fatigue, which mediates reductions in safety compliance and participation; loneliness and social isolation also impair safety behaviour via anxiety and depression. Lone-worker risk tools emphasise dynamic risk assessment and organisational monitoring. Adler's "perception of reality" suggests that discouraged lifestyles distort threat appraisal, while a creative, socially oriented self supports realistic, cooperative risk management (Juárez-García et al., 2024).

Some forms of isolated or home-based work can buffer or exacerbate loneliness depending on autonomy and connection. Empirically, loneliness often co-occurs with gaps in support and desire for more participation, consistent with an inferiority-based withdrawal. Alternatively, where organisations provide a strong safety climate and support, autonomous roles can enhance responsibility and engagement, resonating with socially useful striving. Social support moderates links between risk perception and negative psychological effects among health workers. Safety climate and structured psychosocial risk management correlate with better safety behaviour and reduced stress. Adler's creative self, when embedded in cooperative structures, transforms lone working into a context for courageous contribution rather than neurotic isolation.

DISCUSSION

Empirical studies show that social isolation and loneliness are strong predictors of mortality risk, psychological distress and loss of functionality. However, these findings encompass not only the physical absence of others but also the individual's subjective sense of disconnection. This distinction aligns with Adler's approach, which argues that health is related not to constant physical contact but to an internal tendency that develops toward social interest, cooperation, and contribution to society.

For lone workers, the same objective condition (being alone) can thus take two forms:

Discouraged solitude: high loneliness, support gaps, and fatigue, associated with poorer safety behaviour and health. This reflects lifestyles shaped by feelings of inferiority, distrust, and avoidance.

Constructive solitude: autonomy embedded in supportive networks and a clear sense of usefulness. In this context, risk perception is grounded in reality; safety rules are internalised as a natural component of an individual's responsibility towards both themselves and others. Occupational health and safety research targeting those working in the oil and gas sector reveals how mental fatigue and psychological well-being shape the relationship between isolation and unsafe behaviours. From an Adlerian perspective, these mediating variables can be seen as reflections of a demoralising and maladaptive private logic that undermines courage and hinders collaborative participation (e.g., implicit beliefs such as "I am alone and unprotected" or "the rules have no meaning for me").

Individuals working alone must perform dynamic risk assessments by continually reviewing hazards under variable conditions. Empirical findings show that when isolation is combined with inadequate social support and increased psychological pressure, workers' levels of participation in safety and compliance with rules decrease significantly. Adler's concepts of "organ language" and

special logic suggest that such behaviours are the expression of a deeper, often unconscious narrative; this narrative can manifest as resilience, with the person disregarding rules at times, or as surrender to a state of passive helplessness at other times.

Corporate tools such as bow-tie analyses and rapid risk checklists can help externalise and correct distorted risk perceptions by making hazards and control mechanisms visible. When applied in a democratic and participatory manner, these tools foster social interest not only at the individual level but also at the organisational level; thus, security ceases to be a burden imposed from above and becomes a shared, jointly assumed responsibility.

Studies on loneliness and remote work in the workplace reveal that there are multi-layered, reciprocal interactions between autonomy and interpersonal relationships. Some employees, in line with Adler's neurotic forms of striving for superiority, may consciously choose to work alone in order to avoid perceived criticism or competition; this preference often serves as an avoidance strategy to protect fragile self-esteem. In contrast, some individuals use autonomy to deepen their capacity for mastery and service to others, which is a socially constructive orientation.

Empirical findings showing that those who work alone or in isolation demand more participation and support suggest that, for many people, working alone is less a freely chosen expression of competence and more a context that intensifies unmet relational needs. Therefore, occupational health and safety interventions that focus solely on individual coping skills, without addressing the need for a sense of belonging and recognition, may be insufficient for transforming underlying lifestyle patterns.

Research conducted in an organisational context shows that social support, safety climate, and perceptions of organisational justice both regulate risk perception and reduce the psychological effects of isolation. These findings align with Adler's emphasis on the need for education, working life, and social institutions to embody the principles of equality and cooperation. When organisations provide structured communication channels (regular feedback, monitoring mechanisms, and peer support networks), transparent safety policies, and participatory risk management processes, the creative selves of individuals working alone can align their personal goals with the collective good. In such an environment, autonomy does not imply abandonment; rather, it serves as a form of responsibility grounded in trust and allows solitary work to strengthen rather than weaken social engagement.

CONCLUSION

From an Adlerian perspective, working alone is not, in itself, a pathological condition. Empirical findings reveal that it is not solitude itself that is primarily associated with increased health risks, psychological strain and unsafe behaviour, but rather social isolation and the subjective experience of loneliness. Therefore, whether solitary work evolves into negative isolation or a form of developmental solitude depends on factors such as the worker's capacity for social engagement, the quality of support provided by the organisation, and the extent to which risks are perceived realistically.

Organisations integrating technical and physical risk management with social support mechanisms, a strong safety culture, and participatory risk assessment processes are an effective way to concretise social engagement at the organisational level. Under such conditions, individuals working alone can constructively use their autonomy to develop psychological resilience and build a contribution-oriented, creative self. Therefore, when supported by a sense of belonging, collaboration, and shared responsibility, working alone can become a healthy and sustainable way of life and work.

REFERENCES

Adams, M. E., Lazarsfeld-Jensen, A., & Francis, K 2019. The implications of isolation for remote industrial health workers. Rural and Remote Health, 19(2), 5008. https://doi.org/10.22605/RRH5001

Adler, A 1956. The individual psychology of Alfred Adler: A systematic presentation in selections from his writings (H. L. Ansbacher & R. R. Ansbacher, Eds.). Basic Books.

Alroomi, A., & Mohamed, S 2022. Does fatigue mediate the relation between physical isolation and safety behaviour among isolated oil and gas workers? Safety Science, 150, 105707. https://doi.org/10.1016/j.ssci.2021.105639.

Aslan, E., & Sarı, T 2025. Adler'in bireysel psikoloji yaklaşımı ve dezavantajlı durumlar: "Sınıfın Önünde" filminin analizi. Kocaeli Üniversitesi Eğitim Dergisi, 8(1), 227-247.

Aytekin, T., & Aytekin, H 2023. Alfred Adler'in bireysel psikoloji kuramı ve temel ilkeleri. Elektronik Cumhuriyet İletişim Dergisi, 5(1), 40–47. https://doi.org/10.54089/ecider.1167532.

Bentley, T. A., Caponecchia, C., Onnis, L.-A., Brunetto, Y., Farr-Wharton, B., Cattani, M., Neto, A., & Vassiley, A 2023. A systems model for the design of occupational health and safety management systems inclusive of work-from-home arrangements. Applied Ergonomics, 109, 103966. https://doi.org/10.1016/j.apergo.2023.103966

Bhushan, B., & Malaviya, R 2023. Safety management system for lone working person in industry. International Journal of Advanced Research in Science, Communication and Technology, 3(5).

Chen, Y., McCabe, B., & Hyatt, D 2017. Impact of individual resilience and safety climate on safety performance and psychological stress of construction workers: A case study of the Ontario construction industry. Journal of Safety Research, 61, 167–176. https://doi.org/10.1016/j.jsr.2017.02.014

Chorna, O 2023. Basic provisions of A. Adler's individual psychology: An analysis of modern meaning. Personality and Environmental Issues, 4.

Dahler-Larsen, P., Sundby, A., & Boodhoo, A 2020. Can occupational health and safety management systems address psychosocial risk factors? An empirical study. Safety Science, 130, 104878. https://doi.org/10.1016/j.ssci.2020.104878.

Health Service Executive (HSE) 2022. HSE Policy and Guidance on Lone Working (HSP:013:03). National Health and Safety Function.

Holt-Lunstad, J., Smith, T. B., Baker, M., Harris, T., & Stephenson, D 2015. Loneliness and social isolation as risk factors for mortality: A meta-analytic review. Perspectives on Psychological Science, 10(2), 227–237. https://doi.org/10.1177/1745691614568352.

Juárez-García, A., García Rivas, J., Arias Galicia, L. F 2024. Risk perception, psychological effects, and social support in health care workers with COVID-19 patients in Mexico. Revista Brasileira de Saúde Ocupacional, 49, e7. https://doi.org/10.1590/2317-6369/15722en2024v49e7

Koleva, N 2020. The concept of "social interest" in the paradigm of individual psychology. Diogenes, 28(1).

McCluskey, M. C 2022. Revitalizing Alfred Adler: An echo for equality. Clinical Social Work Journal, 50, 387–399.

Peddie, N., Hoegh, J., Rice, G., Shetty, S., Ure, A., & Cogan, N 2025. Health and social care professionals' experience of psychological safety within their occupational setting: A thematic synthesis review. Nursing Reports, 15(4), 131. https://doi.org/10.3390/nursrep15040131.

Sabates, A. M 2020. Individual psychology of Alfred Adler. In B. J. Carducci, C. S. Nave, & C. S. Nave (Eds.), The Wiley encyclopedia of personality and individual differences: Clinical, applied, and cross-cultural research (Vol. 1). Wiley. https://doi.org/10.1002/9781118970843.ch20.

Suseno, S. A., Ismarina, & Prihayati 2025. Integrating psychological resilience into fit-to-work protocols: A phenomenological study of mental health and safety among offshore workers in high-risk industries. International Journal of Social Health, 4(3), https://doi.org/10.58860/ijsh.v4i3.292.

Van Heerden, R., & Naicker, V 2025. Exploring remote work occupational health and safety perspectives: A theoretical review and synthesis. EUREKA: Social and Humanities, (1). https://doi.org/10.21303/2504-5571.2025.003704.

Tan, K. A 2019. The effects of personal susceptibility and social support on internet addiction: An application of Adler's theory of individual psychology. International Journal of Mental Health and Addiction, 17, 806–816. https://doi.org/10.1007/s11469-018-9872-4.

Wax, A., Deutsch, C., Lindner, C., Lindner, S. J., & Hopmeyer, A 2022. *Workplace loneliness: The benefits and detriments of working from home*. Frontiers in Public Health, *10*, 903975. https://doi.org/10.3389/fpubh.2022.903975.

Yavorska, O., Ikonnikov, M., Lantukh, D., Sushko, N., & Sosuliev, Ye 2024. Occupational risks assessment of lone workers. Journal of Donetsk Mining Institute.

TEACHING THE PHONEME /B/ IN PRIMARY EDUCATION THROUGH INTERACTIVE, MULTISENSORY, AND CULTURALLY RESPONSIVE ACTIVITIES

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ABSTRACT

Literacy development in early primary education requires effective instruction in phonemic awareness, a foundational predictor of later reading success. Phonemic awareness refers to the ability to recognize and manipulate the individual sounds of language and has been repeatedly shown to correlate with reading outcomes when systematically taught within meaningful literacy contexts. This study explores innovative instructional strategies for teaching the phoneme /B/ to first-grade students by integrating interactive, multisensory, and culturally responsive activities into classroom practice. Conducted in a rural school setting, the research involved a mixed-methods design combining teacher-led interventions with quantitative measures of phoneme recognition and qualitative observations of student engagement. Students participated in structured games designed to reinforce the /B/ sound and culturally contextualized tasks such as preparing traditional bakery items to create a multisensory and socially embedded learning environment. The interventions were framed within interactive literacy practices, which have been demonstrated to support oral language and phonemic awareness development in early grades. Results indicated statistically significant gains in phoneme identification, improved pronunciation accuracy, and enhanced active participation during literacy sessions. Teachers reported that the combination of playful learning, hands-on activities, and cultural relevance increased students' motivation and sustained attention. This research supports the integration of interactive and contextualized phonemic teaching practices as effective for fostering early literacy skills. Future studies should examine long-term effects across diverse educational contexts and expand the model to other phonemes and linguistic components.

Keywords: Phoneme Instruction, Early Literacy Development, Interactive Learning, Multisensory Activities, Culturally Responsive Teaching

EFFECTIVE CLASSROOM MANAGEMENT IN PRIMARY EDUCATION: A LITERATURE REVIEW

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ABSTRACT

Classroom management is a critical component for the effectiveness of the teaching process and the academic, social, and emotional development of students. This study presents a literature review on effective classroom management practices in primary education. The literature highlights key dimensions of classroom management, including discipline strategies, methods to enhance student engagement, organization of the learning environment, and the importance of teacher-student relationships. Research indicates that positive behavior support systems and structured classroom rules increase students' attention and motivation to learn. Additionally, interaction-based and student-centered approaches have been shown to strengthen collaboration within the classroom and enhance students' responsibility-taking skills. Literature also demonstrates that the proper use of technology and digital tools in classroom management supports learning processes and reduces teachers' management workload. Furthermore, differences between rural and urban educational settings are important factors for teachers to consider when selecting classroom management strategies. The findings emphasize that the most effective classroom management practices are directly linked to teacher consistency, the quality of teacher-student interaction, and the flexibility of the learning environment. In conclusion, effective classroom management goes beyond maintaining discipline; it requires a holistic approach that supports students' social and emotional development, increases their motivation, and optimizes the learning environment. Future research may focus on the long-term effects of classroom management strategies and conduct comparative analyses across different educational contexts.

Keywords: Classroom Management, Student Engagement, Discipline Strategies, Teacher-Student Relationships, Learning Environment

DIAGNOSIS, CONTROL, AND THERAPEUTIC TREATMENT PRACTICES OF MASTITIS IN LACTATING COWS – A REVIEW

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ABSTRACT

Mastitis occurs when there is inflammation in one or more of the four udder quarters in the lactating cow. The disease results into mammary tissue damage by pathogenic organisms leading to losses such as low milk yield, poor milk quality and early culling. The losses greatly affect the viability and profitability of the dairy farming venture. Routine diagnosis of the disease, early pathogenic detection, prompt treatment and reducing mastitis transmission are necessary.

Genetic selection and other mastitis preventive measures are suggested for the disease. Routine diagnosis of the disease is based on the subclinical and clinical forms. The treatment practices include antibiotic therapy, bacteriophage therapy, vaccination and probiotic. Continuous research on the disease prevention and treatment is necessary as new pathogens do evolve with time.

There should be continued research into the preventive and therapeutic methods for the prevention and treatment of bovine mastitis. Generally, governmental interventions in the formulation of policies and the provision of monitoring and surveillance controls and research facilities should be put in place to facilitate continuous advancement in mastitis management and treatment nationwide.

This write-up reviewed the diagnosis, control and treatment measures, that help in the management of mastitis in the lactating cows.

Keywords: Mastitis, lactating cows, effect on milk production, treatment measures, policy issues

INTRODUCTION

Mastitis was defined as the inflammation of the mammary gland which results in the alteration of the physical, chemical and bacteriological properties of milk and mammary gland tissues of the affected animal (Bhakat et al., 2020, Singh, 2022). In the lactating cow, bovine mastitis (BM) causes the inflammation of the udder, involving either the secreting cells of the mammary glands or connective tissues or both. Various researchers (Kumar et al.,2010, Deb et al.,2013) reported that a single disease of mastitis could be identified to lead to the isolation of more than 135 pathogenic organisms. Some of the most frequent pathogens that could be identified in the milk include *Streptococcus agalactiae*, *Staphylococcus aureus*, *Streptococcus dysgalactiae* and coliform bacteria in bovine mastitis cases. The factors resulting in losses would also result into high cost associated with mastitis preventive practices and therapeutic measures, decreased milk yield and early culling (Ajose et al., 2022).

Bovine mastitis is found to occur in a transmission cycle whereby the contagious pathogenic organism is transmitted to the host animal (Ajose et al., 2022), enhanced by unsanitary environmental conditions and poor nutrition of the dairy cattle on the farm settlement (see Figure 1). Furthermore, these researchers (Ajose et al., 2022), stated that BM could be caused by environmental pathogens and this is characterized by increased somatic cell count (SCC) in the

milk of the affected cows which result in milk wastage. Antibiotics has long been reported to be the first line preventive and treatment therapy for BM (Ajose et al., 2022), however, there had been the occurrence of antibiotic resistance in the host animal and the occurrence of antibiotic residues in the milk and meat of cattle. Khasapane et al. (2021) also stated that the cost implication of mastitis inflammation in the udder of the cow manifest during pre and post-infection and there could be reduced fertility rate and fast onset of culling of bovines (pre and post infection period).

The mastitis inflammation is also classified as subclinical (SCM) and clinical mastitis (CM) (Khasapane et al., 2021). The clinical stage is said to have occurred when there is much more visible inflammatory response in the udder and a swollen udder developed, clots and colour changes in the milk and signs of ill-health is observed such as reduced feed intake and dehydration of the cow (Mpatswenumugabo et al., 2017, Khasapane et al., 2021). The identification of mastitis-causing pathogens previously relied on time-consuming conventional methods, and not less than 48 hours was required to make a diagnosis which made the administration of treatment to be prolonged (Khasapane et al., 2021). However, the adoption of the use of the DNA-based polymerase chain reaction for instant detection of major mastitis-causing pathogens in milk was developed (Paraguison-Alili, 2014). Thereafter, there was the move into the use of molecular methods reported by Hegde (2011), which employed the rapid identification of bacterial pathogens such as *Staphylococcus aureus, E. coli* and other *Streptococci spp*. which cause sub-clinical mastitis. In this instance, there could be early detection of the SCM causing pathogens in the cows, which could also lead to early and prompt healing of cows and to return them back to the producing herd (Khasapane et al., 2021). In this review article is outlined, the current trends in BM management and therapeutic treatment measures in the dairy cattle production sector.

FACTORS RESULTING IN LOSSES AND ESTIMATIONS IN THE PREVALENCE OF BOVINE MASTITIS

The problem of BM could be initiated as an invisible issue which grows into an enormous financial damage (Singh, 2022) to the whole dairy cattle production sector. Singh (2022) mentioned that subclinical mastitis (SCM) affects milk yield, quality and the health of lactating cows. This researcher (Singh, 2022), further explained that bovine mastitis poses a threat to the food security of humans and public health and that the disease should be well tackled at the initial stage of the subclinical mastitis because ‘Prevention is better than cure’. Mastitis was also observed to be an ultimate threat to the dairy production sector resulting into both financial losses in the form of treatment cost and harmful impacts on public health (Ajose et al., 2022). These authors (Ajose et al., 2022) listed the various effect of bovine mastitis as mortality of dairy cows, high losses in the form of cost of medications, veterinary services, laboratory fees, and additional labour for the farmers. Other losses include incurred cost on account of lost milk, culling, deaths and treatment costs.

A study carried out in the North-west region of Nigeria by Amuta et al. (2021), reported that the majority of famers covered in their study considered clinical mastitis (CM) related milk production losses to be significant (55%). In Central India, losses in the value of milk and veterinary expenses as a result of the mastitis infection were found to be about 49 and 37% respectively (Sinha et al., 2014). In another research work carried out at the University of Glasgow, Khan and Khan (2006) stated that mastitis was predicted to cost the global dairy industry between USD 19.7 and 30 billion every year. Furthermore, bovine mastitis inflammation was associated with the cost of a shortening of the lactation length of the dairy cows. According to these authors (Khan and Khan, 2006), each affected animal’s lactation period was reduced by about 57 days, while other researchers (Seegers et al., 2003), also described in quantitative terms that the reductions in the mean milk output was 37 kg/cow per lactation. Clinical mastitis in dairy cows was observed (Khasapane et al., 2021) to

cause visible modification in the milk, such as milk clots and milk colour changes. It also resulted into a swollen udder and cow discomfort.

In an epidemiological triad (Ajose et al., 2022), the factors associated with bovine mastitis inflammation could be put as the host (lactating cow), the agent or pathogen and the environmental factor as shown in Figure 1.

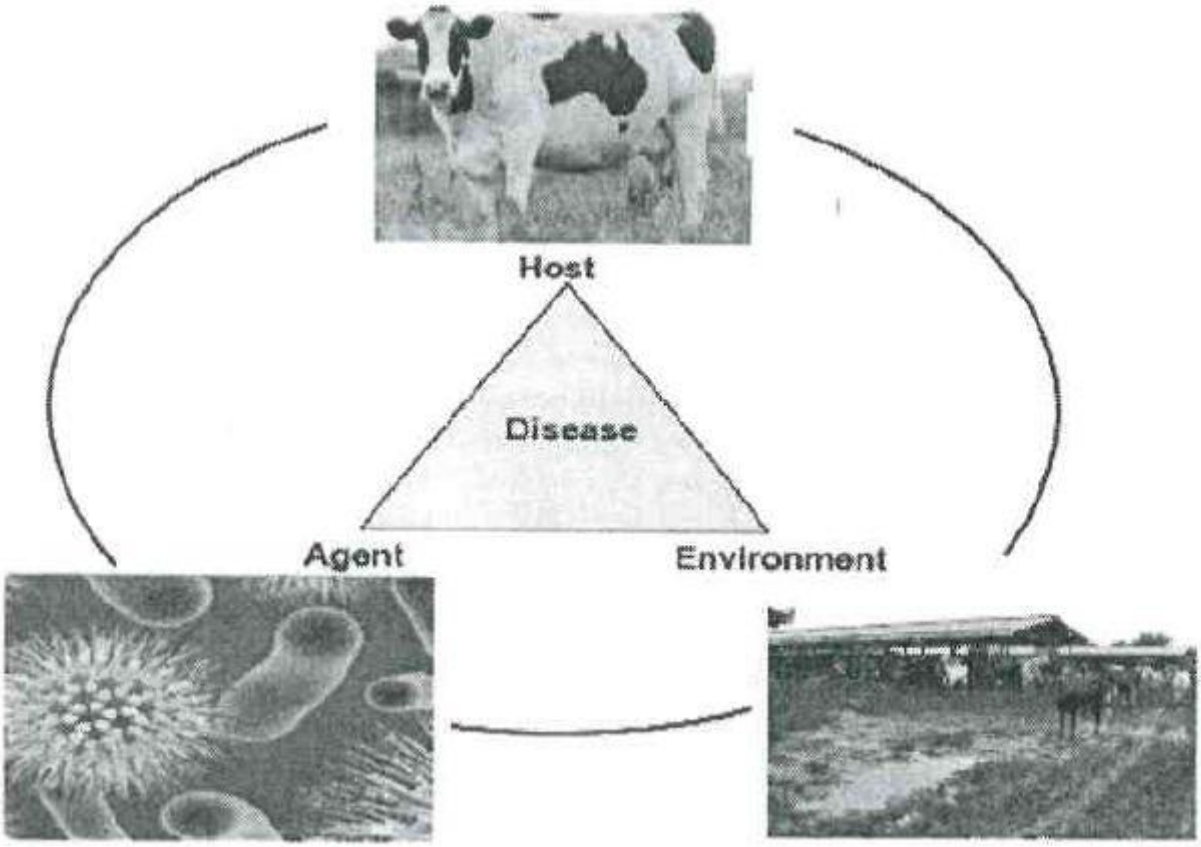


Figure 1. Epidemiological triad of bovine mastitis in the lactating cow; Source: (Ajose et al., 2022)

It was reported by Cheng and Han (2020) that the host animals such as the pure breed or cross breed of high yielding cattle of the Holstein-Friesian are more vulnerable to mastitis than the medium yielding breeds such as the Jersey cattle. It was also observed that multiparous cows were more susceptible to IMI such as mastitis than primiparous cows due to immune-incompetence (Shaheen et al., 2016). The older cows with larger sized teat and udder were observed to be at greater risk and more susceptible to sub-clinical mastitis (Waller et al., 2014). This was explained to be partly due to the fact that the older cows possessed wider opened teat canal resulting from frequent milking (Waller et al., 2014). *Staphylococcus aureus* is known to be the most prevailing gram-positive pathogen associated with clinical and sub-clinical mastitis (Vasudevan et al., 2003). This pathogen throve when the bovine mammary gland is inflamed due to improper hygiene during milking. The *Staph. aureus* pathogens produce degrading enzymes and toxins that irreversibly cause damage to the milk producing cells and this ultimately results into decreasing milk production (Vasudevan et al., 2003). The *Staph. aureus* pathogens have the ability to produce biofilms which are a cluster of bacterial cells which adhere the pathogen to the cell wall surface of the udder. Thus making it harder to treat such mastitis bacteria pathogens (Oliveira et al., 2011). The bacteria pathogen *E. coli* is also known to cause irreversible tissue damage in the bovine

mammary glands, resulting into total loss of milk production and sometimes could lead into the death of the dairy cow (Cheng and Han, 2020). The *Strep. agalactiae* is a gram positive pathogen that causes sub-clinical mastitis with high SCC and low milk production although no abnormalities may be observed in the milk (Cheng and Han, 2020). They form biofilm that enable them to adhere and persist in the mammary gland, causing nutrient deprivation to the host animal and enhancing resistance to its eradication (Kibebew, 2017). The *Mycopasma spp*. is also a mastitis causing pathogen which is less common than *Staph. aureus* and *Strep. agalactiae*. However, it can cause severe mastitis resulting into secretory cells and tissue damage and can also induce gland and lymphatic nodule fibrosis and abscesses (Kibebew, 2017). This pathogen also produces biofilm and invade the host cells and does not respond to antibiotic treatment (McAuliffe et al., 2006). The only effective control measure is doing regular monitoring of the affected cows and rapid segregation or culling of the affected cows (Nicholas et al., 2016). The provision of a clean, healthy and comfortable environment for the dairy cows can reduce the incidence and severity of bovine mastitis (Cheng and Han, 2020). On the contrary, high stocking density, contaminated floor, wet bedding, poor ventilation and hot humid climatic condition can enhance the spread of mastitis pathogens in dairy cow herd (Kibebew, 2017).

ADVANCES IN THE DETECTION, MANAGEMENT AND PREVENTION OF BOVINE MASTITIS

Antibiotics had been considered the first line of defense against bovine mastitis and other bacterial infections (Ajose et al., 2022). Antibiotic residues were found to occur in the milk and there has been the problem of antibiotic resistance. Thus various alternatives to conventional antibiotics and other medical treatments were adopted globally.

Diagnosis of bovine mastitis for hygienic milk production

a. Early diagnosis of BM for economic reasons
b. Early diagnosis of BM for public health concerns
c. Early diagnosis of BM as regards animal welfare issues

Distinction between sub-clinical and clinical mastitis

Subclinical form does not show any clinical signs of mastitis except for the observation of increases in somatic cell counts in the milk. Clinical form of mastitis however will show visible inflammatory changes in the udder tissues and blood stains in the milk. Ramuada et al. (2024) however mentioned that sub-clinically infected cows could serve as source of infection to susceptible animals in the herd, through the common use of infected milking equipments.

The global prevalence rates of subclinical (SCM) and clinical mastitis (CM) were given as 42 and 15% respectively (Ajose et al., 2022). Early diagnosis of BM is necessary for economic reasons (Sharun et al., 2021).

Some of the prevailing intrinsic factors which could be associated to the prevalence of bovine mastitis were listed as species, age, parity, suckling period, antiquity of health condition, environmental conditions and the milk handling conditions (Tekle and Berihe, 2016). In order to carry out the diagnosis of mastitis in the bovine, milk samples from the cows were screened for somatic cell counts (SCC) due to intra-mammary infection (IMI) and sent out to the laboratory for

further diagnostic tests and investigations. The diagnostic tests and investigations include conventional field tests such as the California mastitis test (CMT).

The California Mastitis Test (CMT)

This is a simple indicator test for estimating the somatic cell count (SCC) of milk. In this test, the DNA in the milk cells are made to react with the test reagent and this could result into the formation of a gel (equal amount of milk and reagent are mixed up). The reaction is then scored on a scale of 0 (zero) where the resulting mixture stays unchanged as compared to the score of 2 or 3 where there is a positive result and the mixture changes to form a solid gel. Thereby the prevalence of sub-clinical mastitis (SCM) is detected and this is then followed by the estimation of the SCC of the milk sample (Adkins and Middleton, 2018; Ajose et al., 2022).

Leucocyte Count

A district gel formation with a leucocyte count of 150, 000 - 500,000 mL^{-1} (1.5×10^5 - 5.0×10^5 mL^{-1}) denotes a negative test result; no mastitis infection-very good (Ajose et al., 2022). Count of 400,000 to 1,500, 000 mL^{-1} (4.0×10^5 to1.5×10^6 mL^{-1}) slight precipitate points to a weak positive result; slight mastitis infection. A district gel formation with a leucocyte count of between 8,000,000 and 5,000, 000, 000 mL^{-1} (8.0×10^5 to 5.0×10^9) shows a strong positive result; strong evidence of mastitis infection (see Table 1).

Table 1. Standards of somatic cell count (SCC) of bovine milk in California mastitis test (CMT) (Source: Ajose et al., 2022)

SCC mL^{-1}	Result	Quality of milk
150, 000 to 500,000 (1.5×10^5 - 5.0×10^5)	Negative test result (no gel formation)	High quality
400,000 to 1,500, 000 (4.0×10^5 - 1.5×10^6)	Weak positive result (slight precipitate)	Medium quality
8,000,000 to 5,000, 000, 000 (8.0×10^5 - 5.0×10^9)	Strong positive result (district gel formation)	Low quality

Somaticell Test

The somaticell test is used for the determination of somatic cell counts (SCC) of milk samples. It is a somatic cell counter (SCC) which is well packaged for easy portability. It could be used as initial pilot test for SCC in milk bulk tanks. It consists of a single-use graded plastic vial with a capped preset scale of SCC (Ryskaliyeva et al., 2018; Ajose et al., 2022).

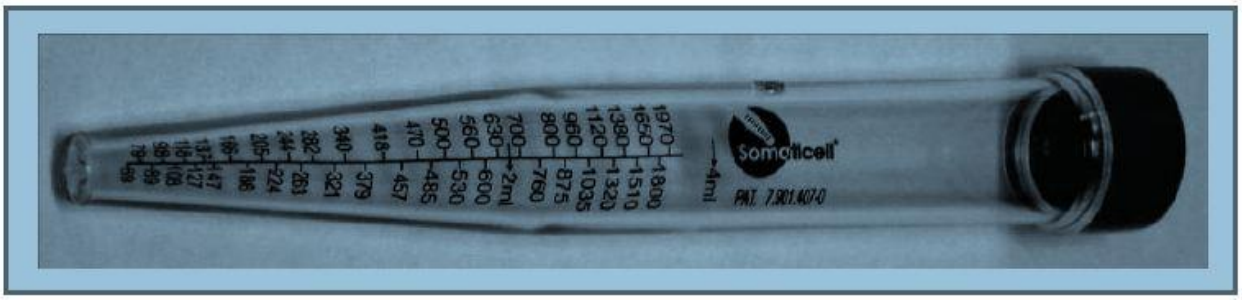


Figure 2. Somaticell test graduated vial of SCC readings; Source: (Ryskaliyeva et al., 2018)

Automatic digital diagnostic test techniques

These are newer testing techniques used to detect the incidence of mastitis in bovine and they determine the SCC (Ajose et al., 2022). They are very easy, fast and field applicable, and they include the DeLaval cell counter which is suitable for determining SCC and the use of magnetic nanoparticles. Magnetic nanoparticles are used for identifying *Staphylococci spp.* such as *Staphylococcus aureus*. It is a proteomic system which was used in diagnosing, preventing and predicating the presence of mastitis cells in the milk of camels (Ryskaliyeva et al., 2018). Other newer techniques include the sensor-based detection system which is usually employed on large farms for SCC (Ajose et al., 2022).

Polymerase chain reaction (PCR) based diagnosis

The PCR study was stated to employ the use of genotypic approach to support phenotypic identification of bovine mastitis pathogens (Ramuada et al., 2024). Polymerase chain reaction (PCR) based detection of mastitis milk samples are faster to conduct than culture based tests (Deb et al., 2013). They are able to detect multiple types of pathogens such as *Straphylococcus spp*., *Streptococcus spp.*, *Escherichia coli*., *Enterococcus* and *Arcanobactorium pyogenes* from mastitis milk samples using real time PCR based detection. However, PCR based instruments are very expensive (Deb et al., 2013). Since the PCR based assay is dependent on the DNA of an organism, it is able to function for live or dead organism but detects lower number of organisms at a time as compared to culture methods (Deb et al., 2013). The multiplex PCR based instrument is used in analyzing milk bacterial DNA to detect the pathogenic organisms in the milk (Khasapane et al., 2021). The multiplex PCR instrument was reported to be very suited for the diagnosis of multiple pathogens in bovine mastitis milk samples. Examples were the fastidious and untraced etiological pathogenic agents like *E. coli* (Amin et al., 2011). Again, the MPCR was found to be helpful in the identification of pathogens so as to obtain enough information about the causes of mastitis and to enable the implementation of appropriate control measures (Khasapane et al., 2021). The commercially available multiplex real-time PCR based technique, known as the Patho-Proof Mastitis PCR assay was introduced as a faster and highly accurate alternative to bacteriological culture (BC) by Mahmmod (2013). The assay has been found suitable for use under field conditions for the detection of different mastitis pathogens from milk samples. Such as in clinical, sub-clinical cases and on the quarter level, the cow level and the herd level Mahmmod (2013). It gives the SCC and helps the dairy advisor to make decision regarding the application of treatment or culling or resampling in the dairy animals affected by mastitis (Mahmmod, 2013).

Protocols in the prevention and control of bovine mastitis

After diagnostic tests have been made for the prevention of mastitis, biosecurity measure also needs to be put in place (Deb et al., 2013). In a research study by Ruegg (2017), it was reported from another earlier research paper (Neave et al., 1969) the results of field experiments that pointed to the importance of the application of full hygienic practices in modern mastitis control measures. These researchers, Neave et al. (1969) described field experiments that assessed the use of pre-milking teat disinfection with individual cow's towel, the wearing of milking gloves while milking, sanitation of teat cups and the evaluation of the use of post-milking teat dip.

In the journal paper written by Ruegg (2017), it was mentioned the formation of a National Mastitis Council (NMC) that was initiated in the United Kingdom (UK). This was chosen to develop a mastitis control program known as the "5-point plan" in the year 1969. This plan outlined the basis for the control of clinical mastitis in bovine. This included the following:

1. The practice of effective post-milking teat dipping.

2. The use of antibiotic dry cow therapy in every udder quarter at the end of each lactation period.

3. The adoption of the appropriate treatment in the clinical mastitis cases.

4. The regular culling of chronically affected cows.

5. Proper maintenance of the milking machine equipment to ensure it has a stable teat end vacuum.

The NMC however upgraded the 5-point plan to the NMC 10 point plan (Seaman, 2014).

Ten (10) point program to prevent and control heifer mastitis

Farm specific interventions that should be in place on any farm are:

1. Improve general udder health management at the farm level to decrease the pressure of infection with udder pathogens from older cows to heifers.
2. Control cross-suckling in calves and young stock.
3. Implement an effective and efficient fly control system.
4. Keep young and primigravid heifers in a clean and hygienic environment and separate from multiparous animals. Provide as much attention to this group of animals related to hygiene and cleanliness as spent on lactating animals.
5. Avoid any nutritional deficiency. Monitor vitamin E and selenium levels when any doubt exists, especially in relation to clinical mastitis. Zinc, copper and vitamin A play a role as well and could be checked if there is doubt.
6. Minimize the risk of negative energy balance before and after calving through appropriate transition feeding systems.
7. Reduce the incidence of udder edema through optimized peripartum management.
8. Minimize stress during calving (example by not moving heifers to the calving pen when already in labour and minimize incidence of dystocia and peripartum disease.
9. Consider use of internal sealants prepartum where there is a high risk of environmental mastitis in the peripartum period.
10. Use prepartum antibiotic treatment in heifers under certain conditions only;

- Under the supervision of the herd veterinarian within the context of a valid veterinary/client/patient relationship.

- After quantification of the problem and identification of major pathogens (not coagulase-negative staphylococci) as the cause through culturing.
- Choice of antibiotics should be based on antimicrobial susceptibility testing.
- Test for residues before every milk delivery.
- Upgrading of management at the same time:

Discontinue treatment as soon as a new management strategies become effective.

IMPORTANT BOVINE MASTITIS PREVENTION STRATEGIES

Genetic selection for mastitis resistance

In a review work carried out by Ruegg (2017), it was reported that as part of a pioneering work, Murphy et al. (1944) stated that heritable differences in IMI were seen to exist among cow families. In another early study carried out by Lush (1950), the inheritance of susceptibility to mastitis in cattle was reported. Early estimates of heritability of mastitis in cattle was reported to range from 0.27 to 0.38. However, not much work on selection for mastitis resistance was pursued by geneticists until the research of Shook and Schutz (1944) was reported. This research work revealed that genetic increases in milk yield were observed to be correlated with increased susceptibility to mastitis in lactating cows. Thus since that period, future innovations in genomic selection technologies were envisaged to be later on proposed to be used to accelerate genetic gains in resistance to mastitis in cattle.

In another review work, Sharun et al. (2021) affirmed that resistance to mastitis could be improved through genetic selection as it had been observed and reported that there was significant genetic variation between individual cows. In an earlier research report (Weigel and Shook, 2018), it was stated that the resistance to mastitis in bovine could be better improved upon by means of sire selection which results in long-term improvement of herd health.

Relationship between genetic selection for mastitis and nutrition

The incidence of sub-clinical and clinical mastitis is found to be high in cows that were raised with dietary deficiencies of selenium and vitamin E (Weiss et al., 1990). The researcher, Ruegg (2017) thus further explained that, the important roles of selenium and vitamin E in maintaining udder health is now well established and this knowledge has now contributed to the modification in the diets offered to lactating cows and has also impacted knowledge about neutrophil function and thus somatic cell counts (SCC). The ability of nutrients such as trace minerals like selenium, copper, zinc and vitamins like vitamin A or B-carotene, vitamin E were reported to positively affect udder health in cattle (O'Rourke, 2009). Selenium supplementation before calving in heifers, given through injection, reduced the incidence of sub-clinical mastitis (Ceballos-Marques et al., 2010). Injectable trace mineral supplement containing zinc, manganese, selenium and copper also lowered the occurrence of chronic clinical mastitis in dairy cows with lowered/improved SCC (Ganda et al., 2016).

The investigation of the role of dietary copper by some previous researchers (Scaletti et al., 2003) showed that the supplementation of copper in the diet decreased the incidence of *E. coli* bacterial count and the SCC (Scaletti et al., 2003) in commercial lactating dairy cows. A dietary combination of selenium and vitamin E was shown to improve resistance to mastitis through elevated levels of neutrophil and α-tocopherol which might have suppressed and prevented the intracellular killing of bacteria by neutrophils (Smith et al.,1997, Sharun et al., 2021). Sharun et al. (2021) also pointed out that in actual fact, adequate quantity of vitamin E is obtained through the intake of fresh grass

and grass silage, though supplementation may however be required in the diet of high milk producing cows reared intensively

Bobbo et al. (2019) stated that proper genetic selection of dairy animals based on morphological characteristics like udder development and functioning and production qualities such as milk yield and composition could have some relationship with SCC in milk and their selection could aid in the control and prevention of SCM. Also the practice of rotational grazing of lactating cows for periods of about 8 hours was reported do aid udder health and production performance in dairy cows, rather than continuous practice of the conventional barn feeding system (Lopez-Benavides et al., 2007).

ADVANCES IN THE BOVINE MASTITIS TREATMENT PRACTICES

Bovine mastitis is a disease that requires effective control program involving early detection of infection and a good understanding of the root cause or pathogenesis of the disease (Sharun et al., 2021). The farmer should aim at adopting preventive strategies. This is because some harm could be done in the animals that may not be completely cured thereafter (Ajose et al., 2022). Some of such defects include harm to the teat and teat canal and udder alveoli. Prior to the application of such treatment, the main cause of the udder inflammation could be ascertained and the causal agents identified. Defects in the teat or udder such as teat fistula, leaky teat, teat spider and udder wounds should be given urgent attention (Sharun et al., 2021).

Appropriate management of the udder health should be effected during the dry phase that precedes the next milking or lactation period (Sharun et al., 2021). The dry-off-treatment could involve the antimicrobial dry cow therapy (Sharun et al., 2021). This is said to be effective at this point in time as the medication is not milked out during this period (Sharun et al., 2021). The treatment of bovine mastitis is stated to be based primarily on the application of antibiotics even though other more recent development could involve the use of other alternatives to antibiotic therapy such as probiotics and herbal therapy (Sharun et al., 2021).

Antibiotic therapy

Antibiotic could be used to prevent intra-mammary inflammations in non-lactating cows and also to manage mastitis infection in lactating cows (Zdunczuk and Janowski, 2020). Antibiotics are most times used as preventive measure during the dry phase in the form of dry cow therapy. Prophylactic measure is thus effected in the lactating cow at subclinical mastitis stage. It was outlined that the selection of antibiotics for the treatment of clinical mastitis should be based on past record of incidence, etiology and antibiotic sensitivity profile (Sharun et al., 2021). There should be the *in vitro* sensitivity testing to detect the causal organism for effective antibiotic therapy (Awandkar et al., 2009). In many instances the examined mastitis bacterial pathogen may be insusceptible to the antibacterial drug being applied. Such drugs could include cephalexin, neomycin, penicillin and streptomycin. Drawbacks in antibiotic usage were pointed out as follows; with the emergence of antibiotic resistance, the selection of antibiotics for treatment should be based on the culture and sensitivity results rather than simple therapy (Tiwari et al., 2013). Another negative effect of antibiotic therapy is the formation of antibiotic residues in milk which could be detrimental to the health of consumers (Gomes and Henrique, 2016). These mean that there should be observance of strict maintenance of withdrawal period of antibiotics in order to minimize post treatment effects in humans that consume the milk. Milk isolates from cows with clinical mastitis showed antibiotic resistance to drugs such as penicillin, chindamycin and cefotaxime (Sharun et al., 2021). However, some previous researchers (Oliver and Murinda, 2012), had explained that although extensive use of antibiotics for prevention of mastitis could contribute to resistance and

antibiotic residues in milk, the advantages of the use of the antibiotics were more important than the disadvantages.

Some of the factors that determine the successful use of antibiotics against mastitis included the microbe types, udder environment and milking type (machine/hand milking) (Sharun et al., 2021). The use of antibiotics plus the addition of non-steroidal anti-inflammatory drugs was found to result to lower SCC, reduced milk yield losses, improved clinical outcomes, and reduced cutting rates as compared with antibiotic therapy alone (McDougall et al., 2009).

In *E. coli* mastitis, non-steroidal anti-inflammatory drugs were reported to be effective in the management of clinical mastitis (Suojala et al., 2013). *Staphylococcus aureus* was reported to be one of the most serious etiological agents that cause clinical mastitis. This was attributed to its peculiar pathogenesis, contagiousness, environmental persistence, skin or mucosal colonization, and the poor response to current therapeutic agents (Rainard et al., 2018).

How antibiotics function

Antibiotics inhibit the following functions in the infective agents: cell wall synthesis, nucleic acid synthesis, ribosome function, cell membrane function and folic acid metabolism inhibition to mention a few (Ajose et al., 2022). Antibiotics are mainly used in cows for the prevention and treatment of mastitis (Ajose et al., 2022). Beta-lactam antibiotics or penicillin G and macrolides (erythromycin), are generally known to be effective for the management of bovine mastitis (Angelpoulou et al., 2019). There should be *in vitro* sensitivity testing of the causal organism in order to propose adequate treatment of mastitis (Ajose et al., 2022). These research workers (Ajose et al., 2022), further explained that bacterial isolation and antibiotic sensitivity tests are always needed to be carried out for effective treatment of bovine mastitis.

Challenges of antibiotic adulteration in the human diets

Milk and also meat made impure with antibiotics can result into some alterations in the microbial composition in the digestive system of humans (Ajose et al., 2022). These could cause the growth of antibiotic resistant bacteria strains in the general public (Ajose et al., 2022). Moreover, the bacteria strains that are resistance to antibiotics such as *S. aureus* and live intracellularly within the udder of lactating cows and cause sores in the udder are difficult to treat. Such bacteria as *Staphylococcus aureus* when treated with generally accepted antibiotics as pirlimycin showed a cure rate of just about 10-30% (O'Rouke, 2009, Ajose et al., 2022), since these pathogens were observed to have developed resistance to antibiotic treatment. In this respect, the WHO (2017) had issued restriction on the use of antimicrobials in food producing animals such as the lactating cows. Mastitis causing bacteria could also be zoonotically transmitted from bovine to humans (Maity and Ambatipudi, 2021).

Bacteriophage therapy

It was outlined by Sharun et al. (2021) that the treatment of biofilm forming bacteria such as *Staph. aureus* and *Strep. agalactiae* is quite challenging due to their resistance against conventional antibiotics. Thus other modes of therapy need to be employed for the successful elimination of such etiological agents. Bacteriophages are a group of viruses that possess the ability to infect and kill bacteria (Tiwari et al., 2014). They have high potential to replicate exponentially, to target and destroy specific bacterium and thus could be used against pathogenic bacteria (Carson et al., 2010). Some bacteriophages had been identified for use against *Staph. aureus* (Dias et al., 2013) and

against *E. coli* (Porter et al., 2016). Dias et al. (2013) reported that the isolated bacteriophages possess qualities such as thermo-stability and high lytic potential which made them effective for use in the treatment of biofilm forming bacteria. However, modification such as the use of a phage cocktail instead of a single bacteriophage was thereafter implemented (Sharun et al., 2021).

Vaccination

Vaccination of cows could be perceived as a preventive mastitis treatment. Most vaccines were produced to target *Staph. aureus, Strep. agalactiae* and *E. coli.* Some researchers (Deb et al., 2013, Ismail, 2017) reported that vaccines produced to target *Staph. aureus*, *Strep. agalactiae* consisted of either the whole organism (inactivated, high encapsulated or un-encapsulated cells and attenuated vaccines) or submits (toxins), bacterial surface extract, and crude extract of polysaccharides); while for *E. coli,* the mutant core antigen J5 was employed. However, various researchers (Ruegg, 2017, Cheng and Han, 2020) have testified that vaccines have not yet been proved to be effective enough to provide reliable protection for cows from developing new intra-mammary infections particularly in bovine mastitis cases. Varying degrees of vaccine efficacies were observed and these were attributed to the multi-etiological nature of the bovine mastitis inflammation. In a field trial, some research workers (Hogan et al., 1992) demonstrated the efficacy of *E. coli* core antigen vaccine. However, Cheng and Han (2020) deduced that regardless of the type of vaccine developed, vaccination alone is not effective in preventing mastitis, especially in dairy herds that have high mastitis rates. Vaccination needs to go hand in hand with other control measures such as hygienic milking, antibiotic treatment, infected cow culling and so on, so as to minimize the incidence and duration of mastitis cases (Schukken et al., 2014). Cheng and Han (2020) however stated that in future it will be necessary to find a vaccine that is able to protect against a wide range of strains of bacteria. This is because multiple strains could be found within a herd as well as within an individual cow. Such vaccines would also need to be available and affordable.

Probiotics

Probiotics are various feed supplements which inhibit growth of mastitis pathogenic organisms, an example of which is the lactic acid bacteria. Probiotics were reported to possess the capacity to prevent and treat bovine mastitis in dairy cows (Sharun et al., 2021, Humayun Kober et al., 2022). There are several microorganisms that have the ability to act as probiotics however the lactic acid bacteria were found to be the major group of probiotic organisms (Sharun et al., 2021). Previous researchers (Pellegrino et al. 2017, Yu et al. 2017, Rainard and Foucars, 2018) mentioned that lactic acid bacteria could provide protection against mastitis infections through their use as feed supplements, teat dip and intra-mammary inoculation due to the fact that they have immunomodulatory activity. This implied that lactic acid bacteria have the ability to colonize the udder and prevent mastitis by forming a protective biofilm in the udder cells. This biofilm inhibits the growth of mastitis causing pathogenic organisms in the udder of the cow (Wallis et al., 2018). The incorporation of lactic acid bacteria as a probiotic in the feed of the dairy cows acts against the bovine mastitis causing pathogens (Pellegrino et al., 2017).

The three major strains of lactic acid bacteria that were observed to invade the bovine mammary epithelial cells were *Lactobacillus brevis* 1595, *L. brevis* 1597 and *L. plantarum* 1610, while other 165 pathogens were also isolated from the sampling of the teat canal. It was found that the use of the teat dip which consists of the novel probiotic lactobacilli-based teat disinfectant was observed to be of superior quality as compared to the ordinary commercial disinfectant in reducing SCC in the milk of bovine (Yu et al., 2017). It was also mentioned in another research work (Humayun

Kober et al., 2022) that immune-biotic lactic acid bacteria could be used as an efficient immuno-biotechnological tool to help in the control of anti-microbial resistance in the dairy cows. This could also ultimately result into the development of the drug independent healthy production of dairy cows (Humayun Kober et al., 2022). Thus in general, probiotics have the capacity to improve resistance to bovine mastitis in the dairy cows.

Other alternative therapeutic modalities

In the comprehensive review work of Yu et al. (2025) is again outlined other alternative therapeutic approaches including the herbal therapy (Ajose et al., 2022), bacteriocins and nanoparticle therapy. These also possess distinctive therapeutic potential. They were also mentioned to have potential for reducing antibiotic dependence and enhancing prevention of mastitis in dairy animals.

FORMATION OF GOVERNMENTAL RESEARCH LABORATORIES AND POLICY ISSUES ON BOVINE MASTITIS GLOBALLY

Prudent use of antibiotics with great awareness and proper scientific basis for the reduction in antibiotic use, backed by the legal requirement for judicious use of antibiotics should be maintained. At the same time, maintaining a low cost in the treatment of mastitis and still maintaining the potential benefits of antibiotic use were suggested (Doehring and Sundrum, 2019). Therefore, there is the need for continuous monitoring of antibiotic resistance of major bacteria pathogens causing mastitis, and also to encourage judicious antibiotic use in bovine (Sharun et al., 2021). Thereby keeping in view the high cost of mastitis disease treatment and the potential treatment benefit.

Government research laboratories need to be formed in individual countries worldwide to enhance advancements in bovine mastitis treatment and control. This should go along with the employment of skilled and trained laboratory technicians and personnel to carry out testing for disease cases in the dairy cow industry.

CONCLUSIONS AND RECOMMENDATIONS

Mastitis is a disease that is of great economic importance in the dairy cattle industry. The continuous advancement in mastitis control is required for sustainable development in the dairy cattle industry globally. The current trends in bovine mastitis management and treatment measures include early diagnosis of subclinical and clinical mastitis cases and the adoption of good management practices and therapeutic measures. Strategies such as routine diagnosis, early and rapid identification or detection of etiological agents are necessary. Therapeutic regimes such as antibiotic therapy, bacteriophage therapy, vaccination, probiotics, nutritional, dry cow and lactation therapy, genetic selection, PCR based diagnosis and nanoparticle technology-based therapy were discussed.

There is need for the observance of biosecurity protocols such as pre and post milking teat disinfection, use of antibiotic dry cow therapy, the adoption of appropriate treatment in the clinical mastitis cases, the practice of regular culling of cows and proper monitoring and maintenance of the milking equipment.

There should be continued research into the preventive and therapeutic methods for the prevention and treatment of bovine mastitis. Generally, governmental interventions in the formulation of policies and the provision of monitoring and surveillance controls and research facilities should be put in place to facilitate continuous advancement in mastitis management and treatment.

Government extension services practitioners could also be involved in the conduct of scheduled training and awareness champagnes for dairy cow farmers in both the developed and developing countries on matters arising on the mastitis disease monitoring and surveillance control. Beneficial information on bovine mastitis could also be transmitted through journal article publications and Dairy Global News Magazines produced and distributed worldwide.

REFERENCES

Adkins PRF, Middleton JR 2018. Methods for diagnosing mastitis. Veterinary Clinical of North American Food and Animal Practice, 34: 479-491.

Ajose DJ, Oluwarinde BO, Abolarinwa TO, Fri J, Montso KP, Fayemi OE, Aremu AO, Ateba CN 2022. Combating bovine mastitis in the dairy sector in an era of antimicrobial resistance. Ethno-veterinary medicinal option as viable alternative approach. Frontiers in Veterinary Science, 9 (800322): 1-15.

Amin AS, Amouda RHH, Abdel-ALL AAA 2011. PCR assays for detecting major pathogens of mastitis in milk samples. World Journal Dairy Food Science, 6:199-206.

Amuta PO, Okolocha EC, Kudi CA, Gates MC 2021. Assessing the perceptions and practices of peri-urban dairy farmers regarding bovine mastitis management in North-Western Nigeria. Preventive Veterinary Medicine, 194:105442.

Angelpoulou A, Warda AK, Hill H, Ross RP 2019. Non- antibiotic microbial solutions for bovine mastitis-live biotherapeutics, bacteriophage, phage lysins. Critical Reviews in Microbiology, 45:564-580.

Awandkar SP, Khode NV, Sardar VM, Mendhe MS 2009. Prevalence and current antibiogram trend of mastitis agents in Udgir and its vicinity, Maharashtra State, India. International Journal of Dairy Science, 4:117-122.

Bhakat C, Mohammad A, Mandal DK, Mandal A, Rais S, Chatterjee A, Ghosh MK, Dutta TK 2020. Readily usable strategies to control mastitis for production augmentation in dairy cattle: A review. Veterinary World, 13 (11): 2364-70.

Bobbo T, Roveglia C, Penasa M, Visentin G, Finocchiaro R, Cassandro M 2019. Genetic relationships of alternative somatic cell count traits with milk yield, composition and udder type traits in Italian Jersey cows. Animal Science Journal, 90 (7): 808-817.

Carson L, Gorman SP, Gilmore BF 2010. The use of lytic bacteriophages in the prevention and eradication of biofilms of *Proteus mirabillis* and *Escherichia coli*. FEMS Immunological Medicinal Microbiology, 59 (3): 447-455.

Ceballos-Marques A, Barkema HW, Stryhn H, Wichtel JJ, Neumann J, Mella A, Kruze J, Espindola MS, Wittwer F 2010. The effect of selenium supplementation before calving on early-lactation udder health in pastured dairy heifers. Journal of Dairy Science, 93 (10): 4602-4612.

Cheng WN, Han SG 2020. Bovine mastitis: risk factors, therapeutic strategies, and alternative treatments – A review. Asian-Australasian Journal of Animal Sciences, 33(11): 1699-1713.

Deb R, Kumar A, Chakraborty S, Verma AK, Tiwari R, Dhama, K, Singh U, Kumar S 2013. Trends in diagnosis and control of bovine mastitis: A review. Pakistan Journal of Biological Sciences, 23:1653-1661.

Dias RS, Eller MR, Duarte VS, Pereira AL, Silva CC, Mantovani HC, Oliveira LL, Silva EdeAM, DePaula SO 2013. Use of phages against antibiotic-resistant *Staphylococcus aureus* isolated from bovine mastitis. Journal of Animal Science, 91(8): 3930-3939.

Doehring C, Sundrum A 2019. The informative value of an overview on antibiotic consumption, treatment efficacy and cost of clinical mastitis at farm level. Preventive Veterinary Medicine, 165:63-70.

Ganda EK, Bisinotto RS, Vasquez AK, Teixeira AGV, Machado VS, Foditsch C, Bicalho M, Lima FS, Stephens L, Gomes MS, Dias JM, Bicalho RC 2016. Effects of injectable trace mineral supplementation in lactating dairy cows with elevated somatic cell counts. Journal of Dairy Science, 99 (9): 7319-7329.

Gomes F, Henriques M 2016. Control of bovine mastitis: old and recent therapeutic approaches. Current Microbiology, 72 (4): 377-382.

Hegde R 2011. Rapid identification of bacterial pathogens causing subclinical bovine mastitis with special reference to *Staphylococcus aureus*, *Escherichia coli* and predominant *Streptococcal species* by molecular methods (doctoral dissertation). Bidar: Karnataka Veterinary, Animal and Fisheries Sciences University, pp. 1-11.

Hogan JS, Smith KL, Todhunter DA, Schoenberger PS 1992. Field trial to determine efficacy of an *Escherichia coli* J5 Mastitis vaccine. Journal of Dairy Science, 75:78-84.

Humayun Kober AKM, Saha S, Islam MA, Rajoka MSR, Fukuyama K, Aso H, Villena J, Kitazawa H 2022. Immunomodulatory effects of probiotics: A novel preventive approach for the control of bovine mastitis. Microorganisms, 10 (2255):1-17.

Ismail ZB 2017. Mastitis vaccines in dairy cows: Recent developments and recommendations of application. Veterinary World, 10:1057-1062.

Khan M, Khan A 2006. Basic facts of mastitis in dairy animals: A review. Pakistan Veterinary Journal., (26): 204 - 208.

Khasapane NG, Nkhebenyane JS, Kwenda S, Khumalo ZTH, Mtshali PS, Taioe MO, Thekisoe OMM 2021. Application of culture, PCR, and PacBio sequencing for determination of microbial composition of milk from subclinical mastitis dairy cows of smallholder farms. De Gruyter-Open Life Sciences, 16:800-808.

Kibebew K 2017. Bovine mastitis: A review of causes and epidemiological point of view. Journal of Biology Agriculture and Healthcare, 7:1-14.

Kumar A, Rahal, A, Dwivedi SK, Gupta MK 2010. Bacterial prevalence and antibiotic resistance profile from bovine mastitis in Mathura, India. Egypt Journal of Dairy Science, 38:31-34.

Lopez-Benavides MG, Williamson JH, Pullinger GD, Lacy-Hulbert SJ, Cursons RT Leigh JA 2007. Field observations on the variation of *Streptococcus uberis* populations in a pasture-based dairy farm. Journal of Dairy Science, 90 (12): 5558-66.

Lush JL 1950. Inheritance of susceptibility to mastitis. Journal of Dairy Science, 33:121-125.

Mahmmod J 2013. The future of PCR Technologies in diagnosis of bovine mastitis pathogens. Advances in Dairy Research, 2:1 (1000e 106). http://dx.doi.org/19.4172/2329-888X.1000e

Maity S, Ambatipudi K 2021. Mammary microbial dysbiosis leads to the zoonosis of bovine mastitis: a one-health perspective, FEMS Microbiology Ecology, 97: 24-31.

McAuliffe I, Ellis RJ, Miles K, Ayling RD, Nicholas RA 2006. Biofilm formation by *Mycoplasma species* and its role in environmental persistence and survival. Microbiology, 152:913-922.

McDougall S, Parker KI, Heuer C, Compton CW 2009. A review of prevention and control of heifer mastitis via non-antibiotic strategies. Veterinary Microbiology, 134 (1/2): 177-185.

Mpatswenumugabo JP, Bebora LC, Gitao GC, Mobegi VA, Iraguha B, Kamana O, Shumbusho B 2017. Prevalence of subclinical mastitis and distribution of pathogens in dairy farms of Rubavu and Nyabihu districts, Rwanda. Journal of Veterinary Medicine, 2017: 8456713.

Murphy JM, Pfau KO, Lepard OL, Bartlett JW 1944. Comparison of the incidence of udder infection and mastitis in two cow families. Cornell Veterinary, 34:185-192.

Neave FK, Dodd FH, Kingwill RG, Westgarth DR 1969. Control of mastitis in the dairy herd by hygiene and management. Journal of Dairy Science, 52:696-707.

Nicholas RA, Fox IK, Lysnyansky I 2016. Mycoplasma mastitis in cattle: To cull or not to cull. Veterinary Journal, 216: 142-147.

O' Rourke D 2009. Nutrition and udder health in dairy cows: A review. Ireland Veterinary Journal, 62(34) S15-S20.

Oliveira M, Bexiga R, Nunes SF, Vilela CI 2011. Invasive potential of bio-film forming *Staphylococci spp.* bovine subclinical mastitis isolates. Journal of Veterinary Science, 12:95-97.

Oliver SP, Murinda SE 2012. Antimicrobial resistance of mastitis pathogens. Veterinary Clinic of North American Food and Animal Practice, 28(2): 165-185.

Paraguison-Alili R 2014. Multiplex polymerase chain reaction for simultaneous detection of major mastitis-cuasing pathogens in buffalo milk. Research, 1 (784) :1 – 5.

Pellegrino M, Berardo N, Giraudo J, Nader-Macias MEF, Bogni C 2017. Bovine mastitis prevention: Humoral and cellular response of dairy cows inoculated with lactic acid bacteria at the dry-off period. Beneficial Microbes, 8:589-596.

Porter J, Anderson J, Carter J, Donjacour E, Paros M 2016. *In Vitro* evaluation of a novel bacteriophage cocktail as a preventative for bovine coliform mastitis. Journal of Dairy Science, 99(3): 2053-2062.

Rainard R, Foucras G 2018. A critical appraisal of probiotics for mastitis control. Frontiers in Veterinary Science, 5 (251):1-13.

Rainard P, Foucras G, Fitzgerald JR, Watts JL, Koop G, Middleton JR 2018. Knowledge gaps and research priorities in *Staphylococcus aureus* mastitis control. Trans-bound Emerging Diseases, 65:149-165.

Ramuada M, Tyasi TL, Gumede L, Chutura T 2024. A practical guide to diagnosing bovine mastitis: A review. Frontiers in Animal Science, 5 (1504873):1- 16.

Ruegg PL 2017. A 100-Year review: Mastitis detection, management, and prevention. Journal of Dairy Science, 100:10381-10397.

Ryskaliyeva A, Henry C, Miranda G, Faye B, Konuspayeva G, Martin P 2018. Combining different proteomic approaches to resolve complexity of the milk protein fraction of dromedary, Bactrian camels and hybrids, from different regions of Kazakhstan. P*L*oS ONE, 0197026.

Scaletti RW, Trammell DS, Smith BA, Harmon RJ 2003. Role of dietary copper in enhancing resistance to *Escherichia coli* mastitis. Journal of Dairy Science, 86 (4): 1240-1249.

Schukken Y, Bronzo V, Locatelli C 2014. Efficacy of vaccination on *Staphylococus aureus* and coagulase-negative *Staphylococci spp*. intrammamary infection dynamics in two dairy herds. Journal of Dairy Science, 97:5250-64.

Seaman AA 2014. 10-point plan for heifer mastitis prevention and control. Progressive Dairy Weekly Digest (September 30, 2014) http://www.agproud.com>articls>22391-a-10-point Accessed June 20, 2023.

Seegers H, Fourichon C, Beaudeau F 2003. Production effects related to mastitis and mastitis economic in dairy cattle herds. Veterinary Research, 34: 475-91.

Shaheen M, Tantary H, Nabi S 2016. A treatise on bovine mastitis disease and disease economics, etiological basis, risk factors, impact on human health, therapeutic management, prevention and control strategy. Advances in Dairy Research, 4 (1): 1-10.

Sharun K, Dhama K, Tiwari R, Gugjoo MB, Iqbal Yatoo M, Patel SK, Pathak M, Karthik K, Khurana SK, Singh R, Puvvala B, Amarpal, Singh R, Singh KP, Chaicumpa W 2021. Advances in therapeutic and managemental approaches of bovine mastitis: A comprehensive review. Veterinary Quarterly, 41 (1): 107-136.

Shook GE, Schutz MM 1994. Selection on somatic cell score to improve resistance to mastitis in the United States. Journal of Dairy Science, 77:648-658.

Singh AK 2022. A comprehensive review on subclinical mastitis in dairy animals: Pathogenesis, factors associated, prevalence, economic losses and management strategies. CAB International Reviews, 17, No. 057: 1-16.

Sinha MK, Thombare N, Mondal B 2014. Clinical mastitis in dairy animals: incidence, economics and predisposing factors. Scientific World Journal, 523984.

Smith KL, Hogan JS, Weiss WP 1997. Dietary vitamin E and selenium affect mastitis and milk quality. Journal of Animal Science, 75 (6): 1659-1665.

Suojala L, Kaartinen L, Pyorala S 2013. Treatment for bovine *Escherichia coli* mastitis-an evidence-based approach. Journal of Veterinary Pharmacology Ther., 36 (6): 521-531.

Tekle Y, Berihe T 2016. Bovine mastitis: prevalence, risk factors and major pathogens in the Sidamo Zone SNNPRS, Ethiopia. European Journal of Bio-medical Science Research, 4:27-43.

Tiwari R, Chakraborty S, Dhama K, Rajagunalan S, Singh SV 2013. Antibiotic resistance an emerging health problem: Causes, worries, challenges and solutions-a review. International Journal of Current Research, 5(07): 1880-1892.

Tiwari R, Dhama K, Chakraborty S, Kumar A, Rahal A, Kapoor S 2014. Bacteriophage therapy for safeguarding animal and human health: A review. Pakistan Journal of Biological Sciences, 17(3): 301-315.

Vasudevan P, Nair MKM, Annamalai T, Venkitanarayanan KS 2003. Phenotypic and genotypic characterization of bovine mastitis isolates of *Staphylococcus aureus* for biofilm formation. Veterinary Microbiology, 92:179-185.

Waller KP, Persson Y, Nyman AK, Stengarde L 2014. Udder health of beef cows and its association with calf growth. Acta Veterinary (Scandinavia), 56 (9) : 1-8.

Wallis JK, Kromker V, Paduch JH 2018. Biofilm formation and adhesion to bovine udder epithelium of potentially probiotic lactic acid bacteria. AIMS Microbiology, 4(2): 209-224.

Weigel KA, Shook GE 2018. Genetic selection for mastitis resistance. Veterinary clinics: Food Animal Practice, 34 (3): 457-472.

Weiss WP, Hogan JS, Smith KL, Hoblet KH 1990. Relationships among selenium, vitamin E, and mammary gland health in commercial dairy herds. Journal of Diary Science, 73: 381-390.

World Health Organization (WHO), 2017. WHO Guidelines on use of medically important antimicrobials in food producing animals. WHO, 2017 at https://apps.who.int/iris/bitstream/handle/10665/258970/9789241550130-eng.pdf.

Yu J, Ren Y, Xi X, Huang W, Zhang H 2017. A novel lacto-bacilli-based teat disinfectant for improving bacterial communities in the milks of cow teats with subclinical mastitis. Frontiers in Microbiology, 8 (1782) 5:25.

Yu W, Zhang Z, Wang Z, Lin X, Dong X, Hou Q 2025. Comprehensive prevention and control of mastitis in dairy cows: From etiology to prevention. Veterinary Sciences, 12 (800): 1-42.

Zdunczyk S, Janowski T 2020. Bacteriophages and associated endolysins in therapy and prevention of mastitis and metritis in cows: current knowledge. Animal Reproductive Science, 218:106504.

AN EXAMINATION OF TWIPLOMACY, THE NEW TREND IN THE DIGITAL WORLD

DİJİTAL DÜNYANIN YENİ TRENDİ TWİPLOMASİ ÜZERİNE BİR İNCELEME

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Özet

Günümüz dünyasında teknoloji bir yumuşak güç unsuru olarak birçok fırsatlar yaratmaktadır. Klasik diplomasinin dijital kanallar üzerinden diyalog oluşturularak gerçekleştirilmesi olarak ifade edilen dijital diplomasi de bu fırsatların en etkili olanlarından biridir. Sosyal ağlardan Twitter kullanılarak yabancı kamuoylarının kalplerinde ve zihinlerinde yer edinme çabaları olarak görülen bu yeni trend Twiplomasi olarak adlandırılmaktadır.

Devletler, hükümet dışı organizasyonlar, diğer ülkelerin kamularıyla iletişim ve bilgi aktarımı süreçlerini dijital diplomasi ve dolayısıyla dijital mecralar yardımıyla yapmaktadır. Dijital diplomasi krizlerin önlenmesi ve risklerin azaltılmasını sağlayan bir yöntem olup, amacı hedef kitlelere değil, hedef bireylere hitap etmektir. Yumuşak güç, kültür diplomasisi ve ülke markalaşması gibi konular önemli uygulama alanlarıdır.

Bu eksende dijital diplomasi teknolojik dönüşümün bir çıktısı olarak kamu diplomasisi çerçevesinde bir araç kullanılmaktadır. Günümüzde isteyen birey içerik üreticisi olabilmektedir. Bu nedenle özellikle kriz durumlarında devletlerin dış politika ile ilgili konularda çok hızlı şekilde hareket etmeleri, dezenformasyona engel olmak amacıyla bilgilendirme ve bilgiyi yayma görevini başka odaklara bırakmadan bu işlemi kendileri yapmalıdır. Bu noktada dijital diplomasi en işlevsel araç olarak karşımıza çıkmaktadır. Dijital diplomasi sayesinde çok geniş kitleleri çok hızlı bir şekilde bilgilendirilerek krizlerin önüne geçilebilmekte, mevcut krizler durdurulabilmektedir. Bu bağlamda çalışmanın amacı, dijital dünyanın yeni trendi Twitter aracılığıyla yapılan ve dijital diplomasi olarak tanımlanan twiplomasi ve bu alanda dünyadan ve Türkiye'den uygulama örnekleri içerik analizi yöntemiyle incelenmiştir.

Anahtar Kelimeler: Twiplomasi, dijital diplomasi, Twitter, sosyal ağlar, kamu diplomasisi

ABSTRACT

In today's world, technology creates many opportunities as an element of soft power. Digital diplomacy, defined as the implementation of classical diplomacy through dialogue via digital channels, is one of the most effective of these opportunities. This new trend, seen as efforts to gain a place in the hearts and minds of foreign publics using the social network Twitter, is called Twiplomacy.

States and non-governmental organizations communicate and exchange information with other countries' public sectors through digital diplomacy and, consequently, digital channels. Digital diplomacy is a method that prevents crises and reduces risks, aiming to address target individuals rather than target audiences. Important areas of application include soft power, cultural diplomacy, and country branding.

In this context, digital diplomacy is used as a tool within the framework of public diplomacy as an outcome of technological transformation. Today, any individual who wishes to do so can become a content creator. Therefore, especially in crisis situations, states must act very quickly on foreign policy issues and carry out the task of informing and disseminating information themselves, without leaving it to other entities, in order to prevent disinformation. At this moment, digital diplomacy emerges as the most functional tool. Through digital diplomacy, large audiences can be informed very quickly, preventing crises and halting existing ones. In this context, the aim of this study is to examine twiplomacy—defined as digital diplomacy conducted via Twitter, the new trend in the digital world—and application examples from around the world and Turkey in this field, using content analysis methods.

Keywords: Twiplomacy, digital diplomacy, Twitter, social networks, public diplomacy

DECODİNG RAİNFALL DRİVERS: A SHAP-SUPPORTED MACHİNE LEARNİNG APPROACH

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ABSTRACT

Consistent delivery of clean drinking water depends on accurate precipitation forecasts. Daily precipitation forecasts rely on the ability to accurately forecast precipitation based on environmental conditions. In order to understand how the environment affects daily precipitation five machine learning models; Linear Regression, Random Forest, Support Vector Regression, Multilayer Perceptron, and XGBoost were developed and compared using precipitation forecasts from NASA POWER and R^2 and RMSE metrics. The results of these five models indicated that the Multilayer Perceptron model produced the most accurate precipitation forecasts with an R^2 value of 0.77 and an RMSE value of 2.39mm. By utilizing SHAP Summary Plots to evaluate the relative contributions of the input variables to the model's precipitation forecasts, it was determined that the three most important input variables to the model's precipitation forecasts were air temperature, specific humidity, and shortwave solar radiation. Using correlation heat maps and residual plots to determine bias in the model, the authors demonstrated that by developing and interpreting machine learning models for hydrologic applications and utilizing NASA POWER to supplement or replace historical precipitation measurements at locations where precipitation data does not exist, researchers may develop improved methods to estimate precipitation. Additionally, this research introduced a new technique for combining the output of multiple precipitation models through visual evaluation.

Keywords: rainfall estimation, nasa power, machine learning, feature importance, interpretable ai, hydrological modelling

INTRODUCTION

The ability of accurately predicting rainfalls is of paramount importance for both hydrology and climate risk models. However, due to ground based gauges' limitations, there is a necessity of relying on remote sensing datasets such as NASA POWER which has shown its potential for the hydrologic modeling.

In addition to enabling the development of non-linear regression models such as Random Forest (RF), Multilayer Perceptron (MLP), Support Vector Regression (SVR) and XGBoost, which can be used to describe the complex relationship between the environment and rainfalls, machine learning advances also allow for the use of “black box” models that can achieve high levels of accuracy with little feature engineering. These models however lack interpretability.

Post-hoc methods such as SHAP (SHapley Additive exPlanations) address this issue by providing a method to quantify the contribution of each feature to the decision-making process of the model and therefore provide a bridge to link predictive capability with scientific knowledge.

Studies validate reanalysis data: Zouré et al. (2023) on surface runoff; Darman et al. (2024) on NASA POWER suitability; Nkiaka et al. (2016) on precipitation accuracy; McClean et al. (2023) on flood risk; and Zhu et al. (2019) on multi-source data combinations.

Hybrid models enhance predictions: Pham et al. (2019) integrated RF and LSSVR; Van Phong et al. (2023) used CatBoost for flood maps; Chen and Moraga (2024) applied SHAP to LSTM for dengue; Fan et al. (2023) used Explainable ML for reservoirs; Vinta and Peeriga (2024) used XGBoost; Antonio et al. (2024) post-processed forecasts with Generative ML; and Hassan et al. (2023) reviewed ML rainfall forecasting.

Küllahcı and Altunkaynak (2023) demonstrated that combining wavelet transforms with ML algorithms significantly increases forecast accuracy for time-series data.

XAI potential in hydrology is evident: Tian et al. (2023) used interpretable LSTMs for runoff; Wang et al. (2025) used ensemble deep learning; Mushtaq et al. (2022) interpreted streamflow simulations; Esirge and Beyaz (2022) forecasted intensity; He et al. (2023) applied SHAP to RF; Appiah-Badu et al. (2021) studied ecological zones; Hsu et al. (2024) compared RF and CatBoost; and Patro and Bartakke (2024) used LSTM.

Broader research emphasizes explainability: Duckworth et al. (2024) for hypoglycemia; Katsekpor et al. (2024) analyzing data discrepancies; Zhu et al. (2021) on long-term hydrology; Koteshwaramma and Singh (2025) on cyclone datasets; Nakkazi et al. (2022) on discharge modeling; and Lyu and Yong (2025) on high-resolution estimation. Fundamental XAI components were examined by Cavique (2024), Cheng et al. (2022), Althoff et al. (2021), Muddamsetty et al. (2022), and Kamath and Liu (2021).

This study uniquely associates NASA POWER with SHAP-compatible ML to address interpretability, and This provides answers to the three questions: (1) Is it possible to use Machine Learning to reproduce the nonlinear processes of rainfalls? (2) Are there predictors that are consistently selected? (3) Does SHAP provide evidence of validation of the decisions made by the "black box" models? The study validates the decisions made by the Machine Learning models with respect to the hydrologic principles using limited data in semi-arid environments.

MATERIALS AND METHODS

Study area and data source

Data were obtained from NASA's POWER for Konya, Turkey (37.8746° N, 32.4932° E), a semi-arid region. The 20-year dataset (2001-2020) provides daily meteorological data at approximately 0.5° resolution, derived from GEOS and MERRA-2. Selected atmospheric indicators serve as predictors for daily rainfall. The dataset (.xlsx) includes over 8000 daily records.

Data uncertainty assessment

The NASA POWER dataset (derived from MERRA-2) is valuable for data-scarce regions. As a gridded product (~0.5° resolution), it entails uncertainties compared to point-based gauges due to spatial averaging, parameterizations, and retrieval algorithms. The framework acknowledges these potential systematic biases while utilizing the dataset.

Model uncertainty and assumptions (conditionality statement)

Modelling results are subject to uncertainty and assumptions. First, models utilized default or minimally tuned hyper-parameters (except MLP's maxiter) to ensure standardization; additional tuning could alter performance. Second, stationarity of statistical relationships (2001-2020) is assumed. Finally, a full quantitative uncertainty analysis was not undertaken. Results must be interpreted within these structural limitations.

Feature selection and preprocessing

Candidate predictors included: T2M (°C), QV2M (kg/kg), PS (kPa), WS10M (m/s), ALLSKY_SFC_SW_DWN (W/m²), RH2M (%), T2MDEW (°C), and PRECTOTCORR (kg/m²). Rows with missing values were removed without imputation. The continuous rainfall target was not binarized. Predictors were standardized using StandardScaler to ensure zero mean and unit variance, optimizing models like SVR and MLP.

Model selection

Five supervised regression models were selected based on algorithmic variety: • Linear Regression (LR): A statistical baseline. • Random Forest (RF): A decision tree ensemble using random sampling. • Support Vector Regression (SVR): A non-linear kernel-based model. • Multilayer Perceptron (MLP): A feedforward ANN with back-propagation. • XGBoost: An optimized gradient boosting implementation. Models were implemented in Python (scikit-learn, xgboost) using default settings, except MLP (max_iter = 1000) to ensure convergence. Default parameters were maintained to standardize performance comparison and SHAP Analysis, ensuring interpretability assessments remained unaffected by hyperparameter variations.

Model evaluation metrics

The dataset was divided into a Training set (80% of the data) and a Testing set (20% of the data), with the samples randomly assigned to each set. Random separation was selected as opposed to chronological separation due to the assumption that relationships between the predictor variables were stationary during the time span of the dataset (2001-2020). Model accuracy was assessed using Root Mean Squared Error (RMSE) and R-squared (R^2).

Explainability via SHAP

SHAP (SHapley Additive exPlanations) values were calculated to interpret model predictions using specific explainers:

Tree-based (RF, XGBoost): TreeExplainer.

Linear (LR): LinearExplainer.

MLP and SVR: KernelExplainer.

SHAP values represent the marginal impact of each input variable at the sample level, providing local interpretations that enable global summaries via feature importance lists and violin plots.

Visualization and diagnostic tools

A variety of plots were used in order to visually verify the performance of the models and also interpret them:

Actual vs. Predicted Rainfall - Figure 1: Scatter plot of five different models (LR, RF, SVR, MLP and XGBoost), versus actual rainfall (represented by black dots). The scatter plot is a way of evaluating the models' performance over the entire range of rainfall data. Also, it shows the ability of the models to accurately represent the peaks of the rainfall and general trend.

Correlation Heat Map - Figure 2: Displays Pearson Coefficients in a heat map format to show the correlation between pairs of predictors (e.g. Solar Radiation and Temperature). This is useful for determining which predictors are redundant and may have a negative impact on the model training process or on the determination of feature importance.

SHAP Summary Plots - Figures 3-6: Show the contribution of each feature to the overall output of the models.

Figure 3 - LR Model: Features a relatively small range of SHAP and very little non-linearity; temperature and radiation are the dominant features.

Figure 4 - MLP Model: Displays strong evidence of non-linear relationships in the SHAP values for GWETTOP, QV2M and solar flux. There are positive and negative SHAP values.

Figure 5 - RF Model: Features clustered SHAP values with interaction terms for RH2M, PS and radiation features due to their structure as a tree based model.

Figure 6 - XGBoost Model: Features the largest range of SHAP values and the strongest evidence of non-linear relationships. Consistently, GWETTOP and RH2M are found to be the two most significant contributors to the model's output.

RESULTS

Model performance evaluation

The prediction capabilities of five algorithms—MLP, XGBoost, Random Forest, SVR, and Linear Regression—were evaluated using R^2 (variance explained) and RMSE (error magnitude). According to Table 1, MLP is the superior model, achieving the largest R^2 (0.773) and smallest RMSE (2.39 mm).

Table 1. Performance Metrics of the Selected Machine Learning Models

MODEL	R^2	RMSE
MLP	0.773	2.387
XGBoost	0.689	2.795
RandomForest	0.633	3.037
SVR	0.541	3.398
LinearRegression	0.444	3.738

MLP was able to model non-linear, multidimensional relationships that could be represented as a complex relationship of many variables through several layers. In Figure 1, how closely the observed data match the predictions made by each of the models is presented.

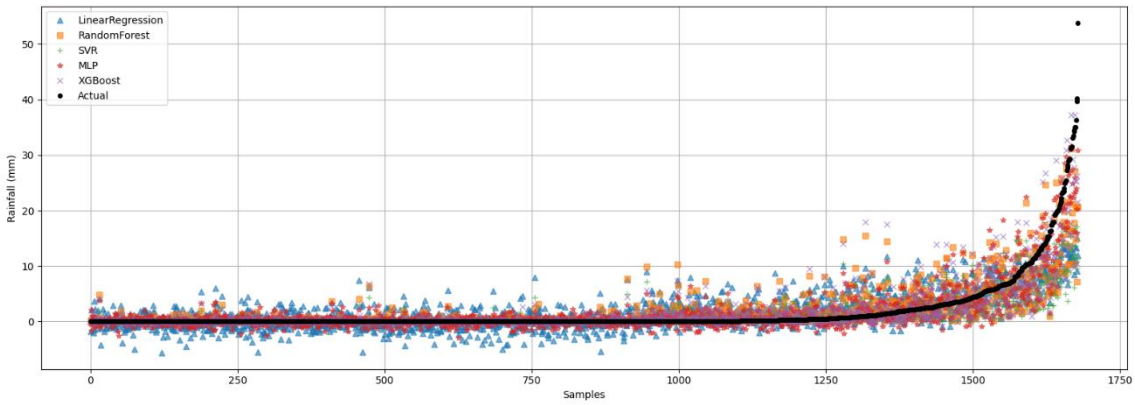


Figure 1. Actual vs. Predicted Rainfall

Although the individual performance of MLP and XGBoost was different at each step, they were able to capture general trends and variability as well as extreme event behavior.

Variable relationships and shap interpretability

To better understand the internal dependencies among the input features, a correlation heatmap was constructed, as presented in Figure 2.

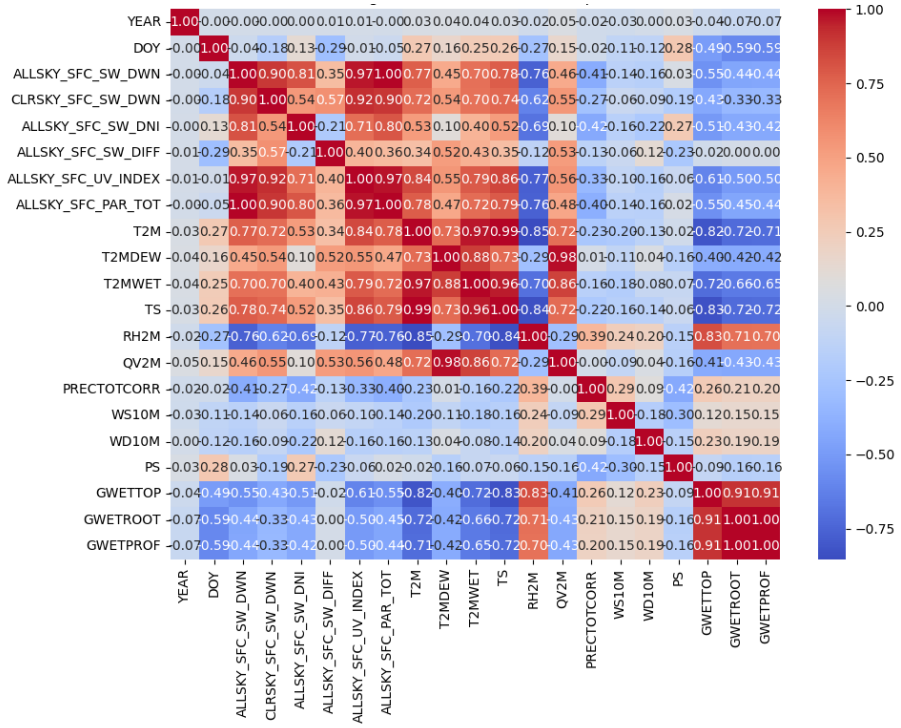


Figure 2. Correlation Heatmap of Input Variables

The relationship among the temperature-based features (T2M, T2MWET, TS), and the radiation-based features (ALLSKY_SFC_PAR_TOT, ALLSKY_SFC_SW_DWN) is extremely strong and redundant as seen in the correlation matrix (Pearson's r > 0.9), creating a high level of multicollinearity for all linear regression models. This creates instability in the coefficients, increases the variance in the coefficients, and results in a model that has both poor RMSE and R^2 performance. On the other hand, the non-parametric models (Random Forest, MLP, XGBoost) performed better than the others since they are less affected by multicollinearity and learn non-linear interactions using an implicit feature selection. Additionally, the SHAP analysis (Figure 3) provided additional diagnostic insight into the contributions of each feature. The horizontal bar in this plot indicates the strength of contribution to the overall model prediction value; the blue color gradient (blue = low, red = high) demonstrates the relative size of each feature used in the model predictions.

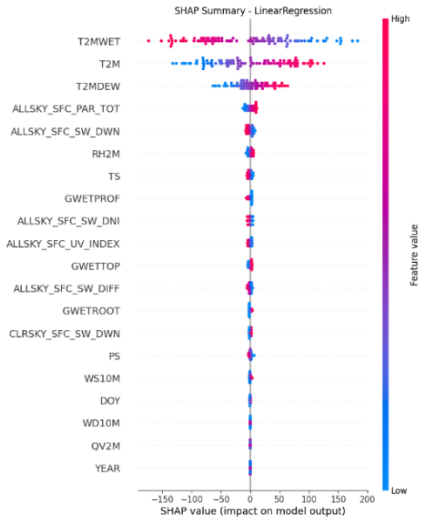


Figure 3. SHAP Summary Plot for the Linear Regression Model

The most relevant factors in a linear model of rainfall were temperature-related (e.g., T2MWET, T2M, T2MDEW) and radiation related (ALLSKY_SFC_PAR_TOT, ALLSKY_SFC_SW_DWN). These indicate that there is an association with precipitation. However, the importance of the features (and their SHAP values) indicates that multicollinearity may exist because two of the three most important features (T2MWET and T2MDEW) have high correlations, which can lead to unstable estimates of the coefficients for these features. The limited range of the SHAP values for GWETTOP, WS10M, and QV2M suggest that the model was unable to identify or model non-linear relationships between the features and rainfall. Conversely, Figure 4 provides a representation of the SHAP Summary Plot for the MLP, which clearly show non-linear transformations; the location on the x-axis of each data point corresponds to the magnitude of its influence on the model's output, and the color of each point corresponds to the feature value it represents (red = high, blue = low).

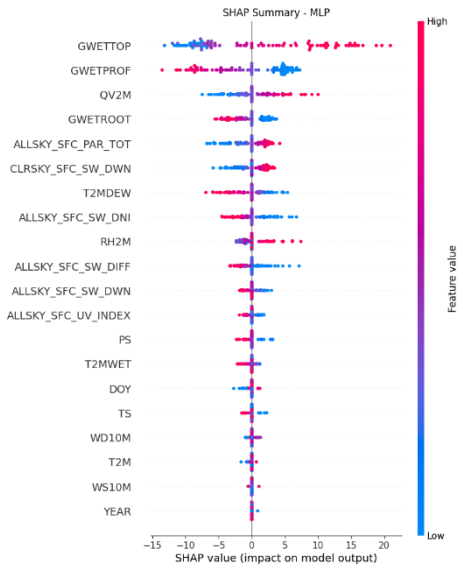


Figure 4. SHAP Summary Plot for the Multilayer Perceptron (MLP) Model

Relative to linear regression, the wide distribution of SHAP values from the Multi-Layer Perceptron (MLP) better described its ability to identify relationships among complex hierarchies of input variables; for example, GWETTOP, GWETPROF, and QV2M were able to link near-surface hydrologic conditions to precipitation, which is not possible using linear models. The MLP also identified ALLSKY_SFC_PAR_TOT as having a significant effect at larger scales, indicating that it had learned about energy exchange and cloud-radiative feedback mechanisms. Additionally, the asymmetry in the SHAP distributions (e.g. GWETTOP vs. RH2M) suggests that the MLP identifies non-linear thresholds and interaction effects. Overall, the results presented in Figure 4 demonstrate that the MLP was able to describe a much broader range of physical processes than the Random Forest model, and support the conclusion that the MLP's higher R2 and lower RMSE are due to the MLP's greater ability to understand these physical processes. Figure 5 shows the Random Forest SHAP summary with the largest values for RH2M, PS, and ALLSKY_SFC_SW_DNI showing the most influence and coherency during the decision tree splitting process.

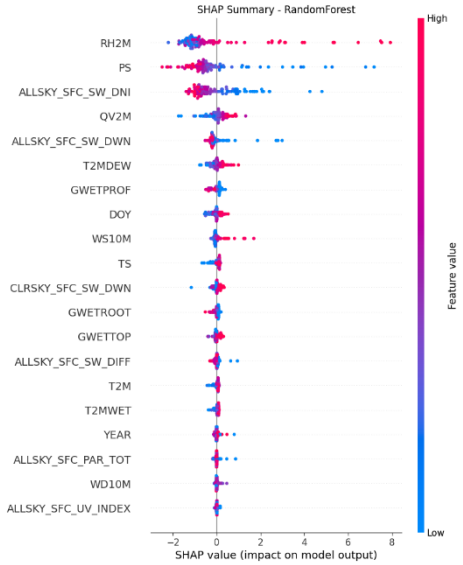


Figure 5. SHAP Summary Plot for the Random Forest Model

Random Forest found the presence of non-linear interaction in a number of factors which also indicates that there is a greater variance of SHAP values for RH2M than for any other factor suggesting that high levels of humidity will significantly increase the probability of rainfall and low levels of humidity will rarely do so. The same pattern holds for the surface pressure (PS). The two radiation features (SWDNI & SWDWN) were also highly significant and suggest that the model was sensitive to the level of atmospheric stagnation as well. The moisture variables (QV2M, T2MDEW), soil moisture (GWETPROF, GWETROOT) show the models ability to be driven by both atmospheric and sub-surface indicators. Random Forest had the greatest influence from multiple factors and was more robust to multicollinearity than either SVR or Linear Regression. In general, Figure 5 illustrates that RF has successfully integrated surface and radiative variables through the process of ensemble partitioning. Figure 6 illustrates the top three features identified by XGBoost (GWETTOP, RH2M, and GWETROOT) supporting its use of both atmospheric and terrestrial signals to enhance predictive performance.

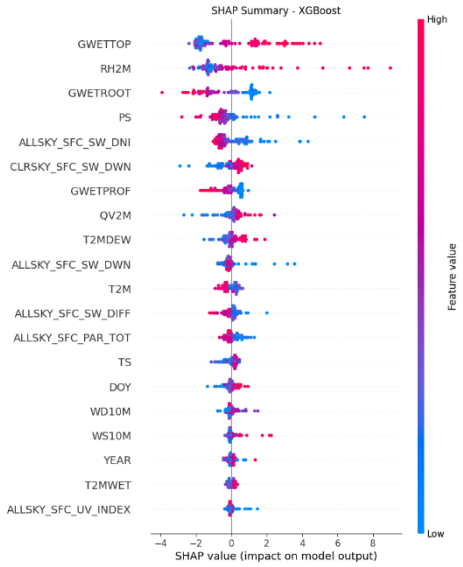


Figure 6. SHAP Summary Plot for the XGBoost Model

The continuous SHAP summary plot ranks soil moisture (GWETTOP, GWETROOT, GWETPROF) highest, showing model sensitivity to surface wetness. Radiation inputs

(ALL_SKY_SFC_SW_DNI, ALL_SKY_SFC_SW_DWN) also contribute positively, consistent with the evaporation-precipitation cycle. Unlike simpler models, XGBoost displays a flat SHAP distribution, indicating less single-variable dependency and better management of complex relationships. Multicollinear features (T2M, QV2M, T2MDEW) were effectively utilized without dominating the model. The inclusion of positive and negative SHAP ranges shows XGBoost captured both magnitude and directionality, such as QV2M's dynamic influence based on saturation levels. Overall, Figure 6 demonstrates XGBoost's ability to extract synergistic information from meteorologic and hydrologic inputs, supporting its high ranking.

DISCUSSION

The differences in the performance of various Machine Learning (ML) techniques using the NASA POWER data could be explained due to the way each technique treated the non-linearities, the interaction among the input variables, and the multicolinearities. In particular, the Multilayer Perceptron (MLP) performed best in terms of accuracy (R^2 = 0.773) because it has been able to represent the complex and non-linear relationships among the variables. Both MLP and XGBoost identified GWETTOP as having a significant impact on the runoff; this is consistent with the physical understanding of semi-arid areas such as Konya where runoff is affected by the soil wetness. Although XGBoost had slightly lower accuracy than MLP, its ability to generalize well over the variability of the data was demonstrated through the balanced feature importance in Figure 6. RF, on the other hand, was much less competitive and was found to rely primarily on the thermodynamic variables in Figure 5 and did not capture the subtle interactions or extreme events. Finally, although LR and SVR were both capable of capturing the trends and patterns present within the data, they were unable to capture the rapid changes and fluctuations in the data which further confirms that linear models are not appropriate for modeling non-linear hydrometeorological processes.

The Correlation Heatmap in Figure 2 illustrated a number of strong correlations among the predictors (T2M and PAR_TOT). These correlations would likely lead to unstable models when attempting to fit linear models to these data sets. However, the non-linear architecture of MLP and RF allow them to handle the multiple correlations between predictors and provide improved predictability of rainfall.

SHAP Analysis indicated that the interaction between solar radiation (PAR_TOT), which drives evaporation, and the soil moisture content (GWETTOP), which controls infiltration, is consistent with the fundamental hydrological principles. Thus, combining non-linear Machine Learning with SHAP Analysis enhances both the predictability of rainfall and provides physical interpretability of the results. This type of approach is especially useful for predicting rainfall in data-poor regions that use re-analysis products such as NASA POWER.

CONCLUSION

The results of this study show that nonlinear models are better suited than linear models at identifying complex relations and extreme weather events (e.g., heavy rainfall). More specifically, both MLP (R2 = 0.773) and XGBoost were found to be the best performers in modeling complex relationships and extreme events. The SHAP-based feature importance also showed that the two models were successful in managing the complex dependencies among input variables. On the other hand, both SVR and Linear Regression failed to capture the extreme weather events due to their limitations in managing the strong correlation between temperature and radiation variables. The SHAP-based feature importance clearly indicated that the four most important variables included in the model were soil moisture, surface radiation, air temperature, and relative humidity which is consistent with hydrometeorological theories. Therefore, it can be concluded that a

combination of advanced machine learning techniques and SHAP analysis provides a powerful method for predicting precipitation in remote areas where there is limited or no data available.

ACKNOWLEDGEMENTS

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DATA AVAILABILITY STATEMENT

All code, datasets, and reproducibility materials are openly available on GitHub at https://github.com/tdmuftuoglu/Decoding-Rainfall-Drivers-NASA-POWER. A permanent archive is available on Zenodo under the DOI: https://doi.org/10.5281/zenodo.18009561, which always resolves to the latest version. The archive includes the complete Python workflow, NASA POWER data preprocessing modules, trained machine learning models (MLP, XGBoost, Random Forest, SVR, Linear Regression), SHAP analysis scripts, and automated evaluation tools.

REFERENCES

Althoff D, Bazame HC, Nascimento JG 2021. Untangling hybrid hydrological models with explainable artificial intelligence. H2Open Journal, 4(1): 13-28.

Antonio B, McRae ATT, MacLeod D, Cooper FC, Marsham J, Aitchison L, Palmer TN, Watson PAG 2024. Postprocessing East African rainfall forecasts using a generative machine learning model. Authorea Preprints.

Appiah-Badu NKA, Missah YM, Amekudzi LK, Ussiph N, Frimpong T, Ahene E 2021. Rainfall prediction using machine learning algorithms for the various ecological zones of Ghana. IEEE Access, 10: 5069-5082.

Cavique L 2024. Implications of causality in artificial intelligence. Frontiers in Artificial Intelligence, 7: 1439702.

Chen X, Moraga P 2024. Forecasting dengue across Brazil with LSTM neural networks and SHAP-driven lagged climate and spatial effects. medRxiv, 2024-12.

Cheng S, Cheng L, Qin S, Zhang L, Liu P, Liu L, Xu Z, Wang Q 2022. Improved understanding of how catchment properties control hydrological partitioning through machine learning. Water Resources Research, 58(4): e2021WR031412.

Darman LP, Januhariadi J, Yudha MP, Aslan A 2024. Assessment of NASA POWER reanalysis products as data resources alternative for weather monitoring in West Sumbawa, Indonesia. In: E3S Web of Conferences, 485: 06006.

Duckworth C, Guy MJ, Kumaran A, O'Kane AA, Ayobi A, Chapman A, Marshall P, Boniface M 2024. Explainable machine learning for real-time hypoglycemia and hyperglycemia prediction and personalized control recommendations. Journal of Diabetes Science and Technology, 18(1): 113-123.

Esirge Z, Beyaz A 2022. Rain intensity forecast with microcontroller based pluviometer and machine learning. Brazilian Archives of Biology and Technology, 65: e22220197.

Fan M, Zhang L, Liu S, Yang T, Lu D 2023. Investigation of hydrometeorological influences on reservoir releases using explainable machine learning methods. Frontiers in Water, 5: 1112970.

Hassan MM, Rony MAT, Khan MAR, Hassan MM, Yasmin F, Nag A, Zarin TH, Bairagi AK, Alshathri S, El-Shafai W 2023. Machine learning-based rainfall prediction: Unveiling insights and forecasting for improved preparedness. IEEE Access, 11: 132196-132222.

He Z, Yang Y, Fang R, Zhou S, Zhao W, Bai Y, Li J, Wang B 2023. Integration of shapley additive explanations with random forest model for quantitative precipitation estimation of mesoscale convective systems. Frontiers in Environmental Science, 10: 1057081.

Hsu SC, Sharma AK, Tanone R, Ye YT 2024. Predicting rainfall using random forest and catboost models. In: Proceedings of the 9th World Congress on Civil, Structural, and Environmental Engineering (CSEE).

Kamath U, Liu J 2021. Introduction to interpretability and explainability. In: Explainable artificial intelligence: An introduction to interpretable machine learning. Cham: Springer International Publishing, pp. 1-26.

Katsekpor JT, Greve K, Yamba EI, Amoah EG 2024. Comparative analysis of satellite and reanalysis data with ground-based observations in northern Ghana. Meteorological Applications, 31(4): e2226.

Koteshwaramma T, Singh KS 2025. Role of regional and global datasets in the simulation of intense tropical cyclones over Bay of Bengal region in a convection-permitting scale. Meteorological Applications, 32(2): e70044.

Küllahcı K, Altunkaynak A 2023. Application of maximum overlap discrete wavelet transform and machine learning to improved daily rainfall prediction modeling. Research Square (Preprint). doi:10.21203/rs.3.rs-3375438/v1

Lyu Y, Yong B 2025. Using an explainable machine learning approach to produce high-resolution hourly precipitation estimates for a typical data-deficiency basin. Journal of Geophysical Research: Machine Learning and Computation, 2(1): e2024JH000489.

McClean F, Dawson R, Kilsby C 2023. Intercomparison of global reanalysis precipitation for flood risk modelling. Hydrology and Earth System Sciences, 27(2): 331-347.

Muddamsetty SM, Jahromi MN, Ciontos AE, Fenoy LM, Moeslund TB 2022. Visual explanation of black-box model: Similarity difference and uniqueness (SIDU) method. Pattern Recognition, 127: 108604.

Mushtaq H, Akhtar T, Zia-ur-Rahman Hashmi M, Masood A 2022. Hydrologic interpretation of machine learning models for 10-daily streamflow simulation in climate sensitive Upper Indus Catchments. Hydrology and Earth System Sciences Discussions, 1-32.

Nakkazi MT, Sempewo JI, Tumutungire MD, Byakatonda J 2022. Performance evaluation of CFSR, MERRA-2 and TRMM3B42 data sets in simulating river discharge of data-scarce tropical catchments: a case study of Manafwa, Uganda. Journal of Water and Climate Change, 13(2): 522-541.

Nkiaka E, Nawaz NR, Lovett JC 2017. Evaluating global reanalysis precipitation datasets with rain gauge measurements in the Sudano-Sahel region: case study of the Logone catchment, Lake Chad Basin. Meteorological Applications, 24(1): 9-18.

Patro BS, Bartakke PP 2024. Daily rainfall prediction using long short-term memory (LSTM) algorithm. Journal of Agrometeorology, 26(4): 509-511.

Pham QB, Yang TC, Kuo CM, Tseng HW, Yu PS 2019. Combing random forest and least square support vector regression for improving extreme rainfall downscaling. Water, 11(3): 451.

Tian Q, Gao H, Tian Y, Jiang Y, Li Z, Guo L 2023. Runoff prediction in the Xijiang River Basin based on long short-term memory with variant models and its interpretable analysis. Water, 15(18): 3184.

Van Phong T, Nguyen DD, Pham BT 2023. Modeling and mapping of flood susceptibility at Que Son District, Quang Nam Province, Vietnam using CatBoost. In: IOP Conference Series: Materials Science and Engineering, 1289(1): 012019.

Vinta SR, Peeriga R 2024. Rainfall prediction using xgb model with the australian dataset. EAI Endorsed Transactions on Energy Web, 11.

Wang J, Li Z, Zhou L, Ma C, Sun W 2025. Ensemble streamflow simulations in a Qinghai–Tibet Plateau basin using a deep learning method with remote sensing precipitation data as input. Remote Sensing, 17(6): 967.

Zhu D, Ilyas AM, Wang G, Zeng B 2021. Long-term hydrological assessment of remote sensing precipitation from multiple sources over the lower Yangtze River basin, China. Meteorological Applications, 28(3): e1991.

Zhu Q, Gao X, Xu YP, Tian Y 2019. Merging multi-source precipitation products or merging their simulated hydrological flows to improve streamflow simulation. Hydrological Sciences Journal, 64(8): 910-920.

Zouré CO, Kiema A, Yonaba R, Minoungou B 2023. Unravelling the impacts of climate variability on surface runoff in the Mouhoun river catchment (West Africa). Land, 12(11): 2017.

INTERAGENCY STANDARDIZATION IN CHEMICAL INCIDENT MANAGEMENT: STRATEGIES FOR ESTABLISHING A COMMON LANGUAGE IN TRIAGE ALGORITHMS

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ABSTRACT

Chemical incidents and industrial accidents are inherently high-threat scenarios that demand simultaneous intervention from multiple agencies, including Emergency Medical Services (EMS), Fire Departments, Disaster Management Authorities (like AFAD), and Law Enforcement. In such chaotic environments, the primary obstacle to effective management is often not a lack of medical capacity, but rather a deficiency in operational coordination and terminological discrepancies in triage processes across different agencies. Conventional triage models, such as START and SALT, are primarily designed for static and secure environments. They often fail to address the tactical requirements of the "Hot" and "Warm" zones in chemical scenarios. The misalignment between the medical priorities of healthcare providers and the decontamination or safety priorities of technical rescue teams leads to critical delays during the "golden hour" and increases the risk of secondary contamination. Furthermore, decision-makers operating under extreme stress within the framework of "bounded rationality" often struggle when utilizing conflicting algorithms, which disrupts the interagency flow of information. This study proposes a "Hybrid Triage Model" that integrates traditional triage systems with the principles of Tactical Emergency Casualty Care (TECC). The proposed model incorporates rapid assessment tools, such as Rapid Assessment of Mentation and Pulse (RAMP), with chemical-specific requirements like immediate antidote administration and decontamination prioritization. The core of this strategy is the establishment of a "Tactical-Medical Threshold" terminology, universally accepted by all responding agencies. This ensures a unified language, ranging from radio discipline among personnel in Personal Protective Equipment (PPE) to seamless data transfer at casualty collection points. Success in chemical incident management depends not only on technical equipment but also on the ability of diverse agencies to achieve a "recognition-primed decision-making" unity through a single algorithm. A standardized hybrid model reduces cognitive load, minimizes decision-making errors, and accelerates interagency transitions. Ultimately, establishing a common triage language is the most fundamental strategic step toward increasing survival rates in mass casualty chemical incidents.

Keywords: Chemical Incident Management, Triage Standardization, CBRN, Hybrid Triage Model, Interagency Coordination, Tactical Emergency Care.

KİMYASAL OLAY YÖNETİMİNDE KURUMLAR ARASI STANDARDİZASYON: TRİYAJ ALGORİTMALARINDA ORTAK BİR DİL OLUŞTURMA STRATEJİLERİ

ÖZET

Kimyasal olaylar ve endüstriyel kazalar, doğaları gereği Acil Sağlık Hizmetleri (ASH), İtfaiye, Afet ve Acil Durum Yönetimi Otoriteleri (AFAD vb.) ve Kolluk Kuvvetleri dâhil olmak üzere birden fazla kurumun eşzamanlı müdahalesini gerektiren yüksek tehdit içeren olaylardır. Bu tür kaotik ortamlarda, etkili yönetimin önündeki temel engel genellikle tıbbi kapasite eksikliği değil, operasyonel koordinasyon noksanlığı ve farklı kurumlar arasındaki triyaj süreçlerinde yaşanan terminolojik tutarsızlıklardır. START ve SALT gibi geleneksel triyaj modelleri temel olarak statik ve güvenli ortamlar için tasarlanmıştır. Bu modeller, kimyasal olaylardaki "Sıcak" ve "Ilık" bölgelerin taktiksel gereksinimlerini karşılamada çoğunlukla yetersiz kalmaktadır. Sağlık profesyonellerinin tıbbi öncelikleri ile teknik kurtarma ekiplerinin dekontaminasyon veya güvenlik öncelikleri arasındaki uyumsuzluk, "altın saat" içinde kritik gecikmelere yol açmakta ve ikincil kontaminasyon riskini artırmaktadır. Dahası, "sınırlı rasyonellik" çerçevesinde aşırı stres altında çalışan karar vericiler, birbiriyle çelişen algoritmalar kullandıklarında zorlanmakta ve bu durum kurumlar arası bilgi akışını kesintiye uğratmaktadır. Bu çalışma, geleneksel triyaj sistemlerini Taktik Acil Yaralı Bakımı (TECC) prensipleriyle bütünleştiren bir "Hibrit Triyaj Modeli" önermektedir. Önerilen model, Zihinsel Durum ve Nabzın Hızlı Değerlendirmesi (RAMP) gibi hızlı değerlendirme araçlarını, acil antidot uygulaması ve dekontaminasyon önceliği gibi kimyasala özgü gereksinimlerle birleştirmektedir. Bu stratejinin özü, müdahale eden tüm kurumlar tarafından evrensel olarak kabul gören bir "Taktik-Medikal Eşik" terminolojisinin oluşturulmasıdır. Bu, Kişisel Koruyucu Donanım (KKD) kullanan personel arasındaki telsiz disiplininden, yaralı toplama noktalarındaki kesintisiz veri aktarımına kadar birleşik bir dil sağlar. Kimyasal olay yönetimindeki başarı, yalnızca teknik donanıma değil, aynı zamanda farklı kurumların tek bir algoritma aracılığıyla "tanımaya dayalı karar verme" birliğine ulaşma yeteneğine de bağlıdır. Standartlaştırılmış bir hibrit model bilişsel yükü azaltır, karar verme hatalarını en aza indirir ve kurumlar arası geçişleri hızlandırır. Sonuç olarak, ortak bir triyaj dili oluşturmak, çoklu yaralanmalı kimyasal olaylarda hayatta kalma oranlarını artırmaya yönelik en temel stratejik adımdır.

Anahtar Kelimeler: Kimyasal Olay Yönetimi, Triyaj Standardizasyonu, KBRN, Hibrit Triyaj Modeli, Kurumlar Arası Koordinasyon, Taktik Acil Bakım.

GİRİŞ

Kimyasal, Biyolojik, Radyolojik ve Nükleer (KBRN) tehditler ile büyük çaplı endüstriyel kazalar, modern afet yönetiminin en karmaşık, dinamik ve yüksek riskli alanlarından birini oluşturmaktadır. Bu tür olaylar, yalnızca yıkıcı fiziksel etkileriyle değil, aynı zamanda alana ilk müdahale eden ekipler (first responders) için yarattığı asimetrik tehdit ortamıyla da karakterizedir. Toksik bir kimyasal ajanın salınımı sonrası saniyeler içinde gelişen olay örgüsü; Acil Sağlık Hizmetleri (ASH), İtfaiye, Afet ve Acil Durum Yönetimi Başkanlığı (AFAD), Ulusal Medikal Kurtarma Ekipleri (UMKE) ve Emniyet güçlerinin eşgüdümlü, hızlı ve hatasız çalışmasını zorunlu kılmaktadır. Ancak sahada karşılaşılan temel problem, tıbbi ekipman veya personel yetersizliğinden ziyade, olay yerinde görev alan farklı disiplinlerin ortak bir operasyonel dil konuşamaması ve taktiksel saha yönetimindeki koordinasyon eksikliğidir (FEMA, 2017; Wanner, Atti, & Jasper, 2019).

Afet ve acil durum yönetiminde kurumsal standardizasyon eksikliği, özellikle "Sıcak Alan" (Hot Zone) ve "Ilık Alan" (Warm Zone) olarak tanımlanan tehlikeli bölgelerde triyaj, stabilizasyon ve

tahliye süreçlerini derinden etkilemektedir. Olay Komuta Sistemi (ICS) ve Ulusal Olay Yönetim Sistemi (NIMS) gibi çatı yapılar teorik olarak kurumlar arası entegrasyonu ve ortak bir operasyonel tablo (Common Operating Picture) oluşturmayı hedeflese de, sahada çalışan farklı kurumların kendilerine has algoritmalarla hareket etmesi pratikte ciddi iletişim kopukluklarına neden olmaktadır. Özellikle kimyasal maruziyetin olduğu durumlarda, hastaların hızla dekontamine edilmesi ile acil tıbbi müdahalenin (örneğin antidot uygulaması) hangi sırayla ve kim tarafından yapılacağı konusu kurumsal öncelik çatışmalarına sahne olmaktadır (FEMA, 2024; Cibulsky vd., 2014).

Sağlık profesyonelleri tıbbi müdahale önceliğine (hayat kurtarıcı müdahaleler) odaklanırken, teknik kurtarma ve itfaiye ekipleri olay yerinin güvenliği, izolasyonu ve kurbanların dekontaminasyonu gibi çevresel önceliklere odaklanmaktadır. Bu uyumsuzluk, travma ve kimyasal maruziyette kritik önem taşıyan "altın saat" (golden hour) kavramının ihlaline, hastaların geç müdahale almasına ve müdahale ekiplerinin ikincil kontaminasyon riskine girmesine yol açmaktadır (Chilcott & Amlôt, 2015; Glow vd., 2011). Buradan hareketle bu çalışma; çoklu kurumsal katılım gerektiren kimyasal olaylarda mevcut triyaj algoritmalarının yetersizliklerini incelemeyi, "Taktik Acil Yaralı Bakımı" (TECC) prensiplerini merkeze alan bir "Hibrit Triyaj Modeli" önermeyi ve müdahil tüm kurumlar arasında "Taktik-Medikal Eşik" terminolojisi üzerinden ortak bir karar alma dili inşa etmeyi amaçlamaktadır.

MATERYAL VE METOT

Bu çalışma, kimyasal olaylarda triyaj yönetim süreçlerinin etkinliğini analiz etmek ve operasyonel hızı artıracak bir müdahale algoritması geliştirmek amacıyla nitel bir literatür derlemesi ve kavramsal analiz çalışmasıdır. Çalışma kapsamında; FEMA, OSHA ve uluslararası KBRN protokolleri temel veri kaynağı olarak kullanılarak doküman analizi ve sistematik literatür taraması yöntemleri uygulanmıştır. Google Akademik, PubMed ve ScienceDirect veri tabanları üzerinden "kimyasal olay yönetimi", "KBRN triyajı", "START", "SALT" ve "dekontaminasyon" anahtar kelimeleri kullanılarak son 20 yıla ait akademik yayınlar, teknik raporlar ve mevcut triyaj modelleri (START, SALT, ASSET) detaylı bir şekilde incelenmiştir. Elde edilen veriler analitik bir yaklaşımla karşılaştırılarak, kimyasal ajanların fizyolojik etkileri ile saha operasyonlarındaki karar verme süreçlerini entegre eden, ilk müdahale ekiplerine yönelik özgün bir triyaj algoritması kurgulanmıştır.

GELENEKSEL TRİYAJ MODELLERİ VE SINIRLILIKLARI

Kitlesel yaralanmalı olaylarda (Mass Casualty Incidents - MCI) triyaj, kaynakların yetersiz kaldığı durumlarda tıbbi faydayı maksimize etmek ve en fazla sayıda kazazedeye yaşama şansı sunmak amacıyla uygulanan hastaları önceliklendirme sürecidir. Tarihsel süreçte geliştirilen ve günümüzde sivil alanda en yaygın kullanılan triyaj algoritmalarının başında START (Simple Triage and Rapid Treatment) ve SALT (Sort, Assess, Lifesaving Interventions, Treatment/Transport) gelmektedir. Bu geleneksel sistemler, fizyolojik parametrelere (solunum, perfüzyon ve mental durum) dayalı hızlı bir değerlendirme sunarak hastaları kategorize etmede (Kırmızı, Sarı, Yeşil, Siyah) standart bir yaklaşım sağlamıştır (Lerner vd., 2008; Lee vd., 2014).

Bununla birlikte, START ve SALT gibi konvansiyonel triyaj modelleri, yapısal olarak statik, dış tehditlerden arındırılmış (Soğuk Alan - Cold Zone) ve daha çok künt ya da penetran travma olaylarına yönelik tasarlanmıştır. Söz konusu modeller; kimyasal ajanların aktif yayılım gösterdiği, solunum ve temas yoluyla bulaş riskinin en üst düzeyde seyrettiği dinamik 'Sıcak' ve 'Ilık' alanların (Hot and Warm Zones) taktiksel gereksinimlerini karşılamada yetersiz kalmaktadır. Mevcut algoritmalar, kimyasal olay yönetiminde kritik öneme sahip 'erken antidot uygulaması' ve

'öncelikli dekontaminasyon' gibi spesifik müdahale basamaklarını yapısal olarak ihtiva etmemektedir. Örneğin, yoğun bir sinir ajanı maruziyeti vakasında, hastanın yalnızca temel fizyolojik parametreler üzerinden değerlendirilerek doğrudan dekontamine edilmeden tedavi alanına transfer edilmesi, sağlık personelinin maruziyetine ve tedavi zincirini sekteye uğratacak kitlesel ikincil kontaminasyon (secondary contamination) vakalarına sebebiyet verme potansiyeli taşımaktadır (Cibulsky vd., 2014; Neidel & Heller, 2021).

Bununla birlikte, kimyasal kriz anlarının getirdiği kaos ortamı, sahada görev yapan karar vericilerin psikolojik kapasitelerini sınırlandırmaktadır. İnsan zihni, aşırı stres, tehlike algısı ve zaman baskısı altında "sınırlı rasyonellik" (bounded rationality) ile hareket eder. Bilişsel Yük Teorisi (Cognitive Load Theory) perspektifinden bakıldığında, tehlikeli bir madde sızıntısı ortamında ağır Kişisel Koruyucu Donanım (KKD) giymiş bir sağlık çalışanının veya itfaiyecinin; hem kendi güvenliğini sağlaması, hem ajanın niteliğini değerlendirmesi, hem de karmaşık basamaklara sahip statik triyaj algoritmalarını hatırlayıp uygulaması zihinsel kapasiteyi aşırı derecede zorlar. Bu aşırı bilişsel yük, problem çözme yeteneğini düşürür, triyaj hatalarını (over-triage veya under-triage) artırır ve kurumlar arası doğru bilgi aktarımını olanaksız kılar (Sweller, 1988). Bu nedenle, geleneksel modellerin yerini, karar vericinin bilişsel yükünü azaltan, taktiksel tehlikeyi hesaba katan ve kurumsal terminoloji çatışmalarını ortadan kaldıran daha yenilikçi modellere bırakması bilimsel bir zorunluluk haline gelmiştir.

KURUMLAR ARASI ÖNCELİK ÇATIŞMALARI VE BİLGİ ASİMETRİSİ

Kimyasal olaylara müdahalede, sahaya intikal eden farklı disiplinlerin (İtfaiye, KBRN ekipleri, UMKE, ASH) operasyonel hedefleri arasında kaçınılmaz bir öncelik çatışması ortaya çıkmaktadır. Ulusal ve uluslararası afet yönetim protokolleri (örneğin; PRISM Kılavuzları ve FEMA yönergeleri), tehlikeli madde olaylarında olay yeri yönetiminin "önce güvenlik ve izolasyon" prensibiyle hareket etmesini şart koşar. İtfaiye ve teknik kurtarma ekipleri için temel başarı kriteri; kaynağın kontrol altına alınması, alanın izole edilmesi ve kazazedelerin kitlesel olarak dekontaminasyon koridorlarından geçirilmesidir (Chilcott & Amlôt, 2015; FEMA, 2017).

Buna karşın, Acil Sağlık Hizmetleri (ASH) personeli, tıp eğitimlerinin doğası gereği hastanın fizyolojik stabilizasyonuna ve hayat kurtarıcı müdahalelere (ABCDE yaklaşımı) odaklanacak şekilde şartlandırılmıştır. Kimyasal bir ajana maruz kalmış kardiyak veya respiratuar arrest tablosundaki bir hastaya, dekontaminasyon işlemi tamamlanmadan tıbbi müdahalede bulunma eğilimi, sağlık ekiplerinin sıklıkla düştüğü kritik bir taktiksel hatadır. PRISM (Primary Response Incident Scene Management) ve Ulusal Hasta Dekontaminasyon Planlama Kılavuzu (Patient Decon National Planning Guidance) verilerine göre, dekontaminasyon süreçleri ile medikal triyaj süreçleri arasındaki bu uyumsuzluk, sahada ciddi bir "bilgi asimetrisine" neden olmaktadır. Ekiplerin farklı renk kodları, farklı operasyonel formlar ve birbirini tanımayan iletişim kanalları kullanması, özellikle "altın saat" içerisindeki hasta akışını (patient flow) durma noktasına getirmektedir (Cibulsky vd., 2014; Chilcott vd., 2015). Bu durum, kurumların bağımsız hareket etme refleksinden vazgeçip, tıbbi gereksinimler ile taktiksel güvenlik prosedürlerini tek bir çatı altında eriten yeni bir yaklaşıma ihtiyaç duyduğunu açıkça göstermektedir.

ÖNERİLEN HİBRİT TRİYAJ MODELİ: TECC VE RAMP ENTEGRASYONU

Geleneksel triyaj sistemlerinin ve kurumsal öncelik çatışmalarının yarattığı bu boşluğu doldurmak amacıyla, bu çalışmada "Hibrit Triyaj Modeli" kavramı önerilmektedir. Bu modelin temel dayanağını, askeri tıp kökenli olan ve sivil yüksek tehdit ortamlarına uyarlanan Taktik Acil Yaralı Bakımı (Tactical Emergency Casualty Care - TECC) prensipleri oluşturmaktadır. TECC yönergeleri, tıbbi müdahale aşamalarını ortamın tehdit düzeyine göre (Doğrudan Tehdit / Sıcak

Alan, Dolaylı Tehdit / Ilık Alan ve Tahliye / Soğuk Alan) sınıflandırarak, klinisyenlere "önce taktiksel üstünlük, sonra medikal müdahale" felsefesini aşılamaktadır (TECC Guidelines, 2015).

Önerilen Hibrit Model, TECC'in bu tehdit odaklı yaklaşımını, kimyasal olayların spesifik gereksinimleri olan "dekontaminasyon" ve "antidot uygulaması" ile birleştirmektedir. Sıcak ve ılık alanlarda görev yapan, ağır seviye Kişisel Koruyucu Donanım (KKD) giymiş bir müdahale personelinin, geleneksel SALT veya START algoritmalarındaki gibi solunum sayısını (örneğin 30/dk üzeri) veya kapiller geri dolum süresini hassas bir şekilde ölçmesi pratik olarak imkansızdır. Bu bağlamda hibrit model, hastanın değerlendirmesinde RAMP (Zihinsel Durum ve Nabzın Hızlı Değerlendirmesi - Rapid Assessment of Mentation and Pulse) gibi modifiye edilmiş, çok daha hızlı ve kaba motor becerilere dayanan değerlendirme araçlarını merkeze almaktadır.

Bu entegrasyon şu şekilde formüle edilebilir:

- **Sıcak Alan (Doğrudan Tehdit):** Geleneksel triyaj tamamen ertelenir. Müdahale sadece hastanın ortamdan hızla tahliyesi ve varsa çok bariz, durdurulabilir kanamaların (turnike ile) engellenmesiyle sınırlıdır.
- **Ilık Alan (Dolaylı Tehdit ve Dekontaminasyon Koridoru):** RAMP tabanlı çok hızlı bir değerlendirme yapılır. Bu aşamada hastalar medikal kodlardan ziyade "Yürüyebilenler (Ambulatuvar)" ve "Yürüyemeyenler (Non-ambulatuvar)" olarak ayrılarak dekontaminasyona yönlendirilir. Sinir gazı gibi özel durumlarda, oto-enjektör ile hayat kurtarıcı ilk antidot uygulaması (Life-saving Intervention - LSI) sadece bu alanda, dekontaminasyon ile eş zamanlı olarak yapılır (Wanner, Atti, & Jasper, 2019; Lee vd., 2014).
- **Soğuk Alan (Tahliye Öncesi):** Tam dekontaminasyon sağlanmış hastalar güvenli bölgeye alındığında, geleneksel triyaj algoritmaları (SALT vb.) devreye girer ve hastaneye sevk öncelikleri belirlenir.

Bu üç aşamalı hibrit yapı, tıbbi öncelikler ile teknik kurtarma ve dekontaminasyon önceliklerini kronolojik bir sıraya koyarak, sahada görev yapan tüm kurumlar için tek bir ortak eylem planı sunmaktadır.

FARKLI AFET TÜRLERİNDE TRİYAJ DİNAMİKLERİNİN KİMYASAL OLAYLARLA KARŞILAŞTIRMALI ANALİZİ

Önerilen hibrit modelin gerekliliğini tam olarak ortaya koyabilmek için, kimyasal olayların dinamiklerini, literatürde sıkça işlenen diğer kitlesel afet olaylarıyla (MCI) karşılaştırmak elzemdir. Geleneksel triyaj algoritmalarının (START, SALT) ve afet müdahale protokollerinin, deprem, yanık ve travma gibi konvansiyonel afetlerdeki başarısı yadsınamaz (Glow vd., 2011; Lerner vd., 2008). Ancak bu başarı, olay yeri güvenliğinin (sahadaki yapısal çöküntüler hariç) büyük oranda sağlanabildiği ve sağlık personelinin standart donanımla hastaya temas edebildiği varsayımına dayanır.

Deprem ve Ezilme (Crush) Sendromu Vakaları

Deprem gibi geniş çaplı doğal afetlerde, travma ve ezilme sendromu (crush syndrome) yönetimi ön plandadır. Abu-Zidan, Idris ve Cevik (2023) ile Gautschi vd. (2008) tarafından yapılan çalışmalarda vurgulandığı üzere, deprem enkazından çıkarılan bir hastada kompartman sendromu gelişimi, hiperkalemi ve akut böbrek yetmezliği gibi komplikasyonlar saatler veya günler içinde gelişir. Sağlık personeli, enkaz alanı (sıcak alan) dışında nispeten güvenli bir bölgede hastaya damar yolu açabilir, sıvı resüsitasyonuna başlayabilir ve geleneksel triyaj formlarını doldurarak hastayı hastaneye sevk edebilir. Bu olayda tehdit statiktir (artçı sarsıntılar hariç) ve "bulaşıcı" değildir. Oysa bir kimyasal sızıntıda tehdit dinamiktir, hava yoluyla yayılır ve hastanın bizzat

kendisi (kıyafetleri, cildi) müdahale ekibi için ölümcül bir tehdit (ikincil kontaminasyon) kaynağıdır.

Kitlesel Yanık Olayları

Benzer şekilde, endüstriyel patlamalar veya toz patlamaları (powder explosion) sonucu ortaya çıkan kitlesel yanık vakalarında da farklı bir triyaj dinamiği işler. Ng ve ark. (2018) tarafından yapılan geriye dönük kohort çalışmasında, kitlesel yanık olaylarında triyajın; hastanın bilinci, solunumu ve Toplam Vücut Yüzey Alanı (TBSA - Total Body Surface Area) yanık yüzdesi gibi doğrudan gözlemlenebilir fiziksel parametrelere dayandığı belirtilmiştir. Konvansiyonel bir patlamada termal tehdit olay anında başlar ve biter. Ancak kimyasal bir olayda (örneğin kükürt hardalı veya fosgen gazı maruziyeti), hastanın cilt yüzeyinde kalan ajan hem hastayı yakmaya devam eder hem de buharlaşarak etraftaki personeli zehirler. Bu nedenle kimyasal bir olayda TBSA hesaplamak veya yara bakımı yapmak, "hızlı soyunma (disrobe) ve dekontaminasyon" işlemlerinden (PRISM Kılavuzları, Chilcott ve Amlôt, 2015) kesinlikle daha öncelikli olamaz.

Hayati Bulguların Triyajdaki Rolü

Geleneksel afet triyajında hayati bulguların (solunum sayısı, nabız karakteri, sistolik kan basıncı) kullanımı standart bir uygulamadır. Hogan ve Brown (2014) afet triyajında hayati bulguların kullanımının, kritik hastaların tespitindeki doğruluğu artırdığını savunmaktadır. Ne var ki, Seviye A veya B (Tam korumalı, temiz hava tüplü) Kişisel Koruyucu Donanım (KKD) giymiş bir müdahale personelinin, kalın kauçuk eldivenlerle radyal nabız sayması, vizörün buğulanması nedeniyle kapiller geri dolum süresini (CRT) değerlendirmesi veya steteskop kullanması kimyasal sıcak alanda taktiksel olarak imkânsızdır. Bu durum, önceki bölümlerde önerilen TECC (Taktik Acil Yaralı Bakımı) ve RAMP (Kaba Zihinsel Durum ve Nabız Değerlendirmesi) tabanlı hibrit modelin, kimyasal olayların dayattığı fiziksel engelleri aşmak için neden zorunlu olduğunu bir kez daha kanıtlamaktadır.

"TAKTİK-MEDİKAL EŞİK" TERMİNOLOJİSİ VE ORTAK BİR DİL İNŞASI

Farklı afet türlerinden elde edilen veriler ışığında, itfaiye/emniyet birimlerinin güvenlik öncelikleri ile sağlık personelinin tıbbi önceliklerinin kesiştiği nokta olan "Taktik-Medikal Eşik" (Tactical-Medical Threshold) kavramı daha da önem kazanmaktadır (FEMA, 2017; FEMA 2024). Bu eşik, sıcak alandaki tehlikeli madde ve tahliye operasyonunun, soğuk alandaki medikal operasyona dönüştüğü dekontaminasyon koridorunu temsil eder.

Bu bilgi asimetrisini aşmanın temel yolu, "tanımaya dayalı karar verme" (recognition-primed decision-making) mekanizmasını standartlaştırmaktır. Psikoloji ve afet yönetiminde sıkça kullanılan bu kavram, personelin aşırı stres altında bilişsel yükünü (cognitive load) azaltarak hata payını minimuma indirmeyi hedefler (Sweller, 1988). Ortak bir "Taktik-Medikal Eşik" terminolojisi oluşturulduğunda, farklı kurum personeli aynı kavramları (örneğin; "Ambulatuvar", "Dekon Öncelikli", "Acil Antidot") kullanarak zihinsel bir çeviri yapmadan anında ortak eyleme geçebileceklerdir (Lee vd., 2014; Wanner vd., 2019).

SONUÇ VE TARTIŞMA

Geleneksel afet yönetimi literatürü büyük ölçüde deprem, yapısal çökme ve konvansiyonel patlamalara dayalı olaylar üzerinden şekillenmiştir. Bu çalışmada gerçekleştirilen karşılaştırmalı analiz, standart triyaj modellerinin (START ve SALT) bu tür statik afetlerde başarılı olsa da, kimyasal olayların dinamik, bulaşıcı ve zaman kısıtlı doğasında yetersiz kaldığını açıkça göstermektedir (Neidel & Heller, 2021). Hastanın bizzat tehdit kaynağına dönüştüğü KBRN

olaylarında, sağlık ekiplerinin hastanın fizyolojik stabilizasyonuna öncelik vermesi (ikincil kontaminasyon riski nedeniyle) taktiksel bir hatadır.

Bu çalışmada önerilen "Hibrit Triyaj Modeli", askeri kökenli TECC felsefesini sivil kimyasal olay yönetimine entegre ederek, tıbbi gereksinimler ile taktiksel güvenlik (dekontaminasyon) prosedürlerini tek bir çatı altında eritmeyi başarmaktadır. Ağır KKD içindeki personelin sınırlı motor becerilerine uygun olarak tasarlanan bu model; hastaları detaylı hayati bulgular yerine yürüyebilme ve kaba bilinç durumu (RAMP) üzerinden sınıflandırmakta, acil antidot uygulamalarını dekontaminasyon süreciyle senkronize etmektedir (Cibulsky vd., 2014; Chilcott vd., 2015).

Sonuç olarak; kimyasal acil durumların yönetiminde operasyonel başarıyı sağlamanın en temel yolu, eldeki tıbbi donanımdan ziyade, farklı disiplinlerin (itfaiye, AFAD, UMKE) tek bir ortak akıl ve dille hareket edebilmesidir. Ortak bir "Taktik-Medikal Eşik" terminolojisinin ulusal afet müdahale planlarına (TAMP) entegre edilmesi, kaosun yönetilebilir bir operasyona dönüştürülmesindeki en stratejik köprüdür. Gelecekteki çalışmaların, bu teorik hibrit modelin farklı KBRN senaryolarında ve olaylarında sanal gerçeklik (VR) veya saha tatbikatları ile pratik doğruluğunu test etmeye odaklanması önerilmektedir.

KAYNAKÇA

Abu-Zidan, F. M., Idris, K., & Cevik, A. A. (2023). Prehospital management of earthquake crush injuries: A collective review. *Turkish Journal of Emergency Medicine, 23*(4), 199-210.

Chilcott, R. P., & Amlôt, R. (Eds.). (2015). *Primary Response Incident Scene Management (PRISM) Guidance for Chemical Incidents: Volume 1 (Strategic Guidance)*. Biomedical Advanced Research and Development Authority (BARDA).

Chilcott, R. P., & Amlôt, R. (Eds.). (2015). *Primary Response Incident Scene Management (PRISM) Guidance for Chemical Incidents: Volume 2 (Tactical Guidance)*. BARDA.

Chilcott, R. P., Larner, J., & Matar, H. (2015). *Primary Response Incident Scene Management (PRISM) Guidance: Volume 3 (Operational Guidance)*. BARDA.

Cibulsky, S. M., Kirk, M. A., & Ignacio, J. S. (2014). *Patient Decontamination in a Mass Chemical Exposure Incident: National Planning Guidance for Communities*. U.S. Department of Homeland Security & Department of Health and Human Services.

Federal Emergency Management Agency (FEMA). (2017). *National Incident Management System (NIMS)* (3rd ed.). U.S. Department of Homeland Security.

Federal Emergency Management Agency (FEMA). (2024). *20 Years of the National Incident Management System*. U.S. Department of Homeland Security.

Gautschi, O. P., Cadosch, D., Rajan, G., & Zellweger, R. (2008). Earthquakes and Trauma: Review of Triage and Injury-Specific, Immediate Care. *Prehospital and Disaster Medicine, 23*(2), 195-201.

Glow, S. D., Colucci, V. J., Allington, D. R., Noonan, C. W., & Hall, E. C. (2011). Managing Multiple-Casualty Incidents: A Rural Medical Preparedness Training Assessment. *Prehospital and Disaster Medicine, 26*(6), 423-429.

Hogan, D. E., & Brown, T. (2014). Utility of Vital Signs in Mass Casualty-Disaster Triage. *Western Journal of Emergency Medicine, 15*(7), 732-735.

Lee, C. W., McLeod, S. L., Van Aarsen, K., Klingel, M., Franc, J. M., & Peddle, M. B. (2014). First Responder Accuracy Using SALT during Mass-casualty Incident Simulation. *Prehospital Emergency Care, 18*(3), 417-423.

Lerner, E. B., Cone, D. C., Weinstein, E. S., Schwartz, R. B., Coule, P. L., Cronin, M., ... & Hunt, R. C. (2008). Mass Casualty Triage: An Evaluation of the Science and Refinement of a National Guideline. *Disaster Medicine and Public Health Preparedness, 2*(S1), S25-S34.

Neidel, T., & Heller, A. R. (2021). Einfluss der Reihenfolge von Items auf die diagnostische Qualität von Vorsichtungsalgorithmen hinsichtlich der Vergabe der Sichtungskategorie I. *Notfall + Rettungsmedizin, 24*(8), 1025-1032.

Ng, C. J., You, S. H., Wu, I. L., Weng, Y. M., Chaou, C. H., Chien, C. Y., & Seak, C. J. (2018). Introduction of a mass burn casualty triage system in a hospital during a powder explosion disaster: a retrospective cohort study. *World Journal of Emergency Surgery, 13*(38).

Sweller, J. (1988). Cognitive Load During Problem Solving: Effects on Learning. *Cognitive Science, 12*(2), 257-285.

Tactical Emergency Casualty Care (TECC) Committee. (2015). *Tactical Emergency Casualty Care (TECC) Guidelines: Direct Threat / Hot Zone Care*.

Wanner, G. K., Atti, S., & Jasper, E. (2019). Chemical Disaster Preparedness for Hospitals and Emergency Departments. *Delaware Journal of Public Health, 5*(4), 19.

FROM ART'S AURA TO SHARING VALUE: THE COMMODIFICATION OF MUSEUM SPACE IN THE EXPERIENCE ECONOMY

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ABSTRACT

The evolution of art—diverging from traditional aesthetic values to become a new form of commodity within the "Experience Economy," a reflection of late capitalism—constitutes one of the most significant dilemmas of modern art theory. Walter Benjamin's concept of "aura," which defines the uniqueness of an artwork in time and space through a ritualistic approach, has been replaced by an interactive "sharing value" in the digital age. Consequently, the museum space has transformed into a spectacle, leading to the superficialization of the artistic experience. In this context, the experience paradigm conceptualized by Pine and Gilmore accelerates the transition of museums from passive viewing spaces into dynamic stages where visitors construct their personal narratives. Utilizing qualitative research methods, specifically an extensive literature review and theoretical content analysis, this study develops an interdisciplinary model centered on Baudrillard's "simulation" and "hyperreality," Debord's "spectacle," Bourdieu's "cultural capital," and Foucault's "heterotopia." Findings indicate that the phenomenon of "Instagrammability" detaches the museum experience from deep aesthetic engagement, transforming it into a process where experience is commodified through digital images. This commodification of the museum space creates an epistemological rupture that weakens the cognitive and sensory bond between the individual and art. It is observed that in this new ecosystem, the artwork functions as a backdrop serving the visual standards demanded by social media platforms rather than existing as an original entity. The study concludes that rather than developing curatorial methods catering solely to visual consumption and algorithmic expectations, museums must reposition digital possibilities to preserve the sensitivity and historical power of art, thereby inviting the audience into a profound aesthetic experience.

Keywords: Experience Economy, Hyperreality, Instagrammability, Museum Space, Commodification of Art, Simulation and Spectacle, New Generation Museology.

NATURAL STONE AND ARCHITECTURAL FACADE TECHNOLOGIES: GEOLOGICAL ORIGIN, PERFORMANCE ANALYSIS, AND SUSTAINABLE APPLICATION STRATEGIES

DOĞAL TAŞ VE MİMARİ CEPHE TEKNOLOJİLERİ: JEOLOJİK KÖKEN, PERFORMANS ANALİZİ VE SÜRDÜRÜLEBİLİR UYGULAMA STRATEJİLERİ

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ABSTRACT

This study brings together existing knowledge and experience regarding the use of natural stone as a high-performance material in architectural facade applications through a holistic approach from geological origin to life cycle. The physical and mechanical properties of three fundamental stone types magmatic, sedimentary, and metamorphic are comparatively presented in terms of high compressive strength, porosity ratios, and water absorption capacities; the effects of modern surface finishing techniques such as polished, honed, sandblasted, flamed, and CNC processing on performance are compiled. Through pathology examples compiled from field applications, the risks of yellowing due to pyrite oxidation in marble facades, layered spalling caused by freeze-thaw cycles in travertines with high water absorption rates, and panel falling risks resulting from inadequate anchorage applications are exemplified, revealing the effects of incorrect material selection, climate incompatibility, and application errors on early damage mechanisms. Modern preservation technologies such as hydrophobic coatings, consolidation, biocide applications, and micro-crack injection are compiled from the literature; low embodied energy, life cycle analysis, and recycling potential are evaluated from a sustainability perspective. This review proposes an integrated process management model encompassing geology, laboratory testing, engineering design, site application, and maintenance phases, and aims to contribute to science-based decision-making processes in architectural facade design by presenting a comprehensive checklist to be used at project inception.

Keywords: Natural stone, Architectural facade, Stone pathologies, Mechanical anchorage, Sustainability

ÖZET

Bu çalışma doğal taşın mimari cephe uygulamalarında yüksek performanslı bir malzeme olarak kullanımına ilişkin mevcut bilgi ve deneyimleri jeolojik kökeninden yaşam döngüsüne kadar bütüncül bir yaklaşımla bir araya getirmektedir. Magmatik, tortul ve metamorfik olmak üzere üç

temel taş türünün fiziksel ve mekanik özellikleri, yüksek basınç dayanımı, gözeneklilik oranları ve su emme kapasiteleri açısından karşılaştırmalı olarak sunulmuş; polished, honed, sandblasted, flamed ve CNC işlem gibi modern yüzey bitirme tekniklerinin performans üzerindeki etkileri derlenmiştir. Saha uygulamalarından derlenen patoloji örnekleri üzerinden, mermer cephelerde pirit oksidasyonuna bağlı sararma, yüksek su emme oranlı travertenlerde donma-çözülme döngüsü kaynaklı katmansal dökülme ve yetersiz ankraj uygulamalarından kaynaklanan panel düşmesi riskleri örneklendirilerek, yanlış malzeme seçimi, iklim uyumsuzluğu ve uygulama hatalarının erken hasar mekanizmalarına etkisi ortaya konmuştur. Hidrofobik kaplamalar, konsolidasyon, biyosit uygulamaları ve mikro-çatlak enjeksiyonu gibi modern koruma teknolojileri literatürden derlenmiş; sürdürülebilirlik perspektifinden düşük gömülü enerji, yaşam döngüsü analizi ve geri dönüşüm potansiyeli değerlendirilmiştir. Bu derleme, jeoloji, laboratuvar testleri, mühendislik tasarımı, şantiye uygulaması ve bakım aşamalarını kapsayan entegre bir süreç yönetimi modeli önermekte ve proje başlangıcında kullanılabilecek kapsamlı bir kontrol listesi sunarak mimari cephe tasarımında bilimsel veri temelli karar verme sürecine katkı sağlamayı amaçlamaktadır.

Anahtar Kelimeler: Doğal taş, Mimari cephe, Taş patolojileri, Mekanik ankraj, Sürdürülebilirlik

INTRODUCTION

Natural stone has been used throughout history as one of the most enduring building materials that shaped the identity of civilizations. In this process extending from ancient times to the present day, stone has become one of the fundamental components of architectural structures through its durability, aesthetic value, and power to reflect local identity. In modern architecture, natural stone is being redefined as a ‘‘high-performance façade material’’ beyond its traditional use, incorporating engineering calculations, laboratory analyses, and detailed solutions. Within this framework, natural stones are systematically examined in accordance with their physical and mechanical properties, durability performance, deterioration mechanisms, and design and application principles in architectural use [1].

The performance of a stone on a façade is determined during the geological formation process that began millions of years ago. When examining the volumetric composition of the Earth's crust, it is observed that approximately 95% consists of igneous and metamorphic rocks, while 5% consists of sedimentary rocks; conversely, in terms of surface area, approximately 75% of the Earth's crust is covered with sedimentary rocks and 25% with igneous/metamorphic rocks [2]. The physical and chemical properties that differentiate based on geological origin directly shape the material's response to specific climatic conditions, mechanical loads, and environmental impacts. Therefore, determining the correct stone selection and appropriate application strategy is of critical importance for the long-lasting and safe operation of the façade. Additionally, the porosity level of the stone and water movement within its structure are among the fundamental parameters that determine the long-term durability of the material by triggering physical deterioration processes such as freeze-thaw cycles and salt crystallization [3]. Aggregate production data on the scale of Turkey also supports this picture: approximately 96% of production in aggregate operations consists of sedimentary carbonate rocks (limestone, dolomite, and calcite), 3% from volcanic rocks (basalt and andesite), and 1% from detritic rocks (sandstone, etc.) [4],[5].

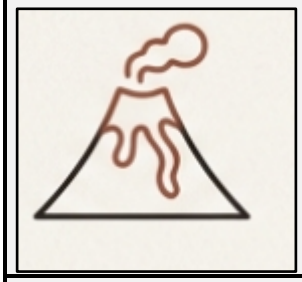
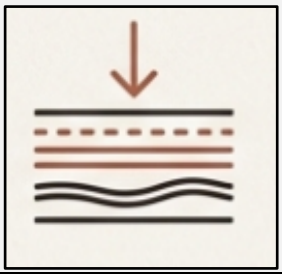
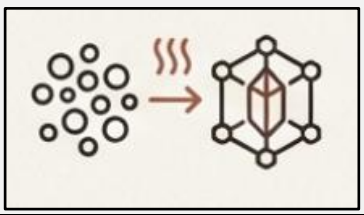
This study examines the process extending from the geological origin of natural stone to its life cycle on the façade. The physical and mechanical properties of igneous, sedimentary, and metamorphic stone types, surface finishing techniques, success and risk factors in field applications, modern protection techniques, and sustainability criteria have been analyzed. Through pathology examples compiled from the literature, the consequences of incorrect stone selection, climate incompatibility, and application errors have been demonstrated. The study presents an evaluation that can integrate material science, engineering, application techniques, and

sustainability perspectives; it aims to contribute to the scientific data-based decision-making process in architectural façade design through a checklist covering all stages from correct stone selection to maintenance.

GEOLOGICAL ORIGIN AND PERFORMANCE CHARACTERISTICS OF STONE TYPES

The performance of a stone in a façade is encoded in its formation process that began millions of years ago. Geological origin directly determines the physical and mechanical properties of natural stones and shapes the material's behavior in architectural façade applications. Igneous stones (granite, basalt) form under high pressure and density, acquiring high compressive strength, low porosity, and superior abrasion resistance. Sedimentary stones (limestone, travertine) form as a result of the accumulation and compression of particles; they exhibit variable porosity, moderate compressive strength, and generally high water absorption capacity. Metamorphic stones (marble, quartzite), on the other hand, gain a homogeneous and dense texture through recrystallization under heat and pressure, offering high strength characteristics. These geological differences make it essential to consider climatic conditions, location of use, and mechanical requirements in stone selection [6].

Table 1. Rock types and their basic characteristics

	*Igneous Rocks:* (e.g., Granite, Basalt) *Characteristic:* Formation under high pressure and density *Performance:* High compressive strength, low porosity, resistance to wear [7].
	*Sedimentary Rocks:* (e.g., Limestone, Travertine) *Characteristic:* Accumulation and compaction of particles *Performance:*Variable porosity, moderate compressive strength, generally high water absorption capacity [8].
	*Metamorphic Rocks:* (e.g., Marble, Quartzite) *Characteristic:* Recrystallization under heat and pressure *Performance:* High strength, homogeneous and dense texture [9].

ENVIRONMENTAL AND STRUCTURAL IMPACT FACTORS IN NATURAL STONE FACADE SYSTEMS

Mechanically anchored natural stone facade systems are subjected to various environmental and structural impacts throughout their service life. Wind load creates positive and negative pressure (suction) forces, generating continuous stress on panels and anchors; as this effect increases in high-rise buildings, anchor design becomes critically important. Seismic effects produce lateral loads that must be considered in connection details and joint spacing due to earthquake acceleration. Thermal expansion causes stone panels to expand and contract due to day-night and seasonal temperature differences; failure to provide this freedom of movement can lead to stress and cracking in the panels. The freeze-thaw cycle creates internal pressure as water entering the stone's pores freezes and increases in volume by 9%, causing surface spalling (delamination). Finally, salt crystallization creates enormous internal pressure that bursts the stone surface, as salt crystals grow in the pores when salt water rising from the ground or mortar through capillaries evaporates. Proper analysis and integration of these five fundamental impact factors into the design is essential for the facade system to be durable and safe [10].

NATURAL STONE FACADE INSTALLATION SYSTEMS: COMPARISON OF ANCHORED AND ADHESIVE BONDING METHODS

Two fundamental installation systems are used in natural stone facade applications: anchored (dry) systems and adhesive bonding systems. These two methods exhibit significant differences in terms of installation principle, structural performance, application scope, and cost.

Anchored (Dry) Systems

This system is based on the principle of suspending stone panels to the load-bearing structure using mechanical fastening elements (anchors). In this system, a layered structure is created comprising the load-bearing wall, thermal insulation, the air cavity required for the ventilated facade (minimum 20-40 mm), and the metal support system/anchors. Anchors are typically manufactured from stainless steel (SS316 or SS304) or aluminum alloys, and a minimum of four-point connection is recommended for each panel. The fundamental advantages of the system include being the most reliable method, offering the only solution for large and heavy panels (50-100 kg/m²), enhancing energy efficiency through water management, vapor diffusion, and building control enabled by the air cavity created between the stone and wall, providing three-dimensional precision adjustment capability during installation, enabling panel replacement in case of damage, and providing flexibility against structural movements (thermal expansion, seismic effects). In anchored systems, joint width is typically maintained between 6-10 mm, and rainwater drainage is provided through open joint application. As shown in Figure 1, this system, which is based on the principle of suspending stone panels to the load-bearing wall using mechanical fastening elements (anchors), is one of the fundamental solutions providing high structural reliability, particularly for large-scale and heavy panels. The air cavity created between the stone cladding and the wall effectively supports water drainage and condensation control within the ventilated facade principle, thereby enhancing the performance of the building envelope and contributing to energy efficiency. Furthermore, the ability to make precise adjustments during the installation process is considered an important advantage in terms of managing application tolerances and improving final surface quality [11].

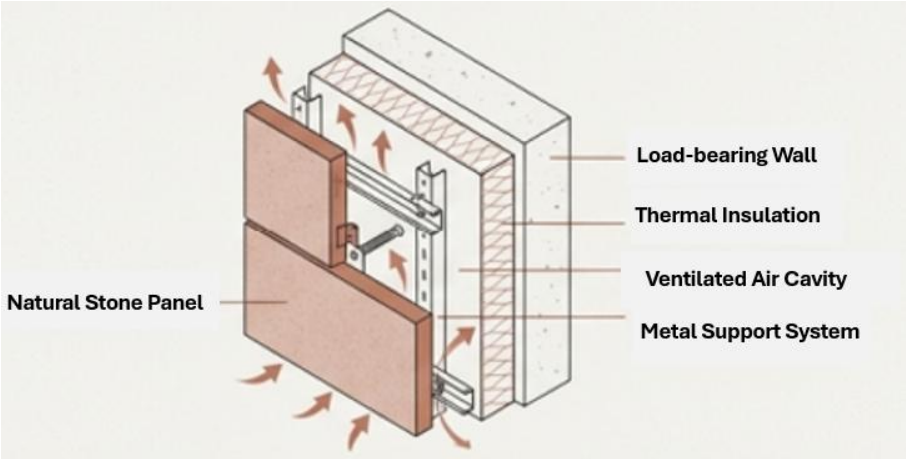


Figure 1. Anchored dry systems

Adhesive Systems

It is based on the principle of bonding the stone directly to the substrate using special adhesive mortars (elastic cement-based or epoxy-based). In this method, the mortar can be applied using full-bed or spot-bedding technique, however the full-bed method is considered more reliable. Adhesive systems are generally suitable only for small-sized (maximum 30x60 cm) and lightweight stones (maximum 25-30 kg/m²), and are preferred in interior spaces or low-rise buildings. Risk factors include limited flexibility against thermal movements, sensitivity to substrate defects (irregularities, moisture, weak bonding), aging of the adhesive over time, and risk of bond loss. Among the most important limitations of the adhesive system are size and weight restrictions, lack of drainage and ventilation capacity, nearly impossible replacement of damaged panels, poor performance on external facades exposed to UV and moisture effects, and long-term reliability uncertainty. Furthermore, in adhesive systems, the water absorption rate of the stone panel is of critical importance; in highly porous stones (above 5%), the risk of staining increases due to moisture absorbed from the adhesive.

In terms of cost, while adhesive systems appear 30-40% more economical initially, anchored systems constitute a more sustainable investment when long-term maintenance, impossibility of repair, and safety risks are taken into account. In high-rise buildings (4 floors and above), anchored systems become mandatory due to wind load and seismic effects; adhesive systems do not meet safety standards. The choice between these two systems should be made considering the project scale, panel dimensions, stone type and weight, climate conditions, structural requirements, safety standards, maintenance plan, and budget conditions. International standards (DIN 18516, ASTM C1242) and national regulations recommend the use of anchored systems in high-risk applications. As shown in Figure 2, this application, which is based on bonding the stone directly to the substrate using special adhesive mortars, offers a practical solution under certain conditions but contains various limitations. The method is generally limited to small-sized and relatively lightweight stone elements in terms of the behavior of the structural and cladding system, and is not suitable for large spans or high-mass panels. Additionally, it may exhibit more sensitive performance against movements caused by thermal expansion and contraction and possible defects in the substrate, thereby increasing the risks of detachment, cracking, and adhesion loss. At the same time, the lack of drainage and ventilation capacity may adversely affect moisture management, creating disadvantages in terms of long-term durability and building envelope performance [12].

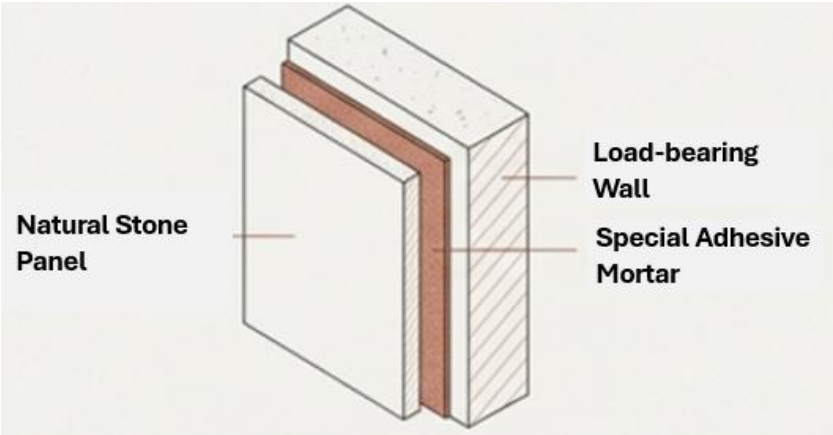


Figure 2. Adhesive systems

As shown in Figure 3, surface finishing processes of natural stone are considered key design and implementation parameters that directly affect both aesthetic perception (color, texture, and gloss) and functional performance (slip resistance, staining resistance, and suitability for the intended use).



Figure 3. Comparison of natural stone surface finishing methods

Polished: Makes the surface reflective, deepens color and texture. It is more resistant to staining as it seals the pores.

Honed: Offers a matte and smooth surface. It does not reflect light, providing a modern and soft appearance.

Sandblasted: Creates a rough and grainy texture. As the slip resistance increases, it may become more prone to staining.

Flamed: The roughening of the surface by thermal shock, especially in silicate stones such as granite. It is ideal for outdoor flooring.

CNC Processing: Modern technology enables the creation of unlimited three-dimensional patterns and forms on stone.

Deterioration Mechanisms In Natural Stones Due To Environmental Factors

The main deterioration mechanisms that develop as a result of natural stones' exposure to outdoor conditions are presented in Figure 4. Atmospheric pollutants and chemical components carried to the stone surface by precipitation can cause loss of surface details and material weakening through reactions such as dissolution and carbonation, especially in carbonate-based stones. The transport of moisture within the porous structure and crystallization of salts in evaporation zones triggers

surface scaling and spalling by increasing internal stresses caused by crystal growth. Similarly, the volumetric changes of water in the pores during freeze-thaw cycles creating repetitive stress leads to the progression of microcracks and eventual disintegration of the material over time. Additionally, while UV radiation accelerates oxidation and color change processes in some minerals, biological colonization (moss, lichen, etc.) on the surface both creates aesthetic deterioration and can support decomposition through biochemical effects [13].

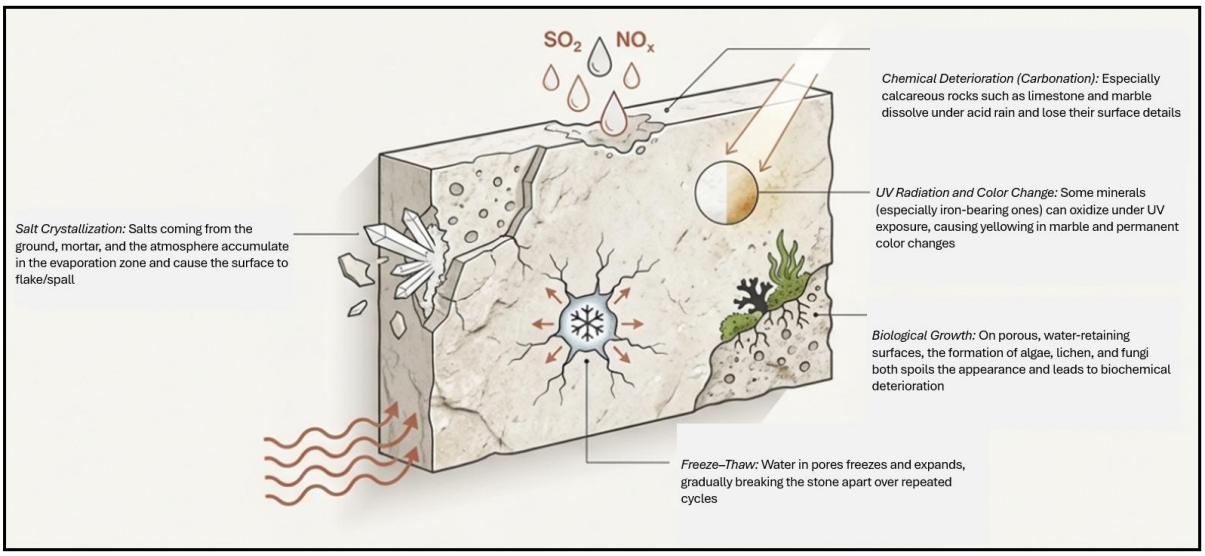


Figure 4. Main types of deterioration in natural stones and their contributing factors

As seen in Figure 5, irregular yellow and brown stains may develop on the surface of white marble panels within a few years. The primary cause of this form of deterioration is the oxidation of iron-bearing minerals within the stone (especially pyrite) in the presence of water and oxygen, with UV radiation acting as a catalytic influence, producing rust products on the surface. At the same time, this staining indicates the adverse long-term aesthetic and performance consequences that can result from selecting stone without sufficiently evaluating its mineralogical composition.



Figure 5. Yellowing on a marble façade

Especially following the winter period, as shown in Figure 6, thin-layer peeling, flaking, and the resulting material loss can be observed on the surface of travertine. This form of deterioration is associated with travertine's high water absorption capacity: after becoming saturated due to moisture, it is subjected to repeated freeze–thaw cycles. The volumetric expansion of water within the porous structure during freezing increases internal stresses, triggering microcrack formation

and layered detachment from the surface; as the process repeats, the rate of disintegration accelerates. This finding indicates that the selected stone does not meet adequate strength and suitability criteria for climatic conditions with frost risk, and that climatic effects must be treated as a key parameter in material selection.



Figure 6. Flaking (scaling) on the surface of travertine

As shown in Figure 7, the detachment and fall of a heavy granite panel from the façade of a high-rise building indicates a significant loss of load-bearing capacity in the mechanical anchorage system. Possible root causes of this type of damage include insufficient tightening of anchor bolts to the specified torque values, selection of an anchor type incompatible with the structural system and loading conditions, or excessive enlargement of the anchor hole beyond tolerance during installation, preventing the connector from achieving effective interlock and proper seating. Under the effects of vibration, wind loads, and thermal movements during service, these deficiencies can lead to progressive loosening of the connection and ultimately to the panel separating after losing its safe load-carrying capacity. Therefore, this is considered a fabrication and installation defect related to shortcomings in application and installation quality control, rather than a material defect.

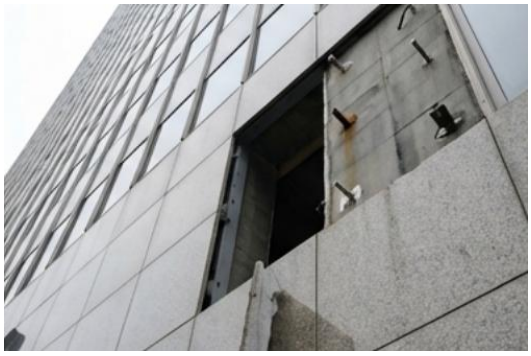


Figure 7. Granite panel detachment and fall (panel falling)

MODERN CONSERVATION AND RESTORATION TECHNIQUES

Hydrophobic Coatings (Water Repellents)

Hydrophobic coatings are surface protection products intended to reduce the capillary water absorption of natural stone, while still allowing a certain degree of water vapour diffusion without completely blocking the pore structure. Such applications can reduce the likelihood of freeze–

thaw-induced internal stresses by delaying the stone's saturation. They may also provide protection against surface deterioration caused by salt crystallization by limiting the transport of dissolved salts within the stone and their crystallization in evaporation zones. Prior to application, product selection should be based on an assessment of the stone's mineralogical structure, porosity, and existing degree of deterioration. Potential side effects, such as reduced breathability due to film formation on the surface or colour changes, should also be considered [14].

Consolidation (Stone Strengtheners)

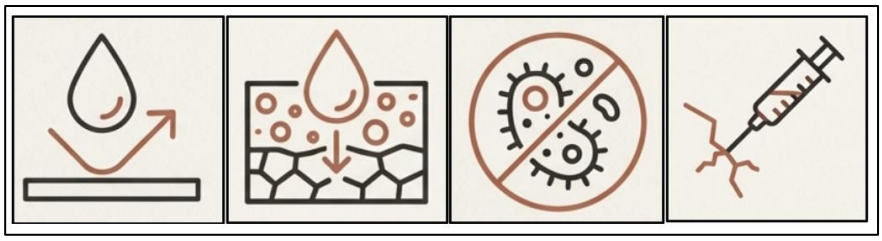
Consolidation treatments are interventions aimed at re-integrating the internal structure of stones whose cohesion has decreased, particularly due to disintegration, granular disaggregation, and loss of the binding phase. Silicate-based consolidants penetrate the porous matrix of the stone and, through reaction and gel formation, aim to strengthen intergranular bonds, thereby improving mechanical properties such as compressive strength and surface integrity. Since effectiveness depends on pore size distribution, moisture condition, and the depth of deterioration, preliminary tests should be conducted to evaluate penetration depth and mechanical gain prior to application. In addition, because excessive consolidation may increase brittleness, reduce vapour permeability, or create differences in surface gloss, it is recommended that the intervention be designed within the framework of the "minimum intervention–maximum compatibility" principle [15].

Biocide Applications

Biocide applications are chemical interventions used to control colonization by mosses, lichens, algae, and bacteria on stone surfaces, and to reduce biologically induced discoloration and biochemical decay processes. Although these treatments can facilitate removal of the biological layer, they may not provide a permanent solution on their own, since recolonization is often directly related to moisture sources, surface roughness, and environmental conditions. Therefore, the selection of the biocide and the application protocol should be determined according to the type of stone and the characteristics of the existing biological growth. After treatment, the surface should be stabilized through mechanical and or chemical cleaning, and the risk of regrowth should be reduced through moisture-management measures, such as improving drainage and minimizing water-retaining details. Within a conservation approach, the toxicity and persistence of biocides should also be evaluated in terms of environmental impact and user health [16].

Micro-Crack Injection

Micro-crack injection is a repair technique aimed at controlling discontinuities by filling cracks that may adversely affect the load-bearing capacity and durability continuity of stone elements. Injection using epoxy or specialized binding mortars can penetrate the crack network under appropriate viscosity and pressure conditions, fill voids, and help reduce stress concentrations at crack tips. However, the success of the intervention depends on correctly identifying whether the cracks are active or passive, ensuring material compatibility (elastic modulus, thermal behaviour, adhesion, vapour permeability), and selecting application parameters that do not damage the stone's original texture. For this reason, injection should be considered only after a structural risk assessment has been carried out and, where necessary, together with detailing and environmental improvements aimed at eliminating the causes of cracking. Figure 8 presents the main methods used in the conservation and repair of natural stone [17].



a) b) c) d)

Figure 8. Basic methods used in the conservation and repair of natural stones

LIFE-CYCLE APPROACH IN NATURAL STONE FAÇADES: ORIGINDATADESIGN-IMPLEMENTATION-MAINTENANCE

As shown in Figure 9, the performance of natural stone façade systems is ensured holistically not only through the aesthetic characteristics of the material, but also by correctly interpreting the geological origin, generating laboratory data, converting these data into engineering design, implementing the design on site with correct details and tolerances, and finally supporting the operation and maintenance phase with proactive protection strategies. Since each stage of the process directly affects the next step, deviations such as incorrect stone selection, insufficient or incomplete test data, faulty sizing, or workmanship defects can create critical risks for system safety and long-term durability. Therefore, for stone façades to be operated in a long-lasting, safe, and sustainable manner, a life-cycle approach requires continuous interdisciplinary coordination and quality control [18].

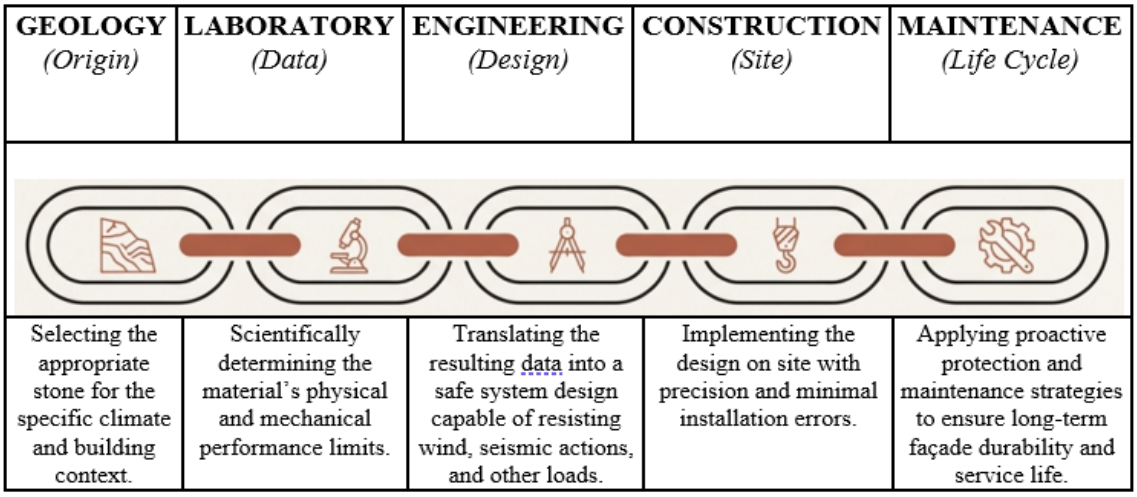


Figure 9. From geology to maintenance: Integrated process schematic

FULL CYCLE: SUSTAINABILITY AND LIFE CYCLE OF NATURAL STONE

When evaluating natural stone as a sustainable façade material, the decisive role of the life-cycle perspective, as shown in Figure 10, becomes evident. Compared to industrial materials, natural stone generally requires relatively low embodied energy in the production process and can be sourced directly from the quarry; therefore, it should be addressed within the framework of Life Cycle Assessment (LCA) in order to analyze environmental impacts in a holistic manner. LCA supports informed material choices by enabling the calculation of indicators such as carbon

footprint and water consumption throughout the stages from quarry extraction to processing, transportation, the use phase, and the end of the building's service life. At the same time, properly designed stone façade systems provide long service life and durability, reducing the need for maintenance and renewal and thus limiting resource use and waste generation. At the end of the building's life, the possibility of dismantling stone panels for reuse or crushing them for recycling into alternative uses such as aggregate further improves the material's environmental performance in line with the principles of the circular economy [19].

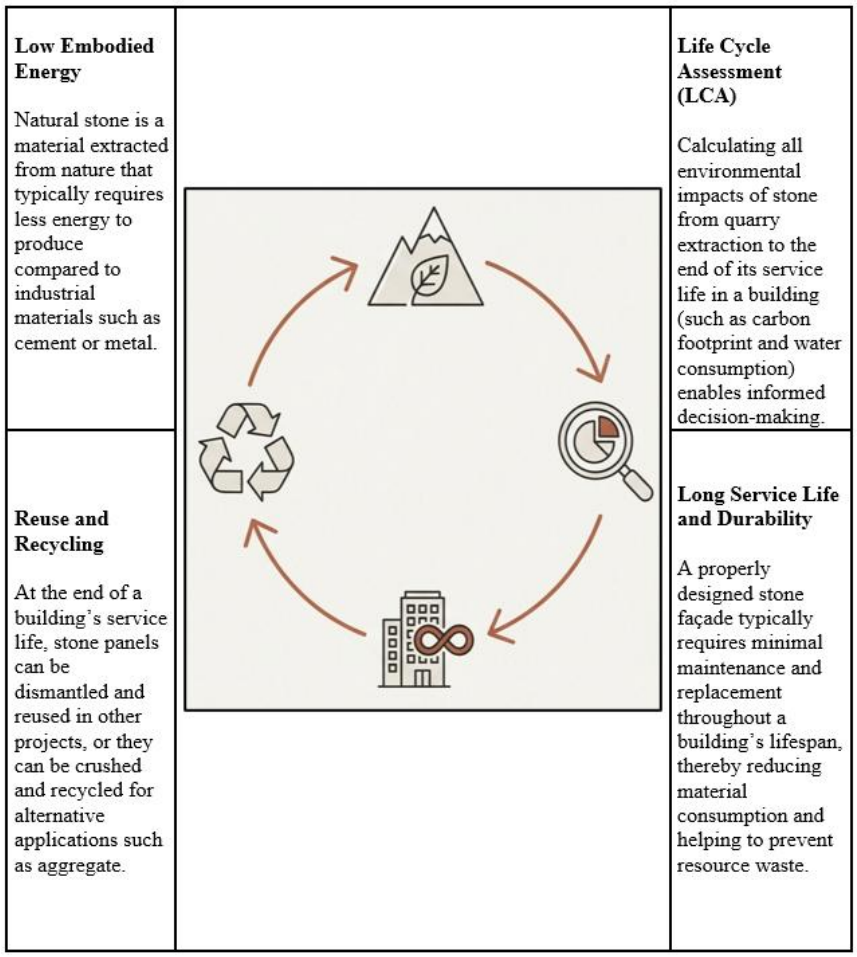


Figure 10. Sustainability performance of natural stone

CONCLUSION

This study demonstrates that the performance of natural stone in architectural façades is not determined solely by visual qualities, but must be addressed in an integrated manner through geological origin, materials science data, engineering design, on-site workmanship quality, and maintenance and operation processes. The findings show that parameters shaped by the stone's formation over millions of years, such as mineralogical and petrographic structure, porosity, and water absorption behavior, directly influence its resistance to environmental factors including freeze–thaw cycles, salt crystallization, chemical weathering (especially dissolution and carbonation in carbonate stones), UV induced color change, and biological colonization. Therefore, façade performance is a process that "begins in the material" but is "completed in the system." It was assessed that when proper stone selection is not supported by appropriate

installation principles and is not managed throughout the life cycle, problems ranging from aesthetic deterioration to structural safety risks can inevitably occur.

Based on geological classification, igneous, sedimentary, and metamorphic stones exhibit different performance profiles. It was concluded that although igneous stones benefit from low porosity and high strength, they require careful detailing and considerations related to workability, whereas sedimentary stones demand a more sensitive evaluation in terms of climate compatibility and surface protection strategies due to variable porosity and water absorption capacity. Metamorphic stones (e.g., marble, quartzite) can show high strength thanks to dense and homogeneous textures, but depending on mineral content, they may be susceptible to chemical processes such as discoloration and staining. The pathology cases presented in the study support these observations with field data. For example, irregular yellow-brown staining developing in marble panels within a few years can be associated with the oxidation of iron-bearing minerals in the presence of water and oxygen, with UV acting as a catalytic factor. Likewise, layered spalling observed in travertine after winter periods was emphasized as being accelerated by high water absorption and repeated freeze–thaw cycles. These findings indicate that incorrect stone selection is often not only an aesthetic issue, but also a performance defect arising from neglecting the material's climatic and physical limits.

In terms of installation systems, the comparison showed that anchored (dry) systems play a decisive role in high-performance façade applications, particularly by ensuring safe support for large and heavy panels, enabling moisture management through ventilated façade principles, and providing flexibility for maintenance and renewal. In contrast, adhesive systems were assessed as potentially increasing risk levels in exterior façades and high-rise buildings due to size and weight limitations, the absence of drainage and ventilation capacity, and greater sensitivity to substrate defects and thermal movements. In addition, critical damage scenarios, such as a heavy granite panel detaching and falling from a high-rise building, were found to be related in most cases not to material defects, but to errors in anchor selection and installation (insufficient torque, incorrect anchor type, hole enlargement beyond tolerance, and deficiencies in quality control). Thus, façade safety was concluded to depend not only on engineering design, but also on on-site execution discipline and inspection mechanisms.

Surface finishing processes (polished, honed, sandblasted, flamed, CNC, etc.) were identified not merely as aesthetic choices, but as design inputs that determine performance through slip resistance, soiling tendency, water retention behavior, and the degree of exposure to external effects. Accordingly, the effectiveness of protection and restoration practices (hydrophobic coatings, consolidation, biocide applications, micro-crack injections) is directly linked to the stone's pore structure, the type of existing deterioration, and moisture management conditions. For this reason, it was emphasized that intervention selection should adopt a "diagnosis and compatibility-oriented" methodology rather than a "product-oriented" approach. In particular, applications that reduce vapor permeability and trap moisture inside the stone may provide short-term protection but can trigger different deterioration mechanisms in the long term.

Another key outcome of the study is the necessity of evaluating the sustainability performance of natural stone through a life-cycle approach. The fact that natural stone may have lower embodied energy than many industrial materials should not be treated as sufficient evidence of sustainability on its own. By using Life Cycle Assessment (LCA) to quantitatively determine environmental impacts (carbon footprint, water consumption, etc.) across extraction, processing, transport, installation, use, and maintenance phases, and even through dismantling, reuse, and recycling scenarios, a comparable decision basis is provided among material and system alternatives. The long service life and low renewal need of well-designed stone façades offer a significant advantage in terms of resource efficiency, and the potential to dismantle panels for reuse or recycle them as aggregate at the end of service life is consistent with circular economy principles.

For natural stone façades to be implemented safely, durably, and sustainably, it is necessary to operate the following steps as an integrated whole: correct material selection based on geological origin and mineralogical composition, scientific determination of physical and mechanical limits through laboratory tests, development of engineering design that accounts for wind, seismic actions, thermal movements, and moisture effects, error-free on-site installation based on tolerance, connection, and quality control criteria, and performance management throughout the life cycle via proactive maintenance and protection strategies. The checklist approach proposed within the scope of this study contributes to treating these steps as an interconnected process chain, providing an applicable framework for promoting a data-driven decision-making culture in architectural façade design and reducing field-induced pathologies.

KAYNAKÇA

[1] Siegesmund, S., & Snethlage, R. (2011). Stone in Architecture: Properties, Durability Springer.

[2] Lutgens, F. K., Tarbuck, E. J., & Tasa, D. (2012). Essentials of geology (11th ed.). Pearson Prentice Hall.

[3] Winkler, E.M. (1997) Stone in Architecture: Properties, Durability. 3rd Edition, Springer-Verlag, Berlin, 313.

[4] Öztürk, Ö., Çelikol, M., & Erkan, M. (2007). Türkiye agrega sektör raporu. Hazır Beton, 84, 52-56.

[5] Gülen, M., Selçuk, M. E., & Kocan, M. (2025). Donma-çözülme döngülerinin İstanbul ili ve çevresinde yer alan kireçtaşının CBR (%) değerlerine etkisi. *Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi*, *25*, 1126–1137. https://doi.org/10.35414/akufemubid.1607298.

[6] British Standards Institution. (2010). *BS 8298-1:2010: Code of practice for the design and installation of natural stone cladding and lining—Part 1: Code of practice for stone cladding mechanically fixed*.

[7] Tarbuck, E. J., Lutgens, F. K., & Tasa, D. (2017). *Earth: An introduction to physical geology* (12th ed.). Pearson. https://www.amazon.com/Earth-Introduction-Physical-Geology-12th/dp/0134074254.

[8] Bell, F. G. (2007). *Engineering geology* (2nd ed.). Elsevier.

[9] Winter, J. D. (2010). *Principles of igneous and metamorphic petrology* (2nd ed.). Pearson.

[10] British Standards Institution. (2010, December 31). *BS 8298-1:2010: Code of practice for the design and installation of natural stone cladding and lining—General*. BSI Knowledge. https://knowledge.bsigroup.com/products/code-of-practice-for-the-design-and-installation-of-natural-stone-cladding-and-lining-general.

[11] ASTM International. (2019). *ASTM C1242-19: Standard guide for selection, design, and installation of dimension stone attachment systems*. ASTM International.

[12] Malanho, S., & Veiga, M. do R. (2019). Bond strength between layers of ETICS – Influence of the characteristics of mortars and insulation materials. *Journal of Building Engineering*. https://doi.org/10.1016/j.jobe.2019.101021.

[13] Dal, M., & Yardımlı, S. (2021). Taş duvarlarda yüzey bozunmaları. *Kent Akademisi Kent Kültürü ve Yönetimi Dergisi, 14*(2), 428–451. https://doi.org/10.35674/kent.922313.

[14] Hashim, H., Dias, L., Martins, S., Pires, V., Costa, M., & Barrulas, P. (2024). Optimization of the application of commercial hydrophobic coatings for natural stone protection and preservation. *Heritage, 7*(7), 3495–3510. https://doi.org/10.3390/heritage7070165.

[15] Acun Özgünler S., 2007. Tarihi Yapılarda Kullanılan Volkanik Tüflerin Konservasyonu Üzerine Bir Araştırma: Od Taşı Örneği, İTÜ Fen Bilimleri Enstitüsü, Doktora Tezi.

[16] Pinna, D. (2014). Biofilms and lichens on stone monuments: Do they damage or protect? *Frontiers in Microbiology, 5*, 133. https://pmc.ncbi.nlm.nih.gov/articles/PMC3980096/.

[17] Selwitz, C. (2005). *Epoxy resins in stone conservation*. Los Angeles, CA: The Getty Conservation Institute.

[18] Sobieraj, J., Metelski, D., & Rostan, J. (2024). Thermal performance analysis and design evolution of ventilated stone facades: A case study of the Praski Student House (Akademik Praski) in Warsaw. *Buildings, 14*(11), 3558. https://doi.org/10.3390/buildings14113558.

[19] de Toldi, T., & Pestre, T. (2023). The relevance of cut-stone to strategies for low-carbon buildings. *Buildings and Cities*. https://doi.org/10.5334/bc.278.

ARTIFICIAL INTELLIGENCE AS A CONTEMPORARY MASS COMMUNICATION TOOL

ÇAĞDAŞ BİR KİTLE İLETİŞİM ARACI OLARAK YAPAY ZEKA

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ABSTRACT

Artificial intelligence, the latest product of technology, is one of the most debated topics both technically and ethically. The question of whether artificial intelligence poses a danger to humans is discussed in every field. Although the development of technology and the products it produces make people's work easier, they cause anxiety in some groups. Artificial intelligence, the most popular and most discussed technology of recent years, has entered people's lives with many opportunities and risks. In addition to being a tool that performs almost every job that humans do, artificial intelligence is also perceived as a tool that threatens humans. In this study, the relationship between media and artificial intelligence is discussed, the character of artificial intelligence is evaluated, and the contributions of artificial intelligence to media studies are emphasized. Artificial intelligence, the most popular technology of recent years, is now found in every field and is used in many sectors, from medicine to education. Although artificial intelligence makes things easier in some sectors, it also poses the risk of causing unemployment in some sectors, which causes many concerns in the hypermodern world.

Key Words: Artificial Intelligence, Mass Media, Technology, Hypermodern Life

Özet

Teknolojinin son ürünü olan yapay zeka, hem teknik hem de etik açıdan en çok tartışılan konulardan biridir. Yapay zekanın insanlar için bir tehlike oluşturup oluşturmadığı sorusu her alanda tartışılmaktadır. Teknolojinin gelişimi ve ürettiği ürünler insanların işini kolaylaştırsa da bazı kesimlerde kaygıya neden olmaktadır. Son yılların en popüler ve en çok tartışılan teknolojisi olan yapay zeka, insanların hayatına birçok fırsat ve riskle girmiştir. Yapay zeka, insanların yaptığı hemen her işi yapan bir araç olmasının yanı sıra, insanları tehdit eden bir araç olarak da algılanmaktadır. Bu çalışmada, medya ve yapay zeka arasındaki ilişki ele alınmış, yapay zekanın karakteri değerlendirilmiş ve yapay zekanın medya çalışmalarına katkıları vurgulanmıştır. Son yılların en popüler teknolojisi olan yapay zeka artık her alanda bulunmakta ve tıptan eğitime kadar birçok sektörde kullanılmaktadır. Yapay zeka bazı sektörlerde işleri kolaylaştırsa da, bazı sektörlerde işsizliğe yol açma riski de taşıyor ve bu da hipermodern dünyada birçok endişeye neden oluyor.

Anahtar Kelimeler: Yapay Zeka, Kitle İletişim Araçları, Teknoloji, Hipermodern Yaşam

INTRODUCTION

Artificiality is the most popular approach of the last centuries. In fact, artificiality, which gained rapid momentum with the Neolithic Revolution, became even more widespread with the changing lifestyles and trends after the Industrial Revolution. In later times, artificiality became a popular approach and application with the perception of it as a show and comfort. While the first shelters, the first clothes, the first art structures inspired by nature were the results of necessity, the last centuries have been the concept in which artificiality changed its meaning and application (Ehrmann, 2016: 96).

It is known that media and journalism organizations actively use various artificial intelligence tools in their working environments. As the development of media technology progresses, it has become increasingly clear that the incorporation of artificial intelligence into various fields is not a futuristic concept, but a concrete reality. Synopsis of AI with writing, editing, producing and directing tools; has changed the fundamentals of approaches to the creation and reproduction of information, news and various contents (Aissani, etc.2023: 25). Ability to create content in one go using artificial intelligence-supported tools, producing at the same speed and therefore increasing productivity is attractive to newspaper publishers and leading media organizations (Steinhau etc, 2024: 41). The prevalence of artificial intelligence is increasing due to its contributions to the media.

Humans have a wide range of finely tuned motor skills. They have skills that enable them to perform complex tasks. This is how it performs tasks that require precision. Machines can also do this. They perform delicate tasks, but they rarely succeed. Media is also considered in this context (Hurtz, 2023: 10). Artificial intelligence (AI) has emerged from the world of science fiction and has become a real tool that can help society solve many problems in media, including the challenges faced by the news industry. Artificial intelligence in media can certainly make journalism easier for overloaded sources without replacing the unique skills of media workers. Additionally, artificial intelligence can foster new forms of engagement and leverage new products that can increase news media consumption (Lima-Santos and Ceron, 2021: 19). While technology is constantly evolving, the effects of artificial intelligence are also changing media work.

Artificial intelligence eases the burden of research, dissemination and publishing in the media world can contribute to the creation of media content (Zydorek, 2023: 15). Artificial intelligence, which changes scientific data and all kinds of elements in life, also reshapes the media. In the media, artificial intelligence now plays an active role in the design, realization and organization of shows (Schlütz and Zillich, 2025: 9). Media, like other fields, frequently uses artificial intelligence.

The media now uses the most advanced technologies and wants to address larger audiences. Especially in the field of journalism, whether artificial intelligence-based journalism meets the requirements of the journalism profession and the question is whether anthropogenic journalism fulfills its requirements (Oster, 2019: 36). Despite all the debates and concerns, the use of artificial intelligence in the media is increasing.

DEVELOPMENT PROCESS OF ARTIFICIAL INTELLIGENCE

Digital technology has been one of the great revolutions in history. Rapid increase in computing power of computers; economics, research and, last but not least, communication via social media generate large amounts of digital data. Intelligence is based on sensory perception, especially visual perception. Many experts in this field believe that 80 percent of what people learn every day comes from their eyes. Here certain patterns are created that determine thoughts. Newly emerging perceptions constantly try to interact with these patterns, complete or rearrange the stored ones

(Dengel et al., 2019: 15). While human nature has the potential and power to do these things, the same mind has designed machines that think and act instead of itself.

While people have developed techniques that make their lives easier, they have also invented techniques that allow them to access all the information in the world. Artificial intelligence is one of the most important and distinctive technological innovations that is reshaping all aspects of human life, starting from magnitudes such as shopping, data collection, driving, daily life, medical approach and many more. Artificial intelligence is now widely used in services, from back-office tasks to front-line interactions with customers (Bolton et al., 2018: 53). Prejudice, credibility and transparency are important issues in the hypermodern age, with intelligent systems generally representing greater objectivity and impartiality in implementation and decision-making (Bitkom e. V., 2017: 161). In the hypermodern age, where traditional tools and values are left behind, tools that make decisions for people have begun to dominate life.

“Since birth, people have been trying to replace the functioning of a part of the human brain with machines, according to the contemporary level of knowledge and technical conditions. After a long period of development of science and technology, until the beginning of the 20th century, some groundbreaking studies were carried out in the field of artificial intelligence. A historic conference held at Dartmouth College in the United States in 1956 has been regarded as marking the birth of the science of artificial intelligence. During the conference, McCarthy formally introduced the concept of artificial intelligence, which includes mathematics, computers, neurophysiology, psychology and other disciplines. From that point on, artificial intelligence technology began to develop as a formally emerging discipline” (Cao, 2017: 701). Artificial intelligence has always been at the forefront of computer science, and its theories and results are approaching the level that can greatly control science and technology and determine the direction of computer technology development.

It has always been people's dream to produce vehicles that do what humans do. Artificial intelligence is the ability of a machine to imitate human abilities such as logical thinking, learning, planning and creativity. Artificial intelligence enables technical systems to perceive their environment, deal with what they perceive, and solve problems in order to achieve a specific goal. Artificial intelligence systems can adapt their actions by analyzing the results of previous actions and working autonomously (Artikel, 2023: 5). In a robotic world, robots do many of the jobs of humans and seem to make life easier. Human beings, who are always in favor of the easy by nature, prefer a life dominated by smart machines (Braun et al., 2018: 22). Man, who has reached the digital age from the plow, lives in an age where the highest technology dominates life.

The central developments and technical foundations of artificial intelligence, its capabilities in certain fundamental areas that are particularly formative for humans, such as recognition, learning or action, and the idea of machines that resemble or even exceed human capabilities can be traced back to Greek mythology, dating back thousands of years before the invention of software systems. With the construction of the first computers in the 20th century, the existence of machine intelligence became accessible for the first time. In 1950, mathematician Alan Turing formulated a criterion for artificial intelligence, later known as the Turing test; Accordingly, machine intelligence will exist if the behavior of a machine appears to human observers to be indistinguishable from that of a human. Early research on artificial intelligence assumed that human learning or intelligence could be described in enough detail that a machine could be built to simulate it. From the very beginning, specific AI research topics that still play a role today include pattern recognition, language processing, ABSTRACTion ability, creativity, and flexible problem solving (Deutscher Ethikrat, 2023: 12). Actions that humans have been doing with their minds for hundreds of thousands of years are now performed by machines.

Social networks, robotics, and artificial intelligence are viewed as techniques of human culture that themselves become cultural environmental factors of human social behavior. High technology has created a new cultural life in the world with vehicles that think and act like humans (Funk et al., 2020: 37). Just as the computer replaced the typewriter, artificial intelligence is expected to replace many human actions. However, perhaps the most concerning development is that artificial intelligence produces productions by replacing the media (Haas, 2024: 245). Mass media are still tools that work with human intelligence and effort.

ARTIFICIAL INTELLIGENCE IN MEDIA

The impact of artificial intelligence on opinion formation and media production also raises legal, ethical and socio-political questions, especially distribution (Bayerische Landeszentrale für neue Medien, 2023: 1). Digitalization and the introduction of artificial intelligence (AI) in the media industry are having a formative impact on the industry. This situation raises many legal, social and ethical questions. Current media economics and media ethics approaches to artificial intelligence in the media industry, opportunities and challenges of integrating artificial intelligence into processes and production workflows in the media industry, aspects of quality assurance and control in the media industry have been frequently discussed recently (RTR Medien, 2024). Artificial intelligence seems to have a significant dominance over the media, as in other areas.

Artificial intelligence technologies lead to a multi-layered change in the media industry. Allowing for even greater personalization, semantic AI systems can also take over content-related work. There are numerous applications in the media for adaptive AI systems (Lossau, 2018: 7). Predicting future trends in the media industry is one of the biggest challenges, not only because of the number and variety that are conditioned by technological changes, but also because of the increasingly demanding media audience that expects personalized content. In this context, the role of AI, with its huge amount of data and analytics, occupies a key position at every stage of the value chain (Sančanin and Penjišević, 2022: 5). Artificial intelligence has work to do at every stage of media work.

The term “synthetic media” is used for media content created by or with the help of artificial means; artificial texts, images, sounds, Avatars, video game environments, and even synthetic humans and artificial news anchors are emerging with the help of artificial intelligence (Belfin, 2023: 37). While media content created with artificial intelligence is often described as unrealistic, texts created by artificial intelligence it is also claimed that people do not recognize him (Vogler etc. 2023: 43). Despite all its unreal appearance, the use of artificial intelligence in the media is rapidly spreading.

With artificial intelligence, the limits of subjective media education are being reached and applications in relevant disciplines and (pedagogical) application areas are realized for artificial intelligence, research fields and media education (Knaus, 2024: 26). It also appears as a future area of activity in the context of pedagogy.

Changes in society and users' need for fast information play a role in the use of artificial intelligence in the media sector. Especially rapid creation of online content, the increasing amount of data and the complexity of analyzing big data direct the media towards artificial intelligence. When an algorithm is already creating weather forecasts or reports it provides information about sports events and allows people, for example, researchers or those who need sensitive research, to focus on these issues. In addition, people's working time can be saved by delegating processes to algorithms (Greiner ve Michel, 2020: 4). Artificial intelligence provides cheaper and more efficient business environments in the media.

Artificial intelligence in media and mass communications is a transformative force that is revolutionizing the way information is produced, distributed and consumed. In today's digital age, technologies are easily reshaping the structure of media by automating tasks, improving content personalization, and learning all aspects of audience behavior. The uniqueness of AI lies in its ability to process large amounts of data and perform complex tasks that were previously laborious and time-consuming, such as natural language generation, real-time in-depth sentiment analysis, and predictive analytics. AI-powered tools are used to detect fake news, streamline important processes, create rich content, create photo/video content, and more (Iordanishvili and Kacharava, 2024: 12). Like other sectors, media now works on the basis of artificial intelligence.

These are all resources that people did not have before and they are now vital because they save people a lot of time is the most important thing for people today. What all artificial intelligence systems have in common is that they are based on machine learning, which aims to imitate human intelligent behavior (Engemann, 2024: 68). The media also benefits from this.

Artificial intelligence supports the entire production process in media, from newsroom and research to production. Algorithms, automation and artificial intelligence have become an indispensable part of any media brand's portfolio (Schützeneder etc. 2024: 8). Artificial intelligence is a tool that has the ability to produce all media products.

Artificial intelligence systems not only make journalistic work easier by distributing news, they can also support research activities and even write articles independently. In a sense, artificial intelligence has now reached the point of being able to produce all media works (MeMo:KI, 2022). Artificial Intelligence (AI) has significantly transformed digital media content creation, particularly with the rise of AI-Generated Content (AIGC). AIGC applications—spanning micro-video production, digital storytelling, journalism, and new media art—highlight its profound impact on content workflows, distribution, and audience engagement (Shao and Yin, 2025: 11). Artificial intelligence is now at a level where it can produce all media products.

Supporting creative activities through artificial intelligence tools and applications, using existing content to create new content and formats, improving tools for media production and processing, it is clear to many in computer science and beyond that a major wave of automation is very likely to occur, even though the functionality is not yet developed. emerges (Schmidt, 2023). AI-powered tools enable automated content production, data-driven decision-making, and the development of immersive media experiences (Abed and Farrokhi, 2025). This increases the effectiveness of artificial intelligence in the media.

Driverless cars, humanoid robots, adaptive nanodrones or smart supermarkets While developing rapidly, the relationship between media and artificial intelligence, the media of artificial intelligence and the approach to neoliberal capitalism and its social model continue to be discussed (Klimczak etc., 2019: 45). Opinions that artificial intelligence can produce media without the traditional approaches and experiences of the media are becoming widespread and discussed (Trejos-Gil and Gómez-Monsal, 2024: 22). This paves the way for further discussion.

According to Spengler or Heidegger, technology will remain essentially untouched as long as it is a human form. The technology necessary for development will be beneficial to humans as long as it takes human qualities into account. Artificial intelligence is also considered in this context (Schnödl, 2019: 133). As long as artificial intelligence does not ignore human existence and human experiences, it is considered natural to produce media.

CONCLUSION

While technology develops mind-blowingly every day, it also brings with it many risks and concerns. Artificial intelligence, the most popular product of technology recently, is now used in many areas. Artificial intelligence, which plays important roles in various fields from medicine to education, makes things easier, but also causes concerns.

Techniques that make people's lives easier and increase efficiency are becoming more advanced every day. Artificial intelligence, which can do almost everything that humans can do with its algorithms, creates controversy about the quality of what it produces. It is also discussed whether the products produced by artificial intelligence, which has now become one of the main production tools of the media, are real or not.

Artificial intelligence, which makes things easier in areas important to human life, is undoubtedly becoming widespread very quickly. Media are the tools that direct the hypermodern age and have an impact on the world. Artificial intelligence, which can produce media productions produced by humans, from news to dramas, is frequently used by the media in the hypermodern age, when technology has established wide dominance all over the world.

The rapid advancement of Artificial Intelligence (AI) has also significantly transformed digital media content creation, particularly with the rise of AI-Generated Content (AIGC). AIGC applications spanning micro-video production, digital storytelling, journalism, and new media art highlight its profound impact on content workflows, distribution, and audience engagement.

Media has traditions, disciplines and approaches that have been formed over hundreds, even thousands of years. Artificial intelligence has undoubtedly emerged as a result of thousands of years of technical experience. However, it is of course controversial that artificial intelligence produces by ignoring the historical experiences and discipline of the media. However, artificial intelligence is progressing in producing media on its own.

Transformation of digital media contents by artificial intelligence is another dimension of the issue. Artificial intelligence is changing both life and the era with various functions and productions. Getting the most efficiency from artificial intelligence depends on using it correctly.

REFERENCES

Abed, N. and Farrokhi, N. (2025). The Role of Artificial Intelligence in Media Communications. AI and Tech in Behavioral and Social Sciences, 3 (1).

Aissani, R. and Abdallah, R. A. and Taha, S. and Al Adwan, M. N. (2023). Artificial Intelligence Tools in Media and Journalism: Roles and Concerns. 2023 International Conference on Multimedia Computing, Networking and Applications (MCNA), 19-22 June 2023, Valencia, Spain.

Artikel (2023). Was ist künstliche Intelligenz und wie wird sie genutzt? Brussels: E Generaldirektion Kommunikation Europäisches Parlament - Sprecher: Jaume Duch Guillot.

Bayerische Landeszentrale für neue Medien (2023). Leitlinien des Medienrats. https://www.blm.de/files/pdf2/ki-leitlinien-v1.pdf, 03.02.2025.

Belfin, R. (2023). Künstliche Intelligenz im Mediensektor Themenüberblick zu Möglichkeiten, Einsatz, Herausforderungen & Lösungsansätze. Einsatz künstlicher Intelligenz im Mediensektor Anwendungen, Möglichkeiten, Herausforderungen & Optionen, Wien: Rundfunk und Telekom Regulierungs-GmbH, pp. 36-51.

Bitkom e. V. (2017). Künstliche Intelligenz Wirtschaftliche Bedeutung, gesellschaftliche Herausforderungen, menschliche Verantwortung. Berlin: Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e. V.

Braun, T. ve Eckerstorfer, A. ve Kneißl, R. ve Köhl, J. ve König, F. ve Lebek, M. ve Ottwald, T. ve Trost, C. ve Vollmer, S. (2018). Künstliche Intelligenz – KI. file:///C:/Users/Lenovo/Desktop/2018-04%20KI_Final%20Document%20from%20Students.pdf, 19.11.2024.

Cao, Z. (2017). Development and Application of Artificial Intelligence. Advances in Computer Science Research, 70: 701-704.

Dengel, A. ve Socher, R. ve Kirchner, R. A. ve Ogolla, S. (2019). Künstliche Intelligenz Die Zukunft von Mensch und Maschine. Hamburg: ZEIT Akademie GmbH.

Deutscher Ethikrat (2023). Mensch und Maschine – Herausforderungen durch Künstliche Intelligenz. Berlin: Deutschen Ethikrat.

Ehrmann, D. (2016). Künstliches Leben. Biologisches Wissen und die Politik der Künste. Lebenswissen, Ed. Peter Schnyder, Judith Preiss, Benjamin Brückner, Rangsdorf: Natur+Text Verlag, s. 75-96.

Engemann, M. (2024). Künstliche Intelligenz im (Fach-)Unterricht. Einsatz von ChatGPT bei der Fallarbeit im Pädagogikunterricht. Medien – Bildung – Forschung. Integrative und interdisziplinäre Perspektiven, Ed. Aßmann, Sandra; Grafe, Silke; Martin, Alexander; Herzig, Bad Heilbrunn: Verlag Julius Klinkhardt, pp. 67-83.

Funk, M., ve Frauenberger, C.,ve Reichl, P. (2020). Vom künstlichen Leben zur Lebenskunst: Was die Ethik digitaler Bildung von ökologischer Verantwortung lernen kann. Medienimpulse: Beiträge zur Medienpädagogik, 58 (3): 26-50.

Greiner ve Michel, 2020 Künstliche Intelligenz im TV. Unpublished Master's Thesis, Hochschule der Medien Stuttgart Wissenschaftliche Arbeit im Master-Studiengang Audiovisuelle Medien.

Haas, J. G. (2024). Soziale Medien und künstliche Intelligenz: eine alte Allianz und neue Folgen. Psychologie in Österreich, 3: 243-247.

Hurtz, S. (2023). Was können wir, was Maschinen nicht beherrschen? Tendenz, 2 (23): 7-10.

Iordanishvili, T. and Kacharava, K. (2024). The Impact of Artificial Intelligence on The Media. Moambe International Precised and Reviewed International Precised and Reviewed Scientific-Practical Magazine, 53: 9-13.

Klimczak, P. Kusche, I. ve Tschöpe, C. ve Wolf, M. (2019). Menschliche und maschinelle

Entscheidungsrationalität Zur Kontrolle und Akzeptanz Künstlicher Intelligenz. Zeitschrift für Medienwissenschaft, Heft 21: Künstliche Intelligenzen, Ed. Gesellschaft für Medienwissenschaft, pp. 39-45.

Knaus, T. (2024). Warum Kı Kein Hype İst Und Die Medienpädagogik sich damit befassen sollte, Medien + Erziehung, 68 (3): 21-30.

Lima-Santos, M. F. and Ceron, W. (2021). Artificial Intelligence in News Media: Current Perceptions and Future Outlook. Journal. Media, 3 (1): 13-26.

Lossau, N. (2018). Wie Künstliche Intelligenz die Medien verändert. Berlin: Konrad-Adenauer-Stiftung e.V.

MeMo:KI (2022). Künstliche Intelligenz im Journalismus: Wie nimmt die Bevölkerung den Einfluss von Künstlicher Intelligenz auf die Zukunft des Journalismus wahr? Factsheet, 4.

Oster, J. (2019). Rechtliche Antworten auf die Künstliche Intelligenz im Mediensektor Algorithmischer Journalismus zwischen Sorgfaltspflichten und Medienprivileg nach deutschem und europäischem Recht. MedienWirtschaft, 1: 32-37.

RTR Medien (2024). Studie "Künstliche Intelligenz in der Medienwirtschaft". https://www.rtr.at/medien/aktuelles/publikationen/Publikationen/Kuenstliche_Intelligenz_in_der_Medienwirtschaft.de.html, 03.02.2025.

Sančanin, B. and Penjišević, A. (2022). Use of Artificial Intelligence for The Generation of Media Content, Social Informatics Journal, 1 (1): 1-7.

Schlütz, D. and Zillich, A. F. (2025). Forschungsethik und wissenschaftliche Integrität: Herausforderungen und Chancen für Forschung in und mit digitalen Medien. Handbuch Digitale Medien und Methoden, Ed. Sven Stollfuß; Laura Niebling; Felix Raczkowski, Wiesbaden: Springer VS, Wiesbaden, pp. 1-18.

Schmidt, A. (2023). KI in der Medienbranche: Content-Erstellung, Mediendesign und Produktion. MedienWirtschaft, 20 (1): 64.

Schnödl, G. (2019). Emanation, Umkehrung, Ausstreichung Naturalisierungen in Technik- und Medientheorie. Zeitschrift für Medienwissenschaft, Heft 21: Künstliche Intelligenzen, Ed. Gesellschaft für Medienwissenschaft, pp. 133-144.

Schützeneder, H. ve Graßl, M. ve Meier, K. (2024). Grenzen überwinden, Chancen gestalten

Shao, Y. and Yin, Q. (2025). A Review the Role of Artificial Intelligence in Media Content Creation for SDGs Development. Journal of Lifestyle and SDGs Review, 5 (2): 1-17.

Steinhau, H. and Binder, M. and Münch, M. and Biskup, L. (2024): Künstliche Intelligenz und Beschäftigte im Journalismus, Working Paper Forschungsförderung, No. 345, Düsseldorf: Hans-Böckler-Stiftung.

Trejos-Gil, C. A. and Gómez-Monsal, W. D. (2024). Artificial Intelligence in Media and Journalism. Systematic Review on Spain and Latin America in Scopus and Web of Science Databases (2018–2022). Palabra Clave, 27 (4): 1-35.

Varghese, M. ve Raj, S. ve Venkatesh, V. (2022). Influence of AI in human lives.

Vogler, D. ve Eisenegger, M. ve Fürst, S. ve Udris, L. ve Ryffel, K. ve Rivière, M. ve Schäfer, M. S. (2023). Künstliche Intelligenz in der journalistischen Nachrichtenproduktion Wahrnehmung und Akzeptanz in der Schweizer Bevölkerung. Jahrbuch Qualität der Medien 2023, Zürich: fög - Forschungsinstitut Öffentlichkeit und Gesellschaft, pp. 33–45.

Zydorek, C. (2023). KI in der digitalisierten Medienwirtschaft. Tendenz, 2 (23): 15.

IMPACT OF DERMATOLOGICAL HEALTH ON THE QUALITY OF LIFE IN LOWER LIMB AMPUTEES: A SPECIALIZED FOCUS ON PROSTHETIC INTEGRATION AND PSYCHOSOCIAL WELL-BEING

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ABSTRACT

Background: For lower limb amputees, the skin-prosthesis interface is the cornerstone of functional mobility. While prosthetic technology has advanced, the dermatological burden of stump-related issues ranging from contact dermatitis to chronic ulcers, often remains an invisible barrier. Previous studies have indicated that skin problems can affect up to 75% of amputees, significantly hindering their daily activities and psychological state [1, 2].

Objective: This study specifically investigates the impact of dermatological complications on the quality of life (QoL) of lower limb amputees and explores the correlation between skin health and prosthetic compliance.

Methods: We conducted a cross-sectional analysis of 187 amputee patients using the Dermatology Life Quality Index (DLQI). The study focused on how specific skin symptoms (pain, pruritus, soreness) interfere with social activities, work, and emotional stability.

Results: Analysis revealed that dermatological issues lead to significant QoL impairment. High DLQI scores correlated most strongly with "social and leisure activities" and "work and school" subscales. A critical finding was the "vicious cycle" where skin discomfort leads to reduced prosthetic wear time, which in turn diminishes the patient's autonomy and self-esteem. Patients with chronic stump dermatoses exhibited significantly higher levels of social isolation compared to those with healthy stump skin ($p < 0.05$). These results align with the literature suggesting that skin health is a major determinant of prosthetic use [3].

Conclusion: The dermatological quality of life is a vital clinical endpoint in amputee rehabilitation. Enhancing QoL in this population requires more than mechanical alignment; it necessitates proactive dermatological care to ensure sustained prosthetic integration and psychosocial health.

Keywords: Quality of Life, DLQI, Amputee Rehabilitation, Psychosocial Impact.

References

1. Meulenbelt HEJ, Geertzen JHB, Jonkman MF, Dijkstra P. Skin problems of the stump in lower limb amputees: 1. A clinical study. Acta Derm Venereol. 2011 Mar;91(2):173-7. doi: 10.2340/00015555-1040. PMID: 21290085.

2. Koc E, Tunca M, Akar A, Erbil AH, Demiralp B, Arca E. Skin problems in amputees: a descriptive study. Int J Dermatol. 2008 May;47(5):463-6. doi: 10.1111/j.1365-4632.2008.03604.x. PMID: 18412862.

3. Hansen C, Godfrey B, Wixom J, McFadden M. Incidence, severity, and impact of hyperhidrosis in people with lower-limb amputation. J Rehabil Res Dev. 2015;52(1):31-40. doi:10.1682/JRRD.2014.04.0108. PMID: 26230919.

BENDING BEHAVIOR OF SIMPLY SUPPORTED NANOPLATES WITH DEFECTIVE ELASTIC FOUNDATION

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ABSTRACT

In this study, the nonlocal bending behavior of nanoplates with defective elastic foundations is formulated using Eringen's nonlocal elasticity theory and Kirchhoff-Love plate theory. It is assumed that the simply supported edges of the nanoplate are subjected to a uniformly distributed load. The elastic foundations of the nanoplate are constructed by modeling each point with a Dirac-delta function. The Galerkin method is used to solve the problem. A computer code is developed to obtain the nonlocal bending results. The maximum number of terms to be used is determined by analyzing the variation in the maximum deflection results. The necessity of using nonlocal elasticity theory instead of classical elasticity theory is demonstrated. First, the results of the current study are validated with a defect-free study in the literature. Then, the effects of randomly oriented defects and intentionally created gaps on the bending behavior of nanoplates are investigated. It is seen that elastic foundations including defects can alter the bending behavior of the nanoplates and that these defects should be considered in mathematical models due to the production difficulties of nanostructures.

Keywords: Nonlocal elasticity theory, defective elastic foundation, Galerkin method, Dirac-delta function

INTRODUCTION

Nano-structural elements exhibit exceptional mechanical, thermal and electrical characteristics and therefore are often utilized in sensors, actuators and as reinforcements for structures due to their unique properties. Their use in biosensors, atomic force microscopy, MEMS and NEMS devices has clearly demonstrated the need to consider size dependent effects at the very smallest scales of structure (Chong et al., 2001; Fleck et al., 1994; Li et al., 2003; Stölken and Evans, 1998). As a result, since the size of the structural layer is approaching or is comparable to the internal material characteristic length scale, it is generally accepted that classical continuum-based plate models are not capable of accurately modeling size dependent behavior. Therefore, numerous investigators have developed size dependent continuum models to provide improved accuracy for analysis of nanometer scale structural elements.

The behaviour of nanoscale structures is studied using both experimental and theoretical studies. These include two primary categories of modelling, quantum mechanical based models and continuum mechanics-based models. As continuum mechanics requires significantly fewer computations than quantum mechanical models, it has become the more commonly applied type of modelling. However, classical continuum mechanics does not capture small scale effects and therefore cannot accurately compare with molecular dynamics data (Govindjee and Sackman, 1999). To address this issue, numerous size dependent theories have been developed to include nonlocal elasticity, couple stress, strain gradient and modified couple stress theories (Apuzzo et al., 2018; Eringen, 1972; Kumar and Mukhopadhyay, 2023; Shakouri et al., 2013). Of all of these, Eringen's nonlocal theory is the most widely applied as it is simple and agrees well with MD based predictions. Eringen's nonlocal elasticity theory (Eringen, 1972, 1983; Eringen and Edelen, 1972) is a popular size dependent continuum approach to model small scale effects. Classical continuum theory considers the stress at a single point within a material to depend solely upon the strain at that same location. Nonlocal elasticity incorporates the entire strain field of the continuum into the constitutive relationship to account for small scale effects.

Several analytical and numerical methodologies have been employed to determine the solution to the governing equations for nonlocal structural analysis, including the Navier method, Ritz method, finite element method, differential quadrature method, Galerkin method and others (Anjomshoa and Tahani, 2016; Ansari et al., 2010; Ghannadpour et al., 2013; Murmu and Pradhan, 2009; Pradhan and Phadikar, 2009) The majority of studies on nanoplates in the scientific literature have primarily been concerned with understanding the general bending behavior of nanoplates using different types of material models, shear deformation theories, elastic foundations, nonlinear effects, and small-scale parameters. The existing body of literature is comprised of many studies investigating the general bending behavior of nanoplates, for example; Hung et al., (2024) performed an investigation of the bending response of functionally graded saturated porous nanoplates supported on a Pasternak foundation, Aghababaei and Reddy (2009) analyzed the bending and free vibration of simply-supported rectangular nanoplates, Yan et al., (2015) evaluated the effects of scale on bending deflections with comparison to molecular dynamics data, and Thai et al., (2014) presented a nonlocal sinusoidal plate model for analysis of bending, buckling, and vibration of nanoplates. Mousavi et al., (2017) also proposed a full modified nonlocal theory to improve the representation of small-scale effects in bending and buckling problems.

In contrast to the aforementioned studies concerning the general behavior of nanoplates, there are fewer studies that focus specifically on more unique or irregular structural configurations. Dastjerdi et al., (2016) studied the effects of eccentric empty defects on the bending behavior of circular graphene sheets using the frameworks of nonlocal elasticity and Mindlin plate theory. Jafarinezhad et al., (2024) studied both the static and free-vibration behavior of annular nanoplates having moderate thickness and different boundary conditions using stress-driven nonlocal elasticity and the finite-element method. Additionally, Daghigh et al., (2020) studied the bending and buckling responses of composite nanoplates containing agglomerated carbon nanotubes supported on a Pasternak foundation and including consideration of the effects of CNT agglomeration as well as nonlocal and foundation parameters. Overall, this indicates that while the general bending behavior of nanoplates has been extensively studied, more specialized configurations incorporating defects, nonuniform geometric configurations, or irregularities in materials have generally been studied less frequently. In this study, the nonlocal bending behavior of simply supported nanoplates with defective elastic foundation is investigated. The aim of this study is to examine and discuss the changes in the bending performance of nanoplates in cases of realistic situations such as gaps or defects that may occur in the elastic foundation. In order to create these gaps or defects, the elements in the elastic foundation are modeled with the help of

Dirac-delta function. A computer code has been developed to be able to solve the problem. Number of terms for the double trigonometric assumed deflection function, number of springs used for the elastic foundation, applied load, boundary conditions, material properties and geometric dimensions are considered as inputs in the computer code. The Galerkin method is utilized to solve the unknown coefficients and then nonlocal deflection and stress results are obtained.

PROBLEM DEFINITION

Figure 1 depicts a simply supported nanoplate resting on elastic foundations. A uniformly distributed load is applied to a nanoplate. The elastic foundations are represented individually in a continuous way with uniformly spaced spring constants utilizing Dirac-delta functions, hence facilitating the creation of defects or gaps in the elastic foundations by setting the appropriate elastic foundation modulus to zero.

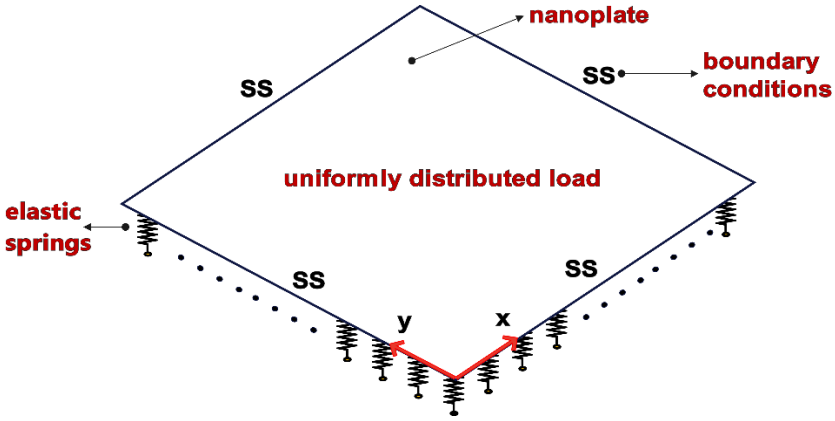


Figure 1. Illustration of nanoplate subjected to uniformly distributed load with elastic foundations

MATHEMATICAL FORMULATION

Eringen provides an acceptable solution to the difficulties of analytically deriving constitutive equations in integral form by converting them into differential equations. This conversion has demonstrated exceptional efficiency and simplicity for the analytical examination of nanostructured systems. The nonlocal constitutive relationship can be expressed as follows:

$$(1 - \mu\nabla^2)\sigma_{ij} = t_{ij} \tag{1}$$

where $t_{ij} = C_{ijkl}\varepsilon_{kl}$ is the classical stress tensor, $\mu = (e_0\tilde{a})^2$ is the nonlocal parameter, and ∇^2 is the Laplacian. Kirchhoff's Plate Theory defines displacement components as follows (Kirchhoff, 1850):

$$u_x = -z\frac{\partial w}{\partial x}, \quad v_y = -z\frac{\partial w}{\partial y}, \quad w_z = w(x,y) \tag{2}$$

The displacement fields are then provided as follows:

$$\varepsilon_{xx} = -z\frac{\partial^2 w}{\partial x^2}, \quad \varepsilon_{yy} = -z\frac{\partial^2 w}{\partial y^2}, \quad \gamma_{xy} = -2z\frac{\partial^2 w}{\partial x \partial y} \tag{3}$$

The equilibrium equations, which are expressed in terms of stress resultants, can be obtained by using D'Alembert's principle:

$$q + N_x \frac{\partial^2 w}{\partial x^2} + N_y \frac{\partial^2 w}{\partial y^2} + \frac{\partial Q_x}{\partial x} + \frac{\partial Q_y}{\partial y} = \rho h \frac{\partial^2 w}{\partial t^2}$$

$$Q_x = \frac{\partial M_x}{\partial x} + \frac{\partial M_{xy}}{\partial y} \quad (4)$$

$$Q_y = \frac{\partial M_y}{\partial y} + \frac{\partial M_{xy}}{\partial x}$$

The governing equation of motion for the nanoplate can be found by substituting the final two expressions of equations (4) into the first expression of equation (4):

$$q + N_x \frac{\partial^2 w}{\partial x^2} + N_y \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 M_x}{\partial x^2} + \frac{\partial^2 M_y}{\partial y^2} + 2\frac{\partial^2 M_{xy}}{\partial x \partial y} = \rho h \frac{\partial^2 w}{\partial t^2} \quad (5)$$

The partial differential equation of motion in terms of transversal displacements and applied load is obtained by considering equation (1), equation (2) and equation (3). And the final version of nonlocal governing equation becomes as follows:

$$D\left(\frac{\partial^4 w}{\partial x^4} + \frac{\partial^4 w}{\partial y^4} + 2\frac{\partial^4 w}{\partial x^2 \partial y^2}\right) + \mu \frac{\partial^2 q}{\partial x^2} + \mu \frac{\partial^2 q}{\partial y^2} - q = 0 \quad (6)$$

In order to apply the Galerkin method, the relationship between virtual work ΔW, virtual displacement Δw, and applied load q is expressed as follows:

$$\Delta W = \int_0^a \int_0^b q(x,y) \Delta w dy dx \quad (7)$$

Using equation (6) in equation (7), following equation is obtained:

$$\int_0^a \int_0^b \left(D\left(\frac{\partial^4 w}{\partial x^4} + \frac{\partial^4 w}{\partial y^4} + 2\frac{\partial^4 w}{\partial x^2 \partial y^2}\right) + \mu \frac{\partial^2 q}{\partial x^2} + \mu \frac{\partial^2 q}{\partial y^2} - q \right) \Delta w dy dx = 0 \quad (8)$$

Assuming a trial solution, the displacement equation becomes as follows:

$$w(x,y) = \sum_{n=1}^{m} a_n f_n(x,y) \quad (9)$$

Substituting equation (9) into equation (8), following expression is obtained after some mathematical operations:

$$\int_0^a \int_0^b \left[D\left(\frac{\partial^4 w}{\partial x^4} + \frac{\partial^4 w}{\partial y^4} + 2\frac{\partial^4 w}{\partial x^2 \partial y^2}\right) + \mu \frac{\partial^2 q}{\partial x^2} + \mu \frac{\partial^2 q}{\partial y^2} - q \right] \sum_{n=1}^{m} f_n \, dy dx \quad (10)$$
$$= 0 \rightarrow n = 1,2,3, \ldots$$

Equation (10) can be rewritten as below:

$$\int_0^a \int_0^b \Gamma(x,y) f_n(x,y) dy dx = 0 \rightarrow n = 1,2,3,\ldots \tag{11}$$

where

$$\Gamma = D\left(\frac{\partial^4 w}{\partial x^4} + \frac{\partial^4 w}{\partial y^4} + 2\frac{\partial^4 w}{\partial x^2 \partial y^2}\right) + \mu\frac{\partial^2 q}{\partial x^2} + \mu\frac{\partial^2 q}{\partial y^2} - q \tag{12}$$

Assuming a shape function for the simply supported nanoplate, following expression is used in order to solve the problem:

$$w(x,y) = \sum_{m=1}^{\sqrt{t}} \sum_{n=1}^{\sqrt{t}} A_{mn} sin\left(\frac{m\pi x}{a}\right) sin\left(\frac{n\pi y}{b}\right) \rightarrow t = 1,4,9,16,\ldots \tag{13}$$

where t represents the number of terms, and the assumed load function, similar to deflection shape function:

$$q(x,y) = \sum_{m=1}^{\sqrt{t}} \sum_{n=1}^{\sqrt{t}} q_{mn} sin\left(\frac{m\pi x}{a}\right) sin\left(\frac{n\pi y}{b}\right) \rightarrow t = 1,4,9,16,\ldots \tag{14}$$

And the Fourier coefficients are calculated as follows:

$$q_{mn} = \frac{4}{ab}\int_0^b \int_0^a q(x,y) sin\left(\frac{m\pi x}{a}\right) sin\left(\frac{n\pi y}{b}\right) dx dy \tag{15}$$

To create defects or gaps on the elastic foundation, elastic foundations or spring elements are modeled one by one within the nanoplate's area with the aid of Dirac-delta function and they are expressed as below:

$$\Theta = \sum_{m=1}^{\sqrt{p}} \sum_{n=1}^{\sqrt{p}} k_{mn}\delta\left(x - \frac{na}{\sqrt{p}+1}\right)\delta\left(y - \frac{mb}{\sqrt{p}+1}\right) \rightarrow p = 1,4,9,16,\ldots \tag{16}$$

where p and δ respresent the number of springs and Dirac-delta functions, respectively. The applied load is obtained by using the following equation:

$$q = q_0 - w\Theta \tag{17}$$

According to Galerkin's principle:

$$\int_0^a \int_0^b \Gamma(x,y) sin\left(\frac{m\pi x}{a}\right) sin\left(\frac{n\pi y}{b}\right) dy dx = 0 \rightarrow \begin{pmatrix} m = 1,2,3,\ldots\sqrt{t} \\ n = 1,2,3,\ldots\sqrt{t} \end{pmatrix} \tag{18}$$

Using equation (18), the coefficients A in equation (13) are found. Depending upon the number of terms taken, t number of equations and t number of coefficients are obtained, and the solution is

found. Since the nonlocal and classical deflection equations are obtained by determining the coefficients A, the nonlocal and classical stress equations are determined by using equation (1).

RESULTS

A convergence study was first carried out to determine the appropriate number of terms by monitoring the deflection values. The corresponding deflection results for the single-layer armchair graphene sheet are listed in Table 1. The material and geometric properties used in the analysis are $\boldsymbol{a = 3.692}$nm, $\boldsymbol{b = 3.6892}$nm, $\boldsymbol{h = 0.335}$nm, $\boldsymbol{E = 803.38}$GPa, $\boldsymbol{\nu = 0.25}$, $\boldsymbol{q = 0.30}$GPa, and $\boldsymbol{e_0 a = 0.7678}$ nm (Yan et al., 2015).

Table 1. The variation of deflection results with the number of terms

Number of Terms	Classical Deflection (nm)	Classical Variation (%)	Nonlocal Deflection (nm)	Nonlocal Variation (%)
1	0.0862	-	0.1599	-
9	0.0840	2.55	0.1488	6.94
25	0.0842	0.24	0.1508	1.34
49	0.0842	0	0.1501	0.46
81	0.0842	0	0.1504	0.20

Figure 2 is a reproduction of the data generated, illustrating the variation of nonlocal deflection-to-classical-deflection with increasing nonlocality (Yan et al., 2015). Nanoplate dimensions were the same as in the previous convergence study. The results were derived from the utilization of 49 terms of the series, excluding any elastic ground elements. The graph indicates that, with increasing nonlocality, the nonlocal deflection findings diverge from classical deflection. The results obtained were also in good agreement with the literature review.

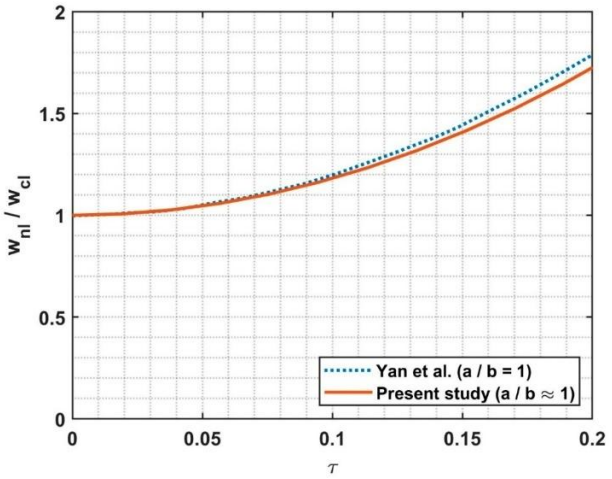


Figure 2. Validation of the current study

As shown in Figure 3, line-type defects were introduced in multiple regions of the elastic foundation to examine the effect of their spatial distribution on the bending response. In contrast to a single localized imperfection, this defect configuration makes it possible to evaluate how different defect locations and arrangements influence the bending behavior of the nanoplate. The elastic spring constants were taken as 10 nN/nm³.

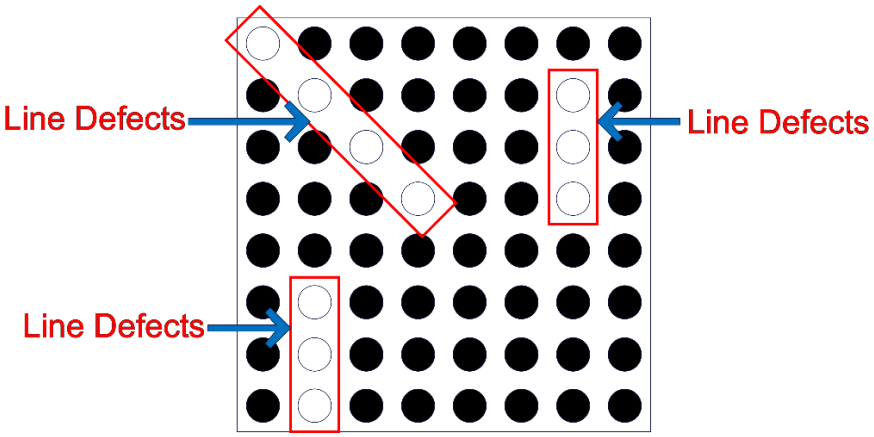


Figure 3. Line defects in the elastic foundation

Figure 4 presents the bending response of the nanoplate with multiple line defects in the elastic foundation, where Figures 4(a), 4(b), 4(c) and 4(d) illustrate the distributions of deflection, $\boldsymbol{\sigma_x}$, $\boldsymbol{\sigma_y}$, and $\boldsymbol{\tau_{xy}}$, respectively. The nanoplate dimensions are $\boldsymbol{a = b = 5}$ nm, and the material properties are the same as those used in the convergence study. The nonlocal parameter is taken as $\boldsymbol{e_0\tilde{a} = 0.7678}$ nm, as determined in the validation study, and the structure is subjected to a uniformly distributed load of $\boldsymbol{1.5}$ GPa. As seen in Figure 4(a), the maximum deflection occurs in the regions where the line defects are located, showing that these defected zones dominate the flexural response of the nanoplate. The maximum deflection is obtained as 0.08 nm.

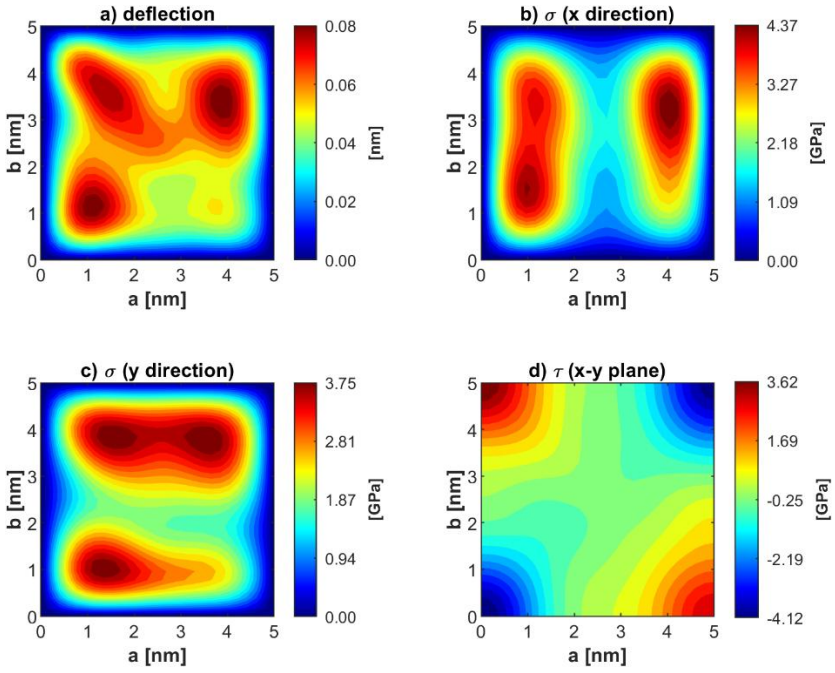


Figure 4. Bending behavior of a graphene sheet with line defects in the elastic foundation

A similar trend is observed for the normal stress components. In Figure 4(b), the maximum $\boldsymbol{\sigma_x}$ values are concentrated around the same defective regions, reaching 4.37 GPa, while Figure 4(c) shows that the maximum $\boldsymbol{\sigma_y}$ values also occur in these areas with a peak value of 3.75 GPa. In contrast, Figure 4(d) indicates that the extreme $\boldsymbol{\tau_{xy}}$ values appear mainly near the corners of the nanoplate. The maximum negative shear stress is -4.12 GPa, whereas the maximum positive value is 3.62 GPa. Among the corners, the lower-right one exhibits the smallest $\boldsymbol{\tau_{xy}}$ magnitude, which can be attributed to the absence of a nearby defect. Overall, the results demonstrate that the location

of multiple line defects strongly affects both the displacement field and the stress distributions of the nanoplate.

DISCUSSION

The results clearly show that the bending response is highly sensitive to the spatial arrangement of the line defects. Since the maximum deflection occurs directly in the defected regions, these areas behave as locally weakened zones and become the dominant areas controlling the bending response. The same trend is also observed for σ_x and σ_y, indicating that the defect lines not only increase local flexibility but also create stress concentration regions. This means that the defected areas of the elastic foundation are mechanically the most critical zones.

The locations where the highest shear stresses occur near the corners of the plate are a result of the interaction of the applied loads and the defect distributions, and thus the effect of the foundation defects on the shear response is evident. The low shear stresses at the lower right corner of the plate indicate that there is little or no influence from a defect located in that area; however, the shear stresses at the other corners are elevated due to the proximity of a defect and the resultant increased shear response.

These observations show that the presence of multiple line defects that have a significant impact on the global deformation characteristics of the nanoplate. Additionally, it was found that both the presence and placement of the defects significantly affect the deformation and stress characteristics of the nanoplate. Thus, understanding how defects are distributed in the elastic substrate is crucial when assessing the mechanical properties of the nanoplate.

CONCLUSION

The research of this study examined the bending response of a simply supported nanoplate that rests on an elastic foundation with line defects using the nonlocal elastic theory and a uniformly distributed applied load. The studies revealed that areas with line defects in the elastic foundation corresponded to the highest level of deflection and the highest levels of normal stress, while the maximum shear stresses were located primarily at the corner points of the plate due to the combined effects of the boundary conditions and the defect distribution. This study shows that local defects in the substrate, which is used to support the nanoplate, must be considered when conducting analysis at the nano level since these can significantly affect the overall mechanical behavior of the system. Thus, this study shows the importance of the distribution of defects in the elastic foundation and offers valuable information for designing nanoplates interacting with imperfect elastic bases.

REFERENCES

Aghababaei, R., Reddy, J. N. 2009. Nonlocal third-order shear deformation plate theory with application to bending and vibration of plates. *Journal of Sound and Vibration*, *326*(1), 277–289.

Anjomshoa, A., Tahani, M. 2016. Vibration analysis of orthotropic circular and elliptical nano-plates embedded in elastic medium based on nonlocal Mindlin plate theory and using Galerkin method. *Journal of Mechanical Science and Technology*, *30*(6), 2463–2474.

Ansari, R., Rajabiehfard, R., Arash, B. 2010. Nonlocal finite element model for vibrations of embedded multi-layered graphene sheets. *Computational Materials Science*, *49*(4), 831–838.

Apuzzo, A., Barretta, R., Faghidian, S. A., Luciano, R., de Sciarra, F. M. 2018. Free vibrations of elastic beams by modified nonlocal strain gradient theory. *International Journal of Engineering Science*, *133*, 99–108.

Chong, A. C. M., Yang, F., Lam, D. C. C., Tong, P. 2001. Torsion and bending of micron-scaled structures. *Journal of Materials Research*, *16*(4), 1052–1058.

Daghigh, H., Daghigh, V., Milani, A., Tannant, D., Lacy, T. E., Reddy, J. N. 2020. Nonlocal bending and buckling of agglomerated CNT-Reinforced composite nanoplates. *Composites Part B: Engineering*, *183*, 107716.

Dastjerdi, S., Lotfi, M., Jabbarzadeh, M. 2016. The effect of vacant defect on bending analysis of graphene sheets based on the Mindlin nonlocal elasticity theory. *Composites Part B: Engineering*, *98*, 78–87.

Eringen, A. C. 1972. Nonlocal polar elastic continua. *International Journal of Engineering Science*, *10*(1), 1–16.

Eringen, A. C. 1983. On differential equations of nonlocal elasticity and solutions of screw dislocation and surface waves. *Journal of Applied Physics*, *54*(9), 4703–4710.

Eringen, A. C., Edelen, D. G. B. 1972. On nonlocal elasticity. *International Journal of Engineering Science*, *10*(3), 233–248.

Fleck, N. A., Muller, G. M., Ashby, M. F., Hutchinson, J. W. 1994. Strain gradient plasticity: Theory and experiment. *Acta Metallurgica et Materialia*, *42*(2), 475–487.

Ghannadpour, S. A. M., Mohammadi, B., Fazilati, J. 2013. Bending, buckling and vibration problems of nonlocal Euler beams using Ritz method. *Composite Structures*, *96*, 584–589.

Govindjee, S., Sackman, J. L. 1999. On the use of continuum mechanics to estimate the properties of nanotubes. *Solid State Communications*, *110*(4), 227–230.

Hung, D. X., Thinh, L. T., Long, N. Van, Tu, T. M., Trung, D. X. 2024. Bending analysis of FGSP nanoplate resting on elastic foundation by using nonlocal quasi-3D theory. *Thin-Walled Structures*, *196*, 111510.

Jafarinezhad, M., Sburlati, R., Cianci, R. 2024. Nonlocal stress-driven model for functionally graded Mindlin annular plate: bending and vibration analysis. *Archive of Applied Mechanics*, *94*(5), 1313–1333.

Kirchhoff, G. 1850. Über das Gleichgewicht und die Bewegung einer elastischen Scheibe. *Journal Für Die Reine Und Angewandte Mathematik (Crelles Journal)*, *1850*(40), 51–88.

Kumar, H., Mukhopadhyay, S. 2023. Size-dependent thermoelastic damping analysis in nanobeam resonators based on Eringen's nonlocal elasticity and modified couple stress theories. *Journal of Vibration and Control*, *29*(7–8), 1510–1523.

Li, X., Bhushan, B., Takashima, K., Baek, C.-W., Kim, Y.-K. 2003. Mechanical characterization of micro/nanoscale structures for MEMS/NEMS applications using nanoindentation techniques. *Ultramicroscopy*, *97*(1), 481–494.

Mousavi, Z., Shahidi, S. A., Boroomand, B. 2017. A new method for bending and buckling analysis of rectangular nano plate: full modified nonlocal theory. *Meccanica*, *52*, 2751–2768.

Murmu, T., Pradhan, S. C. 2009. Small-scale effect on the vibration of nonuniform nanocantilever based on nonlocal elasticity theory. *Physica E: Low-Dimensional Systems and Nanostructures*, *41*(8), 1451–1456.

Pradhan, S. C., Phadikar, J. K. 2009. Nonlocal elasticity theory for vibration of nanoplates. *Journal of Sound and Vibration*, *325*(1), 206–223.

Shakouri, A., Ng, T. Y., Lin, R. M. 2013. A study of the scale effects on the flexural vibration of graphene sheets using REBO potential based atomistic structural and nonlocal couple stress thin plate models. *Physica E: Low-Dimensional Systems and Nanostructures*, *50*, 22–28.

Stölken, J. S., Evans, A. G. 1998. A microbend test method for measuring the plasticity length scale. *Acta Materialia*, *46*(14), 5109–5115.

Thai, H.-T., Vo, T. P., Nguyen, T.-K., Lee, J. 2014. A nonlocal sinusoidal plate model for micro/nanoscale plates. *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, *228*(14), 2652–2660.

Yan, J. W., Tong, L. H., Li, C., Zhu, Y., Wang, Z. W. 2015. Exact solutions of bending deflections for nano-beams and nano-plates based on nonlocal elasticity theory. *Composite Structures*, *125*, 304–313.

PARENTAL BURNOUT AND STRESS OF PARENTS OF CHILDREN WITH AUTISM SPECTRUM DISORDER

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ABSTRACT

Parenting a child with autism spectrum disorder (ASD) is a significant challenge, especially due to the communication and behavioral difficulties that these children often exhibit. Such circumstances can lead to high levels of stress and emotional burden, especially for mothers, who are most often the primary caregivers. High levels of parental stress can negatively affect the quality of family life. The aim of this study was to examine the level of perceived stress and parental burnout in parents of children diagnosed with autism spectrum disorder. 90 parents of users of the Autism Center in Rijeka Croatia participated in the study. Data were collected via an anonymous online questionnaire, via two validated instruments: the Parental Burnout Questionnaire (PBA) and the Perceived Stress Scale (PSS). On the PBA scale, parents achieved scores ranging from 23 to 135 points, with an average score of 58.66 points, which is about 36.4% of the maximum possible 161 points. The most pronounced aspects of parental burnout included feelings of exhaustion, emotional exhaustion, and functioning “on autopilot”. On the PSS scale respondents achieved scores ranging from 13 to 37 points. The average score was 25.67 points, indicating a moderately elevated level of perceived stress, with an almost symmetrical distribution of responses. The highest intensity of stress was recorded for items indicating a feeling of being unable to cope with all obligations, nervousness and stress, and loss of control over situations. On the other hand, lower scores were present for positive items, such as feelings of personal efficacy and control. The results obtained indicate the importance of systematic psychological and emotional support for parents of children with ASD. Further research with larger samples is needed to more precisely identify risk and protective factors in the context of parental experience with children with ASD.

Keywords: children, autism, parental burnout, stress.

CONCEPTUAL REPRESENTATIONS OF THE TEACHER'S ROLE IN THE LESSON PLANNING LITERATURE

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ABSTRACT

The aim of this study is to discuss how the teacher's role is conceptualized in the lesson planning literature within a holistic framework. Rather than producing empirical data, the study adopts a theoretical approach grounded in national and international literature. Lesson planning is examined as a central pedagogical practice that reflects the teacher's position and professional responsibility within the instructional process. The literature review indicates that the teacher's role in lesson planning is predominantly discussed through three conceptual representations: the technical implementer, the pedagogical designer, and the reflective–autonomous teacher. These representations are not treated as mutually exclusive categories; instead, they are interpreted as different manifestations of teaching shaped by historical, institutional, and pedagogical contexts. The discussion highlights that lesson planning approaches based on the technical implementer perspective tend to limit teachers' professional judgment, whereas the pedagogical designer and reflective–autonomous perspectives more effectively capture the professional nature of teaching. The findings suggest that lesson planning should be considered not merely as a technical tool for organizing instruction, but as a key domain through which teachers' pedagogical decision-making processes and professional autonomy become visible.

Keywords: Lesson planning, teacher role, teacher autonomy, pedagogical design, conceptual representations

Introduction

Education is not an activity that can be reduced to mere knowledge transfer; it is a complex human activity in which the relationship between knowledge, the subject, and context is constantly being reconfigured. In this process of reconfiguration, the teacher is positioned not as a mere instrument mechanically transmitting predetermined content, but as a subject at the center of pedagogical

meaning-making. How the teacher views teaching, interprets knowledge, and facilitates learning determines the direction of all pedagogical processes occurring in the classroom. For this reason, teaching is regarded as a professional field that must be approached not merely through technical competencies, but also through theoretical assumptions, pedagogical values, and forms of professional judgment.

The quality of the teaching process is largely related to how the teacher designs learning-teaching activities and the pedagogical, theoretical, and contextual assumptions through which this design is implemented. In this context, lesson planning is not merely a technical preparatory phase of instruction; it is regarded as a fundamental pedagogical practice that makes visible the teacher's understanding of the teaching process, the student, and knowledge (Ural, 2024). The decisions teachers make during the lesson planning process directly influence how curriculum is implemented in the classroom, which objectives are prioritized, and how the learning process is structured according to pedagogical principles (Süral, 2025). In this regard, lesson planning stands out as a field that offers significant insights into the professional nature of the teaching profession.

In the literature, lesson planning has primarily been addressed through technical dimensions such as the systematic organization of instructional activities, the setting of objectives, and the selection of content and methods. In this approach, the plan is positioned as a tool that ensures instruction is conducted in an orderly and controlled manner; the teacher's role, meanwhile, is largely defined as that of an implementer who brings the learning outcomes outlined in the curriculum to life within the established framework (Çöğmen & Yılmaz Özelci, 2024). Indeed, the central structure of curriculum programs, the decisive role of textbooks, and the weight of control mechanisms are cited as key factors limiting teachers' scope for initiative in the planning process (Öztürk, 2011). This situation leads to the teacher's role in the lesson planning process being approached primarily at the level of implementing pre-determined structures, rather than in terms of pedagogical decision-making and design.

However, theoretical developments in the fields of teacher education and instructional design point to the inadequacy of treating lesson planning as a purely technical activity. In the lesson planning process, the teacher is not merely an implementer who lists instructional activities; rather, they are a designer who make conscious choices by considering students' learning characteristics, the contextual conditions of the classroom, and the pedagogical meaning of instructional objectives. From this perspective, planning is viewed as a dynamic process that reflects the teacher's professional knowledge, pedagogical judgment, and contextual sensitivity (Çolak & Yabaş, 2017). The teacher's active role in the planning process enables the reinterpretation of curricula at the local level and the adaptation of instruction to students' needs.

In a limited number of studies in recent years, lesson planning has been addressed in relation to the teacher's reflective thinking skills and professional autonomy. In these studies, the teacher conceives of planning not as the production of a pre-completed document, but as a space for thinking that is continually revisited throughout the teaching process and flexibly transformed in response to students' reactions (Akkuş, Akkaş, & Yıldırım, 2018). The teacher's capacity to make spontaneous pedagogical decisions transforms the planning process into one of the fundamental tools for generating learning opportunities (Akkuş et al., 2018). However, it is observed that this approach has not yet established a dominant presence in the lesson planning literature; rather, it is represented by a limited number of studies characterized by high theoretical depth.

In this context, the question of how the lesson planning literature positions the teacher within a particular role gains significance. Is the teacher in the literature typically portrayed as a technical implementer, or as a pedagogical decision-maker and reflective agent? Which teacher's roles are prominently highlighted, and which ones remain relatively in the background, according to them?

These questions hold critical importance for understanding how lesson planning is related to the professional nature of the teaching profession.

The problem statement of this study is that in a significant portion of research conducted in the field of lesson planning, the teacher's role is addressed implicitly, and this role is not systematically discussed at the conceptual level. Existing studies primarily examine teachers' planning competencies, the challenges they face, or their perceptions of the planning process; however, they do not explicitly discuss the underlying understanding of the teacher's role. This situation leads to the teacher's role as a pedagogical subject remaining invisible in the lesson planning literature (Çöğmen & Yılmaz Özelci, 2024; Öztürk, 2011).

In this context, the aim of this study is to reveal the conceptual representations through which the teacher's role is addressed in the lesson planning literature (Ural, 2024). By examining approaches that position the teacher as a technical implementer, pedagogical designer, and reflective-autonomous subject within a thematic framework, the study aims to discuss the dominant and less prominent teacher roles in the literature. In this regard, the study aims to contribute to discussions regarding the professional nature of the teaching profession by offering a conceptual perspective on research conducted in the field of lesson planning (Öztürk, 2011; Ural, 2024).

Theoretical Framework: Three Perspectives on the Teacher's Role in Lesson Planning

This section assumes that the teacher's role in the literature on lesson planning can be understood through three fundamental conceptual representations. The aim here is not to reduce the teacher to a single, fixed role, but rather to reveal the conceptual frameworks within which planning is approached. In some contexts, lesson planning is understood as a standardized "discipline of practice"; in others, as a professional realm of judgment that designs instruction; and in still others, as a "space of pedagogical freedom" that expands the teacher's autonomy and reflective thinking. Interpreting the teacher's role through these multiple representations is consistent with the multidimensional, contextual, and dynamic nature of contemporary frameworks regarding teacher competencies (Zhang & Tian, 2025). Indeed, it is emphasized that teacher competencies are not merely technical skills; rather, they are shaped by a combination of knowledge, values, decision-making, and professional judgment (Selvi, 2010).

3.1. The Technical Practitioner Teacher: The Standardization of Planning and the Logic of Control

In approaches where lesson planning is treated as a "technical" necessity, the plan is viewed as a document that ensures the orderly conduct of instruction, with objectives, content, and activities arranged within predetermined templates. In this representation, the teacher is often reduced to an implementer who translates the framework established by the institution into practice. This reduction places the teacher's role not at the center of pedagogical reasoning but within the continuity of implementation; consequently, planning is structured around the question "how is it done?" rather than "why is it done this way?" The legacy of classical process–product research on teacher competencies has also reinforced the tendency to view teaching primarily through measurable behaviors and outcomes (Medley, 1977). This legacy can lay the groundwork for perceiving lesson planning not as the teacher's intellectual design, but rather as a realm of formal compliance and control.

Discussions regarding planning practices in the Turkish context provide strong indications that planning processes do not afford teachers a broad scope of action; a significant portion of pedagogical decisions—such as choices regarding content, methods, and materials—are pre-determined by the planning system itself (Öztürk, 2012). In such contexts, teachers may face pressure to "conform" to the formal requirements of the plan rather than the concrete needs of the

classroom. Findings regarding teacher guidebooks and daily lesson plans also indicate that while they may create a perception of support that reduces workload, they simultaneously risk narrowing the teacher's planning space and increasing the likelihood of standardizing instruction (Karaman & Kılıç, 2018). In the "technical implementer" representation, the plan may tend to shift from being a space that opens up the teacher's professional judgment to becoming a document that must be "prepared correctly."

A significant aspect of this representation is how the teacher's decision-making domains are shaped by political and institutional regulations. Studies highlighting how standards-based reforms redefine the teacher's role argue that the complexity of the teaching profession is often reduced to measurable standards; this, in turn, can overshadow the teacher's professional judgment (Zuber & Altrichter, 2018). From this perspective, in the "technical implementer" representation, planning is not merely a pedagogical technique; it is also part of an institutional logic that regulates the teacher's professional status and decision-making sphere. The perspective of the sociology of education reminds us that the teacher's role is not only related to in-class actions but also to the functions of the education system, such as producing legitimacy, reproducing inequalities, or transforming them (Becker, 2019). Thus, planning brings to light not so much the question of "what the teacher does" but rather "what the teacher can do within which systemic logic."

The representation of the teacher as a technical implementer clearly demonstrates how lesson planning can narrow the teacher's pedagogical decision-making space. However, approaches that do not limit planning solely to this framework—and that position the teacher not as a passive executor of the teaching process but as an active decision-maker—are increasingly gaining prominence in the literature. These approaches position the lesson plan not merely as a formal document, but as a pedagogical design space that explains how and why instruction is structured. In this context, the representation of the teacher as a technical implementer clearly highlights the potential of lesson planning to narrow the teacher's pedagogical agency; it demonstrates that planning can drift away from serving as a tool that makes the teacher's professional judgment visible.

3.2. The Pedagogical Designer Teacher: Viewing Planning as Instructional Design and the Learning Experience

In the pedagogical designer representation, the lesson plan is not a "pre-written" text of instruction; rather, it is an instructional design that establishes meaningful connections between objectives, learning activities, assessment, and classroom interactions. This approach positions the teacher not as an implementer of the curriculum, but as a professional who reinterprets the curriculum according to students' learning needs. The "subject knowledge–pedagogy–context" unity emphasized in teacher competency frameworks reinforces the theoretical foundation of this designer role (Selvi, 2010; Zhang & Tian, 2025). From this perspective, planning is closely linked to the teacher's capacity to transform professional knowledge into a concrete learning experience.

Studies on lesson plan models by pre-service teachers indicate that planning can be viewed not merely as writing a list of learning outcomes, but as a "model-building" activity that structures the teaching process (Ünver, 2002). Similarly, discussions on teacher-learner roles in constructivist classrooms highlight the teacher's roles in planning authentic learning tasks, organizing the learning environment, and managing interaction processes, thereby drawing attention to the "learning design" dimension of planning (Koç, 2006). Within this framework, the plan transforms into a design tool that concretizes the teacher's pedagogical intent within the classroom.

In contemporary discussions of teaching, the discourse on the "21st-century teacher" also encourages viewing the teacher's planning processes as a more complex sphere of responsibility. In particular, learner-centered instruction, flexible learning environments, and multiple assessment approaches indicate that planning is not merely filling out a template but rather the task of

constructing the learning experience (Jan 2017). However, it should also be noted that while such normative frameworks articulate the teacher's designer role as an ideal, they do not sufficiently detail under which institutional conditions and with what professional support this role might be feasible (Becker, 2019). Therefore, the representation of the pedagogical designer requires not only stating that the teacher "must design" but also discussing the realistic possibilities and limitations of design.

This perspective does not exclude the relationship between planning and teacher autonomy; on the contrary, it treats autonomy as a prerequisite for design. While standardized planning logic pushes the teacher into a narrow role as an implementer, in the pedagogical designer representation, the teacher is a professional who establishes connections between goals, content, activities, and assessment, generates alternatives, and justifies the learning process. For this reason, planning gains meaning as a critical intersection where the "professional" nature of the teacher's role becomes visible.

While the pedagogical designer model frames planning as a central practice that makes the teacher's professional knowledge and pedagogical judgment visible, it also demonstrates that this role often operates within specific institutional and structural constraints. This suggests that planning is closely related not only to design skills but also to the teacher's autonomy and capacity for reflective thinking. Indeed, some studies in the literature treat lesson planning as a more dynamic realm of judgment where the teacher continuously reevaluates their in-class decisions. Within this framework, the representation of the teacher as a pedagogical designer positions lesson planning as a central practice that concretizes the teacher's professional knowledge and pedagogical reasoning; it highlights that planning is one of the fundamental areas that makes the professional nature of teaching visible.

3.3. The Reflective and Autonomous Teacher: Establishing Planning as a Domain of Reasoning, Inquiry, and Adaptation

In the representation of the reflective and autonomous teacher, planning is not merely a preparatory task completed before instruction; rather, it is a space for thinking that is reshaped during instruction and progresses through pedagogical justification and adaptation. This approach involves the teacher continuously reevaluating decisions made in the classroom not solely based on the "correctness" of the plan, but through students' learning responses and the demands of the context. Findings linking teacher autonomy to planning practices emphasize that the teacher's capacity to make decisions in areas such as content, methods, and material choices directly determines the meaning of planning; as the teacher's scope of authority narrows, planning can take on a more formalistic character (Öztürk, 2012). For this reason, planning can also be interpreted as a "space of judgment" where the teacher's professional judgment is evident.

A key aspect reinforcing this representation is the teacher's capacity to manage in-class interactions in real time and generate learning opportunities. Studies focusing on the teacher's role in creating learning opportunities demonstrate that planning is not merely a sequence of predetermined steps; rather, it is intertwined with the ability to redirect instruction by following the student's thinking (Akkuş, Akkaş, & Yıldırım, 2018). Thus, planning transforms from a "pre-written" text into a practice of professional intuition and justification that is updated throughout the teaching process.

Reflective and autonomous teaching is not limited to the classroom context where the teacher works alone; it also extends to processes of collective learning and professional collaboration. Frameworks examining the teacher competencies necessary for the effective implementation of collaborative learning in the classroom emphasize that teachers must address the planning–implementation–monitoring–support–reflection cycle in a holistic manner (Kaendler, Wiedmann, Rummel, & Spada, 2015). This emphasis aligns with an understanding that does not limit planning

to the "pre-instructional" phase but instead establishes it as a form of professional judgment that extends across all stages of the instructional process.

On the other hand, this reflective and autonomous representation of the teacher's role develops in constant tension with educational policy and standardization practices. Discussions on teacher standards reform argue that a policy design that accounts for the complexity of the teaching profession must protect the realm of professional judgment without reducing the teacher to measurable indicators (Zuber & Altrichter, 2018). The sociological perspective, however, broadens this tension by reminding us that teacher autonomy is not merely a matter of in-class choice but a structural issue closely tied to the system's organizational forms (Becker, 2019). Therefore, the reflective and autonomous representation of teachers requires viewing lesson planning as a site of struggle—both pedagogical and institutional.

In summary, in the literature, lesson planning is represented at times as a standardized practice (technical implementer), at times as the center of instructional design (pedagogical designer), and at times as a practice where the teacher's autonomy and reflective judgment come to the fore (reflective/autonomous). These three representations form the theoretical backbone of the conceptual framework that will be discussed in the subsequent sections of this study. Accordingly, the representation of the reflective and autonomous teacher requires viewing lesson planning as a multi-layered field where the teacher's pedagogical reasoning, professional responsibility, and struggle with institutional boundaries intersect.

Discussion

In this study, the lesson planning literature was examined through a conceptual framework that addresses the teacher's role via the representations of the technical implementer, the pedagogical designer, and the reflective-autonomous teacher. This framework makes the ongoing debates in the literature regarding how lesson planning is conceptualized within the teaching profession more visible and reveals different epistemological and political assumptions regarding the teacher's role. Indeed, the literature shows that lesson planning is often treated as a technical necessity for organizing instruction; conversely, approaches that position planning as a central element of the teacher's pedagogical judgment remain relatively limited (Medley, 1977; Öztürk, 2012).

From the perspective of the "technical practitioner" teacher representation, it can be argued that lesson planning largely functions as a standards-based mechanism of control and compliance. The legacy of process-product research ( ), which defines teacher competence through measurable behaviors and outcomes, has positioned planning not as a domain of pedagogical thinking but rather as a tool that ensures the controllability of instruction (Medley, 1977). Studies conducted in the Turkish context also indicate that annual and daily plans are often perceived by teachers as a formal obligation; this situation can narrow the teacher's scope for pedagogical decision-making (Öztürk, 2012; Karaman & Kılıç, 2018). These findings suggest that lesson planning is established in a tense relationship with the teacher's professional autonomy within the technical practitioner representation.

However, the literature also highlights criticisms that the technical-practitioner approach fails to adequately account for the complex and contextual nature of teaching. Studies examining teacher standards reforms emphasize that reducing the multidimensional structure of teaching to measurable indicators may render the teacher's professional judgment and pedagogical responsibility invisible (Zuber & Altrichter, 2018). From the perspective of the sociology of education, this situation is situated within a broader context, revealing that planning practices are shaped not only by pedagogical but also by institutional and political logics (Becker, 2019).

The "pedagogical designer teacher" model offers a significant alternative to this technical, reductionist understanding of lesson planning. In this approach, planning is viewed as a

professional practice in which the teacher integrates subject knowledge, pedagogical knowledge, and contextual knowledge to design the learning experience (Selvi, 2010; Zhang & Tian, 2025). Studies with pre-service teachers and teachers indicate that when planning is treated as a design activity that establishes the logic of the teaching process, the teacher's capacity for pedagogical justification is strengthened (Ünver, 2002; Koç, 2006). However, as seen in the literature, this designer role is often constrained by structural conditions such as program flexibility, professional support, and institutional trust (Becker, 2019).

At this point, critiques of the "pedagogical designer" representation suggest that while the teacher's designer role is presented as a normative expectation, the sustainability of this role has not been sufficiently discussed. In particular, the multiple roles attributed to teachers within the framework of the "21st-century teacher" discourse transform planning into a more complex sphere of responsibility; however, the structural burden this complexity places on teachers are often overlooked (Jan 2017). This situation demonstrates that while the representation of the teacher as a pedagogical designer offers a stronger theoretical framework compared to the technical implementer approach, it can also generate new tensions in practice.

The reflective and autonomous teacher representation, on the other hand, positions lesson planning as one of the areas where the teacher's pedagogical judgment and professional intuition are most evident. In this approach, planning is not a static preparation completed before instruction; rather, it is a thinking practice that is reshaped throughout the teaching process and is responsive to students' reactions and the demands of the context. The teacher's ability to assess learning opportunities in real time and adapt instruction accordingly is among the key elements determining the pedagogical value of planning (Akkuş et al., 2018).

While a limited number of studies in the literature directly center this perspective, research on collaborative learning and teacher competencies emphasizes that planning must be considered alongside the cycle of implementation, monitoring, and reflection (Kaendler et al., 2015). These findings suggest that a planning approach grounded in reflective and autonomous teacher agency more holistically reflects the professional nature of teaching . However, this approach is not independent of the tension between teacher autonomy and educational policies and standardization practices. Indeed, teacher standards reforms entail a constant search for balance between expanding the teacher's scope for reflective judgment and meeting demands for measurability (Zuber & Altrichter, 2018).

Examining these three conceptual representations together makes it possible to situate the fragmented discussions in the literature on lesson planning within a more holistic framework. It can be argued that unless the dominant "technical practitioner" representation in the literature is balanced by the "pedagogical designer" and "reflective-autonomous" approaches, lesson planning will fail to adequately reflect the professional and contextual nature of the teaching profession. This situation necessitates a rethinking of the meaning attributed to lesson planning in teacher education programs and in the implementation processes of curriculum. Thus, the representations of the technical practitioner, the pedagogical designer, and the reflective-autonomous teacher should be understood not as mutually exclusive categories, but as the forms teaching takes under different historical, institutional, and epistemological conditions. The fundamental problem in the literature on lesson planning is the absolutization of one of these representations at the expense of the others. Yet the professional nature of teaching requires that planning be conducted within specific structural frameworks, possess the capacity for pedagogical design and justification, and involve the teacher's context-sensitive reflective judgmental simultaneously. For this reason, lesson planning should be approached as a central professional practice that reveals the tension-filled nature of teaching—situated between institutional boundaries and pedagogical autonomy—rather than reducing the teacher to either a mere implementer or an idealized designer.

Conclusions and Recommendations

In this study, the conceptualization of the teacher's role in lesson planning literature was examined through the representations of the technical implementer, the pedagogical designer, and the reflective-autonomous teacher. The resulting conceptual framework reveals that lesson planning is predominantly treated as a technical field of practice in the literature, while approaching that center the teacher's pedagogical judgment and professional autonomy remain limited. In this context, lesson planning must be re-examined not merely as a tool used by teachers to organize instruction, but as a professional practice that reflects the teacher's pedagogical identity, professional responsibility, and capacity for contextual decision-making. It is important that content related to lesson planning in teacher education programs be structured in a way that goes beyond technical competencies to strengthen the teacher's role as a designer and reflector.

From a practical perspective, restructuring curriculum and planning guidelines to allow teachers a certain degree of flexibility can enhance the pedagogical value of lesson planning. Approaches that enable teachers to justify the decisions they make during the planning process can contribute to the development of a teaching culture that supports teacher autonomy. From a research perspective, increasing the number of qualitative and mixed-methods studies that examine lesson planning within the context of the teacher's role can help fill conceptual gaps in the literature. In particular, research that examines teachers' thought processes, decision-making processes, and contextual adaptations during the planning process will shed deeper light on the place of lesson planning within the teaching profession.

In conclusion, making the conceptual representations of the teacher's role visible in the lesson planning literature enables a rethinking of teaching—beyond a technical field of practice—based on pedagogical reasoning and professional responsibility. This study aims to contribute to both theoretical and practice-oriented discussions by reframing existing debates on lesson planning through the lens of the teacher's role.

References

Akkuş, R., Akkaş, E. N., & Yıldırım, B. (2018). The teacher's role in creating learning opportunities while teaching subject matter. *Primary Education Online, 17*(2), 1135–1149. https://doi.org/10.17051/ilkonline.2018.426534

Becker, R. (Ed.). (2019). *Sociology of education* (2nd ed.). Springer.

Coşkun, H. (2018). Development and implementation of a lesson plan draft in the context of tolerance education. *KAREFAD, 6*(2), 1–26.

Çöğmen, S., & Yılmaz Özelci, S. (2024). The teacher as a practitioner: A systematic review on program literacy. *Western Anatolia Journal of Educational Sciences, 15*(2), 1538–1569. https://doi.org/10.51460/baebd.1508308

Çolak, E., & Yabaş, D. (2017). Investigating lesson plans of teacher candidates according to their self-efficacy levels toward the implementation of the constructivist approach. *İnönü University Journal of the Faculty of Education, 18*(2), 86–103. https://doi.org/10.17679/inuefd.323420

Jan, H. (2017). The 21st-century teacher: Characteristics and development. *Research on Humanities and Social Sciences, 7*(9), 50–54.

Kaendler, C., Wiedmann, M., Rummel, N., & Spada, H. (2015). Teacher competencies for the implementation of collaborative learning in the classroom: A framework and research review. *Educational Psychology Review, 27*(3), 505–536. https://doi.org/10.1007/s10648-014-9288-9

Karaman, H., & Kılıç, D. (2018). Teachers' views on guidebooks and daily lesson plans. *ILTER Congress (September 6–8, 2018, Amasya)*

Koç, G. (2006). Teacher-student roles and the interaction system in constructivist classrooms. *Education and Science, 31*(142), 56–64.

Maiza, M. (2019). An analysis of pre-service teachers' lesson plans. *BIORMATIKA: Jurnal Ilmiah Fakultas Keguruan dan Ilmu Pendidikan, 5*(2), 176–180. https://doi.org/10.35569/biormatika.v5i02.518

Medley, D. M. (1977). *Teacher competence and teacher effectiveness: A review of process–product research*. Washington, DC: American Association of Colleges for Teacher Education. Öztürk, İ. H. (2011). A theoretical examination of teacher autonomy. *Electronic Journal of Social Sciences, 10*(35), 82–99.

Öztürk, İ. H. (2012). The teacher's role and autonomy in instructional planning: An example of annual lesson plan preparation and implementation by secondary school history teachers. *Educational Sciences: Theory & Practice, 12*(1), 271–299.

Putri, A. (2016). EFL teachers' understanding in developing lesson plans. *Indonesian EFL Journal, 2*(1), 1–11.

Selvi, K. (2010). Teachers' competencies. *Cultura International Journal of Philosophy of Culture and Axiology, 7*(1), 167–175.

Süral, S. (2025). Lesson planning and curriculum literacy in the context of teacher competencies: A meta-analysis study. *Journal of Interdisciplinary Educational Research, 9*(21), 340–353. https://doi.org/10.57135/jier.1674728

Ural, A. (2024). An analysis of the characteristics of teacher roles. *TEBD, 22*(1), 687–711. https://doi.org/10.37217/tebd.1396521

Ünver, G. (2002). Lesson plan models of preschool education teacher candidates. *Education and Science, 27*(126), 62–69.

Zhang, L., & Tian, Q. (2025). Multidimensional teacher competencies: A systematic review of research trends and frameworks. *Teaching and Teacher Education, 132*, 104309. https://doi.org/10.1016/j.tate.2024.104309

Zuber, J., & Altrichter, H. (2018). Teacher characteristics and teacher standards: How to account for the complexity of the teaching profession in education policy. *European Educational Research Journal, 17*(3), 407–428. https://doi.org/10.1177/1474904117714502

THE ROLE OF INFLUENCER TRUST, VALUE, AND PERCEIVED INFLUENCE IN SHAPING REPURCHASE INTENTION: EVIDENCE FROM TRENDYOL USERS IN AZERBAIJAN

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ABSTRACT

This study investigates the impact of selected social variables on repurchase intention within the context of an emerging economy. Specifically, it examines the relationships among key predictors and explores whether gender and age differences influence repurchase intention in the case of Trendyol, a widely used e-commerce platform in Azerbaijan. Trendyol was chosen due to its strong presence among Azerbaijani consumers and its strategic collaborations with local influencers to enhance customer engagement. Repurchase intention is chosen as the dependent variable, while Perceived Influence, Influencer Trust, Perceived Value, and Community Platform are considered predictor variables. Data were collected using a convenience sampling method during the summer and autumn of 2025. The proposed hypotheses were tested using regression analysis to assess the impact of the predictors and independent sample tests to evaluate gender and age differences.

Keywords: Trendyol, social factors, Influencer Trust, Azerbaijan

INFLUENCE OF ELECTRONIC SCREEN AND AUDIO-VISUAL DEVICES ON THE COGNITIVE, VISUAL, NEUROPSYCHOLOGICAL FUNCTIONS OF THE HUMAN BRAIN AND THE CARDIOVASCULAR SYSTEM DURING OUR CONTINUOUS EXPOSURE

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ABSTRACT

Electronic screen devices and displays are part of our daily lives and are used increasingly intensively. The extensive and prolonged exposure raises significant scientific questions regarding their impact on the cognitive functions of the human brain, visual comfort and general neuropsychological state. The present study aims to analyze data related to the effects of prolonged use of electronic screen devices on brain activity, with a special emphasis on attention, memory, mental state and sleep, as well as on the possible consequences for the central and cardiovascular nervous systems. The study is based on an interdisciplinary approach, including a questionnaire survey among individuals over 18 years of age, as well as an analysis of experimental studies in the fields of neuroscience, ophthalmology, psychology and information technology. The main research question is whether prolonged use of electronic screen devices leads to functional changes in cognitive processes and visual comfort, without causing direct structural damage to the brain or visual system. The results obtained have scientific and applied value for assessing the risks of prolonged screen exposure and can help develop recommendations for healthy use of digital technologies, such as using protective glasses that reduce the impact of blue light from screens, reducing the time range of using electronic screen devices, even turning them off for a certain time. The report draws attention to the cardiovascular system, as prolonged sitting associated with screen activity can increase the risk of stagnation and heart problems. These problems emphasize the importance of a balanced lifestyle that includes physical activity, adequate sleep and proper nutrition, combined with the use of electronic screen devices. The results obtained are applicable in educational practice, healthcare and the development of protective technological solutions.

Keywords: Electronic screen devices,vision, cognitive processes, risks, cardiovascular system.

INTRODUCTION

For more than two decades, electronic screen devices have been part of our lives. The use of smartphones, tablets, computers, televisions, video walls, interactive displays, e-book readers, touchscreen monitors, luminous screens, etc. has completely changed our daily lives, our connectivity, information channels and the work environment in all its forms. The widespread use of electronic screen devices has raised a number of research questions among scientists around the world. Most notably, questions related to the impact of screens on the cognitive functions of the human brain, our visual abilities and the cardiovascular system during prolonged work with them.

This report aims to make, albeit a cursory analysis of the current state of the impact of luminous displays on the human brain and nervous system. To point out the challenges that we all face during the prolonged use of electronic screen devices, their impact on our memory, psyche, sleep, functions of the cardiovascular and central nervous systems. Visual problems caused by work with

screen exposure will also be considered. The article has a main task to clarify and assess the risks to our health caused by excessive screen use.

The development is based on a survey conducted among 25 people aged 18 and over on the topic: “Survey on the impact of electronic screen devices on the human brain”, a review and comparative analysis of the medical scientific literature and studies by specialists on the subject - neurologists and ophthalmologists; analysis of experimental studies and an interdisciplinary approach (neuroscience, ophthalmology, psychology, information technology). The main question to which an answer will be sought is whether the prolonged use of screen electronic devices leads to functional changes in cognitive processes and visual comfort, as well as in the cardiovascular system without causing direct structural damage to organs in the human body.

REVIEW OF STUDIES RELATED TO THE INFLUENCE OF ELECTRONIC DISPLAYS ON COGNITIVE, VISUAL, NEUROPSYCHOLOGICAL FUNCTIONS AND THE CARDIOVASCULAR SYSTEM

Excessive and uncontrollable screen time leads to impaired attention, memory and self-control, even a slowdown in thinking functions in adolescents, for example, says neurologist Dr. Angel Angelov - Head of the Neurology Department at the Multidisciplinary Regional Hospital for Active Treatment "Dr. Stefan Cherkezov" in Veliko Tarnovo, Bulgaria. In our time, the more active generations in the network, Gen Z and Alpha, are the young people who have suffered from the so-called "brain rot"[1], mostly due to the enormous amount of time spent in front of electronic screen devices. According to a scientific study by the Newport Institute from 2024, "Brain rot" is caused by excessive use of technology. Since screens emit a large amount of blue light, the formation of the hormone melatonin could be affected, which could disrupt sleep, leading to poor concentration, poor memory and impaired cognitive functioning.

Screen media activity [1] may have an impact on neurodevelopment in young people. Moreover, the applied results of the researchers indicate that the covariation (changing behavior) of the structural patterns of the brain is associated with Screen media activity, as well as with the psychopathological state, cognition and sleep in children, for example. On the other hand, the first signals of this condition are observed in a feeling of fatigue, lethargy, reduced concentration, cognitive decline. Characteristic of brain rot is the so-called doomscrolling (“doom” – in translation “death”, and “scrolling” – scrolling, scrolling) [1].

On the other hand, long-term staring at displays and their closer exposure can create visual discomfort in a person, which is associated with an increased risk of myopia, eye fatigue and strain, dryness, decreased visual acuity, and headaches, experts point out in their publications in the Egyptian Journal of Otolaryngology.

Last but not least, increased time in front of electronic screen devices is associated with a risk of increased blood pressure, high cholesterol, and insulin resistance, which are key factors for cardiovascular disease or the so-called cardiometabolic risk in younger and more active people, according to the American Heart Association. Cardiovascular risks increase due to disruption of the biological clock with excessive exposure to blue light from screens. This can lead to increased cortisol, dysregulated heart rate and blood pressure, and metabolic problems, according to a study published in Bentham Science in October 2025.

Watching YouTube videos, scrolling through social media, or switching between different browser tabs, simultaneously surfing the web, texting, and emailing overstimulates the brain.

And when you’re digitally inundated with too much information, you’re at risk of brain rot. Scrolling through social media platforms increases levels of the neurochemical dopamine, which

produces feelings of satisfaction and pleasure. The more you do it, the more you want to do it. In this way, scrolling can become a behavioral addiction [2].

Neurologist, senior research fellow at Oxford, cited as the most popular and successful female scientist in the UK, Susan Greenfield, claims that using the internet and computer games can damage the brain.

Screen time has been blamed for increasing depression in young people, behavioral problems, and insomnia [3].

Neuroscientist Susan Greenfield argues that the use of the Internet and computer games can harm the brains of adolescents. In her latest book, Mind Change, she examines the various ways in which digital technologies can affect not only our thinking patterns and other cognitive skills, but also our lifestyles, culture, and personal perceptions.

She compares changes in consciousness to changes in climate, signals that were considered crazy decades ago but are now generally accepted scientific fact – both are "global, contradictory, unprecedented, and multifaceted" [3]. In today's world, oversaturated with electronic screen devices, we are all constantly exposed to artificial light.

Of all the types of light, blue light is the most talked about and its relationship to hormones, especially those of sleep [4].

The functioning of children's brains is compromised by screen activity in all sorts of ways, but morphological damage is no exception. There is a persistent sleepiness and an inability for the brain to be awake and fully participate in life. On the contrary, one becomes completely dependent on digital heroin and has no will to get out and cope on their own [4].

Mental health challenges of excessive screen exposure

With each use of electronic screen devices, we accumulate the so-called digital fatigue.

This condition, often underestimated, has an increasingly serious impact on mental health, concentration, and even sleep quality [5].

The term "digital fatigue" combines the physiological and psychological effects of excessive use of screens – smartphones, laptops, tablets, televisions and other devices. Symptoms include fatigue, irritability, blurred vision, headaches, lack of motivation and reduced productivity [5].

A number of studies believe that the blue light emitted by electronic screen devices contributes to difficulty falling asleep, as it suppresses the hormone melatonin.

The blue light emitted by screens suppresses the production of melatonin – the sleep hormone. Using devices before bedtime leads to difficulty falling asleep, lower sleep quality and chronic fatigue [5].

Protective tools and mechanisms in modern electronic display devices

In today's digital world with a wide range of electronic devices, from phones and tablets to laptops and monitors, people spend a huge amount of time looking at screens.

Among them, organic light-emitting diode (OLED) displays occupy an important place in the field of electronic displays, due to their remarkable advantages such as high contrast ratio, wide viewing angle, thinness, lightness, and bendability, which are due to their self-emitting characteristics. They are widely applied in various products, including smartphones and televisions [6].

However, with the increasing prevalence of OLED displays, the issue of eye protection has gradually attracted attention. Some OLED displays exhibit screen flicker at low brightness levels, which can lead to uncomfortable symptoms such as visual fatigue, dry eyes, and headaches [6].

Staring at electronic display devices leads to problems with the visual systems. Therefore, eye protection is of great importance for new technologies related to electronic display devices.

Based on the advantages of infrared light, which can resonate with water molecules, activate mitochondria, stimulate blood circulation, and relieve visual fatigue, BOE has developed a screen that can emit infrared light to achieve eye protection effects by adding an infrared light emitting device to the screen [7].

“Eye Comfort Shield” - blue light filtering option

“Eye Comfort Shield” is available in mid-range monitors, laptops, TVs, smartphones and tablets. It is a blue light filter feature. It is filtered to minimize the risk of eye irritation and to prevent sleep disruption. In general, “Eye Comfort Shield” is a complex of optical electronic and software technologies designed to reduce visual strain (asthenopia) by limiting the harmful photobiological effects of light, stabilizing visual adaptation and reducing neurosensory stress during prolonged use of visual displays.

“Eye Comfort Shield” is a set of preventive technologies that, by controlling the light spectrum, brightness and flicker, reduce photobiological, neurosensory and muscle stress on the visual system [8,9,10,11,12].

Blue light is emitted by display devices such as televisions, phones, and lighting fixtures and can irritate the eyes. Blue light also blocks the production of the hormone melatonin, which prevents sleep [13].

Prolonged use of digital displays is associated with an increased incidence of visual fatigue, summarized in the clinical term Digital Eye Strain (DES). Symptoms include asthenopia, dry eyes, headaches, and impaired accommodation. In this context, the concept of an “eye comfort shield” is introduced as a preventive technological approach to reduce visual stress, in which:

Prolonged exposure leads to accelerated visual fatigue and subjective discomfort; Increased stimulation suppresses melatonin secretion; Flicker leads to increased load on the visual cortex and can cause headaches and fatigue; Prolonged fixation on close objects leads to prolonged contraction of the ciliary muscle [8,9,10,11,12].

Impact of electronic screens and audiovisual devices on the cardiovascular system

How does screen time actually contribute to the development of cardiovascular disease and can its duration be controlled as a link to the development of cardiovascular disease?

Coronary artery disease (CAD), heart failure (HF), and ischemic heart disease (IHD) are three common cardiovascular diseases that are closely related to metabolic activity [16].

The reason for the increase in the number of these diseases is an unhealthy lifestyle, where lack of movement, such as screen time, is one of the potential risk factors.

A Mendelian randomization (MR) study investigated the relationship between screen time and three types of cardiovascular disease: coronary artery disease, heart failure, and ischemic heart disease.

Through MR analysis, it was revealed that the use of mobile phones and television screens showed a significant causal relationship with the occurrence of ischemic heart disease. However, no significant relationship was observed between computer use and these three types of cardiovascular disease [16].

Cardiovascular diseases are common, especially in people over the age of 60. They currently account for over half of all noncommunicable diseases worldwide and are the leading cause of death worldwide, accounting for over 17.3 million deaths annually.

The lifetime incidence of CVD is high, as shown by the Framingham Heart Study, where the estimated lifetime risk of developing coronary heart disease (CHD) at age 40 alone was 48.6% for men and 31.7% for women [17].

According to scientific reports, the use of electronic screen devices at night, immediately before sleep, is emerging as the worst practice and has the worst impact on sleep, with a number of scientists focusing on the effect of blue light emitted by displays and screens on the control of circadian rhythm.

Blue light affects the circadian rhythm, delaying the onset of sleep, reducing sleep efficiency and increasing insomnia. Prolonged screen time before bedtime increases cortisol, sympathetic nervous system activity and parasympathetic imbalance. These changes cause stress, visual fatigue, cognitive impairment and metabolic problems. Long-term exposure to artificial light at night causes cardiovascular disease, obesity and insulin resistance [18].

The results of the study on the subject published below in this report will provide a clear answer to how much time people spend in front of a screen device during the day and whether they protect their eyes from the emitted blue light.

SURVEY ON THE IMPACT OF ELECTRONIC SCREEN DEVICES ON THE BRAIN AND VISION

The current scientific study aims to analyze current data on the effects of using screen devices and whether they are dangerous to health or simply burden a person's visual system and psyche. Scientists are still not certain that screens change the brain in a permanent or lasting way for the worse, rather they define the time spent in front of the screen as a key moment for cognitive changes, without disrupting the structure of vision or the human brain.

Description of the study conducted:

The study was conducted online through the JotForm platform - an online form creation and workflow automation tool powered by artificial intelligence (https://eu.jotform.com/workspace/) and is titled: “Survey on the impact of electronic screen devices on the human brain”, including 14 questions: What is your gender?; What is your age range?; How much time do you spend per day in front of electronic screen devices?; What do you most often use devices with electronic screens /smart phones and TVs, watches, video walls, tablet, e-books, laptop, desktop computer with monitor for?; What is the highest level of education you have completed?; How often do you exercise/relax/rest during the week?; How often do you use medications, vitamins, nutritional supplements related to improving your physical and mental condition?; How much time do you need to rest/sleep per day?; How do you feel after using electronic screen devices?; Have you ever had mental discomfort or physical pain after using electronic screen devices?; Do electronic screen devices affect your vision in your opinion?; Have you ever used protective glasses for working with a screen device or eye drops to relieve dry eyes, or used an eye comfort shield from the settings of your smart devices?; Please rate your work with electronic screen devices.; What are your interests?.

Analysis of the data obtained from the study and results

The largest share of 34.78% in the survey covers people aged 35 to 44, which shows that active working people are most often in front of screens. Almost 22% of respondents spend about 10

hours a day in front of screen electronic devices. At most 30.43% between 4 and 6 hours, and nearly 22% over 6 hours. Prolonged exposure raises significant questions about the impact on the cognitive functions of the human brain, visual comfort and general neuropsychological health, as well as on the cardiovascular system. We can put a reasonable focus on the question: Do screen devices affect your vision? In the Questionnaire, the answer of 95.65% is "Yes" (**Table 1.**).

Table 1. Impact of Electronic Screen Devices on Vision.

Do screen devices affect your vision?	**results**
Yes	95.65%
No	4.35%

This shows that according to users, screens affect vision, but a minimum of knowledge is needed in people about what exactly they affect and how to protect themselves. According to a publication in "The Negative Impact of Screens on Children's Development" by Dr. Valentina Dimitrova-Syarova - a clinical neuropsychologist, the blue light from screens has a harmful effect on the eyes and, in particular, on the retina. The wavelengths emitted by screens lead to various chemical reactions that release toxic molecules in photoreceptor cells. The use of screens also contributes to the sharp increase in myopia, according to a scientific study published in Ophthalmology [14].

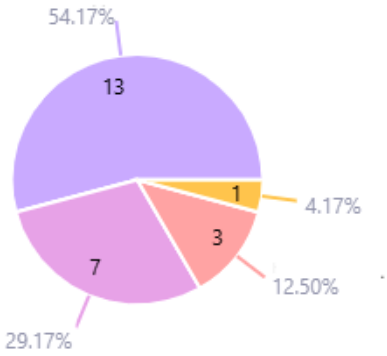
48% of respondents said that they must use protective glasses. 22% believe that modern smart devices have the necessary eye protection, and the same number of participants want to use glasses designed for working with screens, but know nothing about them. 4% believe that the light from screens does not affect them in any way. Eye protection technology such as the "Eye Comfort Shield" discussed above in the article usually reduces blue light and is considered by experts to be a preventive intervention. The lack of information among people about modern digital screens, such as that blue light activates melanopsin-containing retinal ganglion cells, which are involved in the regulation of circadian rhythms, and that increased stimulation suppresses melatonin secretion, which can lead to sleep disorders and secondary increases in cognitive and visual fatigue [8,9,10,11,12], proves to be a major challenge to the use of electronic screen devices. It is the filtering of blue light that improves neuroendocrine balance, which is subjectively felt as "comfort".

Nearly 47 percent, or almost half, of the study participants of all ages, said that they felt tired after exposure to screen light from smart devices and displays (**Table 2.**). This has its own explanation from neuropsychologists. Again in the publication "The Negative Impact of Screens on Children's Development" [14], author and clinical neuropsychologist Dr. Valentina Dimitrova-Syarova writes that with supersensory stimulation, the vestibular apparatus is suppressed, which provokes an artificial lack of mood [14], which is probably why nearly 11% of respondents in the study said they felt overexcited, and almost 4% depressed.

Table 2. How do respondents feel after using electronic screen devices?

tired	**46.43%**
satisfied	**21.43%**
happy	**14.29%**
overexcited	**10.71%**
depressed	**3.57%**

What is the effect on people after using electronic screen devices, and whether the respondents experienced mental discomfort or physical pain, will be answered by the next question in the survey. Nearly 55% or more than half of the respondents said that after using electronic screen devices they experienced mental discomfort or physical pain. Almost 30 percent do not share about such sensations and discomforts, about 4% often experience psychological or physical discomfort, and nearly 13 percent of the respondents do not even pay attention.



Data	Response	%
yes	13	54.17%
no	7	29.17%
I didn't pay attention	3	12.50%
often	1	4.17%

Figure 1. Mental discomfort or physical pain after using screen devices.

While some have reported that frequent SMA is associated with internalizing psychopathology, including depression and anxiety, externalizing psychopathology, riskier behavior, and even suicide, others have found no evidence of a link between SMA and problematic outcomes. Even fewer studies have examined the relationship between different types of SMA and brain structure in healthy young adults [15].

The conclusion here may be ambiguous. The majority of people experience psychological discomfort and physical pain, which is a sign that the impact of excessive use of electronic screen devices would lead to increasingly frequent negative consequences for our psyche and physique, with the caveat that there is no current and definitive scientific evidence yet that the human brain is at risk of structural changes, other than changes in attitudes, cognitive functions, sensations, emotions, and eye fatigue.

Of utmost importance are the answers to the questions: How often do you exercise/relax/rest during the week?; How often do you use medications, vitamins, nutritional supplements related to improving your physical and mental condition?; How much time do you need for rest/sleep per day?.

More than 90% of the participants in the study answered that their required sleep per day should be from 6 to 8 hours. The same number shared that they do not use medications, vitamins, nutritional supplements related to improving their physical and mental condition. As for movement, training and rest during the week, the respondents shared that they spend from 3 to 5 times for these activities.

DISCUSSION

This article describes the impact of screen devices on cognitive, psychological and visual functions, and with prolonged exposure and triggering cardiovascular problems, due to immobility, disturbed sleep and lack of quality rest. Changes in attitudes towards the use of electronic screen devices. Protective mechanisms such as blue light filters, appropriate lighting and changes in behavior.

CONCLUSION

Electronic screen devices cannot lead to a degree of structural damage to the brain and vision, leading health specialists are categorical. This study has somewhat clarified which are the problems that should be addressed. One of them comes from excessive and unconscious use, the lack of boundaries and ignoring the signals of our body. In the digital world, the refusal of electronic screen devices is not on the agenda, rather society should look for ways to balance their use. It is also necessary to pay attention to how we feel after a long stay in front of the glowing screens.

REFERENCES

1. Vinarova, M., (2025). Risks for Children on the Internet: The “Brain Rot” Phenomenon, April 2025, Media and Language Journal 1(17), Available from: https://www.researchgate.net/publication/394945963_Risks_for_Children_on_the_Internet_The_Brain_Rot_Phenomenon#fullTextFileContent, DOI:10.58894/IUKH8464

2. Newport Institute 2024: Brain Rot: The Impact on Young Adult Mental Health [online], https://www.newportinstitute.com/resources/co-occurring-disorders/brain-rot/, 2025

3. Krustev, A., (2014). Digital Technologies and Mind Changes in Susan Greenfield's “Mind Change”, 2014, Azcheta, https://azcheta.com/susan-greenfield-mind-change/

4. Vezenkov, S., (2025). Modern Myths about the Human Brain, "Sto Leta", Sofia, First Edition, Myth 19: Electronic Devices Develop Children's Brain.. Available from: https://www.researchgate.net/publication/368789748_Mit_19_Elektronnite_ustrojstva_razvivat_detskia_mozk#fullTextFileContent, 2025

5. Digital Fatigue: How Do Screens Affect Our Psyche?, April 2025, Tech News, NewTechGen.com

6. Yan, Z., Jiaxin Ye, Gaohui Xie, Mingsheng Li, Ying Cao, Mingwei Ge, Ying Shen, Xiujian Zhu, (2025). Research and Optimization on Eye-Injury Issues of OLED Screens, July 2025, SID Symposium Digest of Technical Papers 56(S1):1742-1744, DOI:10.1002/sdtp.19202

7. Zhang, T., Hu Li, Douqing Zhang, Liangliang Zheng, Hailin Xue, Xibin Shao, Zhiqiang Liu. (2025). Eye protection display technology based on infrared light, July 2025, SID Symposium Digest of Technical Papers 56(S1):1381-1383, DOI: 10.1002/sdtp.19092

8. Rosenfield, M., (2016). Computer vision syndrome: a review of ocular causes and potential treatments. Ophthalmic and Physiological Optics, 2016

9. Sheppard, A.L., & Wolffsohn, J.S., (2018). Digital eye strain: prevalence, measurement and amelioration. BMJ Open Ophthalmology, 2018

10. Chang, A. M., (2015). Evening use of light-emitting eReaders negatively affects sleep, circadian timing, and next-morning alertness. PNAS, et al. 2015

11. Wilkins, A. J., (2010). LED lighting flicker and potential health concerns, IEEE, et al. 2010

12. American Optometric Association (AOA). Digital Eye Strain

13. Popova, B., (2025) What is an "Eye Comfort Shield" and how is it adjusted? - divna.Tech

14. Dimitrova-Syarova, V., (2023). The negative impact of screens on children's development, Neuropsychological research and consultations, February 2023, https://valentinadimitrova.com/negativno-vliyanie-na-ekranite-detsa/

15. Paulus, M., Lindsay M. Squeglia, Kara Bagot, Joanna Jacobus, Rayus Kuplicki, Florence J. Breslin, Jerzy Bodurka, Amanda Sheffield Morris, Wesley K. Thompson, Hauke Bartsch, Susan F. Tapert. (2019). Screen media activity and brain structure in youth: Evidence for diverse structural correlation networks from the ABCD study, NeuroImage, Volume 185, January 15, 2019, Pages 140-153, https://doi.org/10.1016/j.neuroimage.2018.10.040

16. Qiu, Zh., Xueyuan Jia, Yancheng Fu, Yanru Yang (2024), Screen time in the development of cardiovascular diseases: A two-sample Mendelian randomization study, Volume 34, Issue 3p706-717March 2024, DOI: 10.1016/j.numecd.2023.09.029

17. Reynolds, I., Page, R.L., Boxer, R.S. (2019). Cardiovascular Health and Healthy Aging. In: Coll, P. (eds) Healthy Aging. Springer, Cham. https://doi.org/10.1007/978-3-030-06200-2_5

18. Kadiri, S.K., Prashant Tiwari. (2025), Screens after Sunset: The Science of Blue Light, Circadian Disruption, and Sleep Impairment, In Press. Adolescent Psychiatry, Available online October 30, 2025, DOI: 10.2174/0122106766390602251012162712

EXPERIMENTAL ANALYSIS OF THE EFFECT OF SURFACE GEOMETRY MODIFICATIONS ON AIRFOIL AERODYNAMIC PERFORMANCE

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ABSTRACT

In low Reynolds number flow conditions, aircraft are prone to early boundary layer separation, resulting in significant losses in aerodynamic performance. In this study, the aerodynamic effects of stepped and sawtooth surface geometry modifications applied to a NACA 0018 airfoil were experimentally investigated to enhance performance in this flow regime. A representative set of airfoil configurations was selected to examine the influence of key geometric parameters while maintaining a focused experimental scope. Six airfoil models were designed using SolidWorks, representing three distinct sawtooth leading-edge angles, with two stepped configurations evaluated for each angle. The models differed in step height, step location, and sawtooth geometry. All airfoils were manufactured using a three-dimensional printer with PLA filament, followed by post-processing procedures to reduce surface roughness and ensure geometric consistency. Wind

tunnel force measurements were conducted at a Reynolds number of Re = 10^5 over an angle-of-attack range of 0°–24°. Lift (C_L) and drag (C_D) coefficients were obtained for all configurations, and to minimize experimental uncertainties, each measurement was repeated twice and evaluated using averaged values. The results showed that a configuration featuring a stepped and sawtooth leading-edge geometry with a 150° sawtooth angle and an 8.79 mm step length exhibited the highest lift performance among the tested models. In the low to moderate angle-of-attack range (α = 6°–8°), this configuration achieved peak lift coefficients of approximately $C_L \approx 1.35–1.36$. Additionally, it maintained relatively low drag coefficients over a wide angle-of-attack range, resulting in the highest aerodynamic efficiency based on the C_L/C_D ratio. Although other configurations with similar or different sawtooth angles produced comparable lift values, their higher drag coefficients reduced overall efficiency, while some models exhibited more balanced C_L–C_D characteristics, indicating potential applicability for specific design requirements. To support the force measurement results, a TiO_2-based surface oil flow visualization technique was employed, revealing improved boundary layer control, delayed flow separation, and enhanced flow re-energization through secondary vortical structures for the high-performing configuration. Overall, the findings demonstrate that stepped and sawtooth surface geometry modifications can significantly improve the aerodynamic performance of airfoils operating at low Reynolds numbers when appropriate parameter combinations are employed.

Keywords: Stepped Airfoil; Sawtooth Leading Edge; Aerodynamic Performance; Wind Tunnel Testing; Surface Flow Visualization; Lift and Drag Coefficients

TEACHERS' READINESS TO IMPLEMENT INTEGRATED TEACHING IN SLOVAKIA

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ABSTRACT

In 2020 the Government of Slovakia approved National Program for the Development of Education and Upbringing "The Educated Slovakia 2035 Strategy" in which its vision and direction of the Slovak education system for the period until 2035 are defined. The authors emphasize two strategical tasks stated in this document. The first is the task of systematically developing 21st century skills across the entire education system, with the implementation of the STEM or STEAM education concept playing a key role in this process. The second one is the task to introduce compulsory pre-primary education for all children from the age of three, and at the same time to start with implementation of the STEM or STEAM education strategy already at this level of education. Following the above strategies, nationwide research was conducted, aim of which was to assess professional readiness of the pre-primary education environment in Slovakia for this strategy application. The authors, who were the research implementers, present in their paper a selection of the findings resulted from a questionnaire survey, respondents of which were a representative sample of kindergarten teachers. Specifically, the presented findings are related to four questionnaire items: what do you understand by STEM education, how do you apply it in your teaching practice, where does your information on STEM education come from, and how do you rate your general readiness for STEM teaching.

Keywords: education system development strategy, use of integrated teaching, STEAM education, pre-primary teachers

INTRODUCTION

In Slovakia, the concept of integrated teaching and learning is associated with alternative education and the model of integrated thematic education by the American authors Susan Kovalik and Karen Olsen (Kovaliková, Olsenová, 1996), who have significantly contributed to its spread among Slovak teachers. Already since 1992 there has been operating a non-governmental education organization Susan Kovalik Assocciation, named *Education for the 21st Century in Slovakia* (ASK, Figure 1). By focusing on the content of its activities, it has professionally guaranteed implementation of innovative educational programs, within which it has organized various forms of education for teachers, university students, and workers with children and youth in these programs.

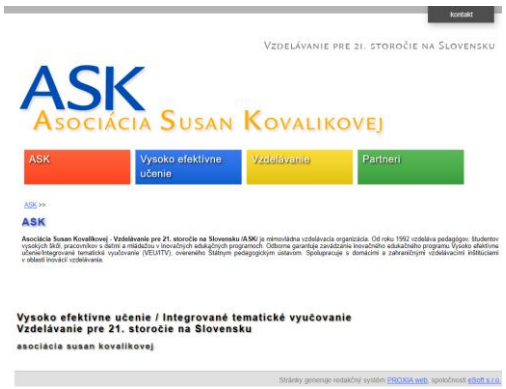


Figure 1. ASK home page

http://www.ask21.sk/sk/Article/91/ASK.proxia

Thematic approach is one of the teaching strategies that involves several subjects based on one theme which provides, or offers active, interesting and meaningful learning. Integrated learning begins with a certain subject or theme and then relates to another subject. A certain concept is related to another, carried out spontaneously or planned, both in one or more fields of study. So, the main idea of it can be defined as connecting various aspects between, or among subjects. In general, it can be characterized as humanistic, experiential, pupil/student-centered education. However, teachers' opinions on including integrated thematic education in school teaching, or on designing school curricula based on inter-subject relationships, vary. But on the other hand, its application to the educational process undoubtedly brings various benefits. The most important of these are activation of pupils/students' activities, deepening the understanding of the connections between knowledge and skills acquired within different subjects, but also within different areas or thematic units of the same subject, pointing out the common use, or rather the usability of acquired knowledge and skills in common life situations (Kuchárová, 2012).

In 2020 the Ministry of Education (in that time Ministry of Education, Science, Research and Sport of the Slovak Republic, nowadays Ministry of Education, Research, Development and Youth of the Slovak Republic) had announced a curricular reform of the regional school system (i.e. of primary and lower secondary schools, which in Slovakia are integrated in so-called basic education, or basic schools, as their first and second levels with grades 1 – 5 and 6 - 9), which already from 2021 has been successfully in progress (MŠ, 2018). This reform has become a component part of the National Program for the Development of Education. The new National Program, named *The Educated Slovakia 2035 Strategy,* defines for the next decade a framework for transformation of the whole system of education, i.e. not only of the regional school system, but from pre-primary education through primary, secondary and higher education, even up to lifelong education. Its primary goal is to anchor, cultivate and accelerate the processes that were started by the curricular reforms in 2021-2025 (MŠ, 2020).

In the frame of our topic the most important strategy is Strategic Area 1 *Modern Education for All* (MŠ, 2020). Main goal of this area is to systematically develop 21st century skills such as critical assessment of information, adaptability, innovation, civic responsibility, etc., while a key role in this process is put on STEAM disciplines and approaches. One may say that STEAM approach to teaching and learning should be introduced into each level of education, starting from pre-primary education, which according to the stated strategic area should become compulsory from the age of three, and ending with higher and lifelong education. At this point a question arises what STEAM approach to teaching and learning means. And the answer to this question takes us again to US,

where we already were at the beginning, speaking about the awareness on the concept of integrated thematic education in Slovakia.

The notion STEAM, originally STEM, arose in USA as a motto for creating a common strategy of American scientists, technicians, engineers, and mathematicians for introducing innovative elements into the education system to link the educational content significantly with applications of acquired knowledge in real practical situations. This call was a reaction on so called *Sputnik crisis* in America*,* for the launch of two artificial Earth satellites into orbit (USSR, 1957) raised strong concerns among Americans that Soviets technologically overtook America, and that not only USSR but also other countries are making significant progress in science, technology, engineering, and mathematics (STEM), in consequence of what the US´s competitiveness in these fields is deteriorating (National Science Board, 1996). While in 90s, of the previous century STEM phenomenon was rather matter of politics than education, now-a-days STEM education is a world-wide accepted teaching strategy reflecting on both social and economic demands of the 21st century. The reason is the fact that solutions to the challenges the world is facing today will require a new multidisciplinary scientific workforce equipped with a skill set of new technology and interdisciplinary thinking that may require the integration of multiple STEM concepts to solve them. And so, it is widely agreed that there is an imperative to train and prepare diverse STEM-literate workforce with the capability to understand and comprehend the technological world, as well as to develop well-informed and highly competent citizens prepared for the life conditions of the Industry Revolution 4.0 (IBE-UNESCO, 2019; Penprase, 2020).

In its nature STEM can be understood as a modified integrated thematic education. Difference between these two approaches to education is that while integrated teaching does not specify which subjects should be the common learning topic from, STEM teaching specifies the need to focus the common learning topic specifically on areas of science, technology, engineering and mathematics. However, despite this strict limitation of the subjects allowed or eligible to be included within the STEM concept of education, currently we are witnessing tendencies to expand the acronym by adding there still new areas. An already commonly introduced acronym of STEM is its modification STEAM, extension of STEM concept to the field of art, but other extensions are also emerging, e.g. STREAM, where the letter R represents Reading and Writing (to stress importance of functional literacy), STEMSM, called also STEM^2 (stressing importance of Social and Moral considerations).

While to implement integrated thematic education depends on a teacher preferences given to two (or more) subjects in relation to which s/he will try to find out a common topic, to implement STEM education does not give a teacher any freedom to chose subjects in relation to which s/he will use some inter-curricular relationships for a an appropriate theme to be taught. Moreover, a strong barrier to the use of any integrated thematic education in school environment, mainly the higher grades, is the the established organization of teaching the established organization of teaching keeping the schedule of traditional separate subjects. In most education systems, schools have a daily timetable for classes of students in which learning is organised by subjects and by corresponding segments of time, and the subjects are taught according to this pre-determined timetable. In this case, the approach to STEM education is more discipline specific. However, there are also schools adopting a partial interdisciplinary approach, where the boundaries between subjects are less obvious. These schools adopt the thematic approach where learning is organised by themes (IBE-UNESCO, 2019). In this context a basic question in relation to STEM education is also the extent to which the four disciplines hidden in the given acronym should be taught as one STEM subject consisted of these four traditionally separate subjects (Vasquez, 2015).

Where the above barrier does not exist is just clearly environment of pre-primary education. Children in kindergartens are not taught according to the separate school subjects, but by means of general discovering how the world around them functions and how particular things operate.

This means that kindergartens offer a natural environment to implement the use of STEM education in practice in a broad scope. At the same time, there is also a requirement, in the Strategic Area 1 of the Slovak National Program for Development of Education, to base the pre-primary education significantly exactly on STEM disciplines and approaches, and thus to support systematical development of the 21st century skills of both children and youth. However, this is not only case of Slovakia specifically, as a lot of authorities world-wide require introduction of STEM education into the official systems of education as early as pre-school education (MacDonald, et al. 2020; Cunningham et al., 2018; DeJarnette, 2018; Tippett & Milford, 2017; Cluver et al., 2013) pointing out the benefits of the early involvement of children into this way of education.

RESEARCH AIM, RESEARCH SAMPLE AND METHODS

Following the National Program of the Slovak Government *The Educated Slovakia 2035 Strategy*, specifically the intention to strengthen pre-primary education by introducing compulsory pre-primary education from the age of three and at the same time to start with implementation of the STEAM education strategy already at this level of education (stated within the Strategic Area 1 *Modern Education for All* of the Program), we conducted research focused on assessing the professional readiness of the pre-primary education environment in Slovakia for this strategy application.

The overall scope of the research was quite extensive, as it largely verified the readiness of kindergarten teachers to apply STEM education within the curriculum prescribed for this level of education in the State Educational Program for Pre-primary Education in Kindergarten Schools from 2022, i. e. already the curricula introduced within the current curricular reform of the regional school system of Slovakia (MŠ, 2022). All necessary research data were collected through a questionnaire, in which most of the items were closed-ended but some were open-ended.

The research was organized nationwide, what means that the basic research set consisted of all (totally more than 3 thousand) kindergartens (all kinds - state, private, church). To compile a representative sample of all teachers working in all these kindergartens meant to have included into it teachers from each kind of the kindergartens (state, private, church), and that from all regions of Slovakia. Another requirement on the research sample compilation was ensuring an objective assessment of the researched phenomena, on which the questionnaire survey respondents were asked to comment. So even while maintaining the essentially random nature of the selection, it was necessary to ensure representation mainly of experienced teachers with an appropriate length of practice. Ultimately, the representative sample of the survey consisted of 372 respondents (Brečka et al., 2025).

Taking into consideration limited presentation possibilities and national specificities of majority of the research, hereinafter are presented only the main general findings. These are related to four questionnaire items, which were:

QI-1: What do you understand by the notion STEM education?

QI-2: How do you apply it in your teaching practice?

QI-3: Where does your information on STEM education come from?

QI-4: How do you rate your general readiness for STEM teaching?

The first three above-stated questionnaire items were open-ended and the responses to them were processed by means of a qualitative analyses and descriptive statistics. In the third questionnaire

item respondents assessed their readiness by means of a five-point Lickert scale, where 1 meant - insufficient, 2 - weak, 3 - I cannot assess, 4 - sufficient and 5 - good.

RESULTS

QI-1 What do you understand by the notion STEM education?

The basic problem that we identified when analyzing the answers to the above question was the lack of knowledge of the term STEM education. Several respondents stated that they had not encountered the term or concept of STEM education or were not familiar with it (approx. 18 %). Majority of respondents (up to 67 %) defined this term very imprecisely. This indicates the need for increased awareness and further education of teachers focusing on this concept. Approximately 3 % of respondents demonstrated with their answers that they can navigate this issue and have a correct basic understanding of the STEM curriculum as education in four basic areas – science, technology, engineering and mathematics. Their basic general understanding of the STEM education concept is correct, but they mostly lack a deeper understanding of the interdisciplinary approach to individual STEM areas. The last group were respondents who perceive STEM education as connecting multiple areas into a single whole, what means they understand its essence correctly (12 %).

QI-2: How do you apply it in your teaching practice?

In terms of the application of various educational approaches, relevant to STEM education, most often mentioned the following ones:

Experiential learning: Many teachers emphasized the importance of experiential learning, in which children carry out activities of investigation, research and experimentation. This approach is characterized by relatively high efficiency, since as result of performing the above activities, children better remember the knowledge they have gained through their own practical experiences.

Use of technology: Most respondents reported using digital technologies, such as interactive whiteboards and various educational tools. One can agree with their understanding of technology integration into education as a key prerequisite for developing technological literacy.

Hands-on activities: Respondents reported that they often engage children in hands-on activities, such as experiments, measurements, and construction activities, which support the development of children's fine motor skills and logical thinking.

Project-based learning: Respondents who reported using project-based learning emphasized setting real-world problems for which children are tasked with finding solutions using STEM principles. Moreover, this approach encourages children’s collaboration and critical thinking.

QI-3: Where does your information on STEM education come from?

A large portion of respondents (almost 39 %) stated that they have no information about the concept of STEM education and have not encountered this term yet.

Analysis of the rest of the respondents' answers to this question pointed out following main sources of kindergarten teachers´ information on STEM:

Higher education: Some respondents (8 %) received information about STEM education during their higher education.

Continuing education (training, courses, webinars): Another important source of information are various types and forms of continuing education for teachers. These were mentioned by 15 % of respondents as the source from which they received information about the STEM concept.

Independent study of professional literature: Up to 23 % of respondents obtained information and acquired some knowledge about STEM education through independent study of professional literature.

Colleagues and other sources: Approximately 10 % of respondents obtained information about STEM education from their colleagues, and approximately 5 % of respondents reported other sources.

QI-4: How do you rate your general readiness for STEM teaching?

Almost 40 % of the respondents stated negative self-assessments regarding their readiness for STEM teaching, specifically they evaluated their readiness as insufficient or weak. More than a third of the respondents (35 %) were very uncertain at claiming this self-assessment and chose the neutral response that they cannot express themselves. On the one hand this can be caused really by their uncertainty whether they are or are not prepared sufficiently, but on the other hand it can be simply related to the fact that they lack sufficient experience with using STEM methodology in their teaching activities. The third reason, the worst one, can be the fact that their readiness is really so weak that they miss the clear understanding of the STEM concept. Positive statements on the above question were stated by a quarter of the respondents (statements claiming that their readiness is either sufficient or even good), what can be perceived significantly differently, as either a pleasing finding or as an alarming finding. However, whether we perceive it in one or the other one meaning, in relation to the recorded number both cases imply a necessity of the teachers to undergo some further education in the field of STEM. In essence, STEM can be considered

DISCUSSION

Now-a-days there have been world-wide growing demands to include STEM education in pre-primary education (Leung, 2023). Different authorities, as researchers, educators and decision makers, stress the significance of engaging this concept into the national systems of education as early as possible (Bybee, 2013; Simoncini & Lasen, 2018; Yakman & Lee, 2012). They state that early childhood education is a significant phase in a child´s development for enhancing the child´s thinking dispositions, curiosity, inquiry, critical assessment and analysis, what are components of STEM education. At the same time these components will children need and use in later stages of their education. However, these demands create new challenges for kindergarten teachers as they must find ways how to integrate STEM content and to it relevant strategies into their curricula and teaching activities. On this context a question is how the kindergarten teachers are prepared to face the above demands. As indicated already in the presentation of the research results, the finding that only a quarter of the respondents (representatives of kindergarten teachers) self-assessed their readiness to implement STEM approach into their teaching activities as good or sufficient can be perceived either as positive news or, conversely, as negative ones. The very idea that only a quarter of the teachers in the kindergartens are aware of the methodology which they are expected to use in their work with children is really slightly a scary one. But only 18 % of the respondents (less than a quarter, and not three quarters) stated that they had not encountered the term or concept of STEM education or were not familiar with it. Contrary to that two thirds (up to 67 %) of the respondents were able to interpret in some way, although not to define or explain exactly the content of this term or concept. That means that majority of the kindergarten teachers have some idea about it, but the acronym is not generally known among them, in some way it is some novelty

for them, which only currently starts to appear in official pedagogical documents and proclaimed strategies of education system development. On the other hand, as it was said, approaches to introduction of some innovations into the traditional ways of education through integrated thematic teaching have already a longer tradition (also thanks to the Susan Kovalik Association). That is why project-based learning was so often mentioned among the ways in which the kindergarten teachers apply STEM in their teaching practice. Moreover, introduction of integrated thematic teaching in Slovakia was supported also by supplies of LEGA Dacta teaching aids in 80s and 90s of previous century (Čirčová, 2013). In its essence STEM education is a modification of integrated thematic education in narrow focus only on the four subjects of science, technology, engineering and mathematics (with the current tendency to add extra to them also arts, STEAM). As Leung (2023) states, concept of STEM teaching represents a dynamic process, and the role of kindergarten teachers in its frame is transformed from the role of a knowledge provider to the role of fostering STEM-related learning in children.

CONCLUSION

Implementation of STEM education into the early childhood education provides a space for designing active learning environments that utilize children's natural curiosity about the world around them. It engages children in authentic investigations, using critical and creative thinking in systematic ways to build knowledge, acquire skills and support self-confidence and dispositions for learning. A key component of children´s learning is solving of a real-life-based problems. But, on the other hand, implementation of STEM education into the early childhood education supposes not only content knowledge provision. It requires also integrated STEM curricula development to meet the learning needs of the pre-school aged children (Larkin & Lowrie, 2023). However, the key factor of the successful implementation of STEM education (and that at which ever level of education, not only at the pre-primary education level) remains still a well-prepared and trained teacher. Kindergarten teachers need to be trained to cope with the knowledge, epistemological and pedagogical principles of the contributory disciplines to be able to embrace STEM integrated approaches (Leung, 2023). This means that it is necessary to offer to kindergarten teachers a school-based and/or further professional development and STEM education training. The need for this offer is also indicated by the results of the above-described research.

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REFERENCES

Brečka, P, Valentová, M, Hašková, A, Tirpáková, A 2025. STEM vzdelávanie v kontexte predškolskej edukácie. [STEM education in the context of preschool education]. Praha, Verbum

Bybee, RW 2013. The Case for STEM Education Challenges and Opportunities. Washington, DC, USA, National STEM Teachers Association

Cluver, A, Heyman, G, Carver, LJ 2013. Young children selectively seek help when solving problems. Journal of Experimental Child Psychology, Vol. 5, no 3, pp. 570-578

Cunningham, CM, Lachapelle, CP, Davis, ME 2018. Engineering concepts, practices, and trajectories for early childhood education. Early Engineering Learning (Eds. L. English, T. Moore), pp. 135–174. Springer

Čirčová, A 2013. Praktické využitie LEGO Dacta v 1, a 2, ročníku základnej školy: Osvedčená pedagogická skúsenosť edukačnej praxe. [Practical use of LEGO Dacta in 1st and 2nd grade of elementary school: Proven pedagogical experience of educational practice]. Prešov, MPC

DeJarnette, NK 2018. Implementing STEAM in the early childhood classroom. European Journal of STEM Education, Vol. 3, no 3, 18

IBE-UNESCO [UNESCO International Bureau of Education] 2019. Exploring STEM Competences for the 21st Century. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000368485

MŠ [Ministry of Education of the Slovak Republic] 2018. Národný program rozvoja výchovy a vzdelávania 2018 – 2027 Kvalitné a dostupné vzdelanie pre Slovensko [National Program for the Development of Upbringing 2018 – 2027 Quality Education and Affordable Education for Slovakia]. Available at:

https://www.minedu.sk/data/att/1bb/13288.e6f863.pdf

MŠ [Ministry of Education of the Slovak Republic] 2020. Národný program rozvoja výchovy a vzdelávania Stratégia Vzdelané Slovensko 2035 [National Program for the Development of Upbringing and Education The Educated Slovakia 2035 Strategy].Available at: https://www.minedu.sk/data/att/379/35028.a06a38.pdf

MŠ [Ministry of Education of the Slovak Republic] 2022. Štátny vzdelávací program pre predprimárne vzdelávanie v materských školách [State Educational Program for Pre-primary Education in Kindergarten Schools]. Available at: www.minedu.sk/data/att/96d/24534.b6f65c.pdf

Kovaliková, S, Olsenová, K 1996. Vzdelávanie pre 21. storočie: Integrované tematické vyučovanie [Education for the 21st Century: Integrated Thematic Teaching]. Bratislava: Nadácia S. Kovalik.

Kuchárová, A 2012. Integrované tematické vyučovanie v primárnom vzdelávaní : Osvedčená pedagogická skúsenosť edukačnej praxe [Integrated Thematic Teaching in Primary Education: Proven Pedagogical Experience of Educational Practice]. Bratislava: MPC

MacDonald, A, Huser, C, Sikder, S, Danaia, L 2020. Effective early childhood STEM education: Findings from the Little Scientists Evaluation. Early Childhood Education Journal, Vol. 48, no. 3, pp. 353-363

Larkin, K, Lowrie, T 2023. Teaching approaches for Stem integration in pre- and primary school: A systematic qualitative literature review. International Journal of Science and Mathematics Education, 21(Suppl 1), 11-39

Leung, WMV 2023. STEM Education in Early Years: Challenges and Opportunities in Changing Teachers' Pedagogical Strategies. Education Sciences, 13, 490, 1-21. https://doi.org/10.3390/educsci13050490

National Science Board 1996. U.S. Science and Engineering in a Changing World. National Science Foundation. Available at: https://www.nsf.gov/nsb/publications/1996/nsb9621/

Penprase, BE 2020. STEM Education for the 21st Century. Springer Nature

Simoncini, K, Lasen, M 2018. Ideas About STEM Among Australian Early Childhood Professionals: How Important is STEM in Early Childhood Education? International Journal of Early Childhood, 2018, 50, 353–369.

Vasquez, JA 2015. STEM - beyond the acronym, Educational Leadership, Vol. 72, no. 4, pp. 10-15

Tippett, C. D., & Milford, T. M. (2017). Findings from a pre-kindergarten classroom: Making the case for Stem in early childhood education. International Journal of Science and Mathematics Education, 15, 67-86.

Yakman, G, Lee, H 2012. Exploring the exemplary STEAM education in the US as a practical educational framework for Korea. Journal of Korean Association of Science Education, 2012, 32, 1072–1086

THE IMPACT OF ERP USE ON ENVIRONMENTAL AND ECONOMIC PERFORMANCE IN TÜRKİYE'S NON-METALLIC MINERAL PRODUCTS INDUSTRY: THE MEDIATING ROLE OF WAREHOUSE MANAGEMENT PERFORMANCE AND THE MODERATING ROLE OF USER COMPETENCE

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ABSTRACT

ERP systems are increasingly adopted in Türkiye's non-metallic mineral products industry (NACE Rev.2 23; glass, ceramics, cement, and concrete), yet empirical evidence on whether ERP-enabled process integration translates into both sustainability and economic outcomes has remained limited. This study investigated the effect of ERP use on environmental performance and economic performance, and explained this relationship through warehouse management performance as a key operational mechanism. In addition, it examined user competence as a boundary condition by testing whether competent users amplified the benefits of ERP use in daily operations. A quantitative, cross-sectional survey design was employed. The respondents consisted of managers or supervisors who were able to evaluate ERP-supported processes in firms operating in the sector and that had been actively using an ERP system for at least one year. Data were collected through a structured questionnaire using 5-point Likert-type measures for ERP use, warehouse management performance, user competence, environmental performance, and economic performance. The research model was analyzed with partial least squares structural equation modeling in Python in order to estimate direct effects, the mediating role of warehouse management performance, and the moderating role of user competence, including the conditional indirect effect. By focusing on an energy- and material-intensive industry, the study clarified how ERP use contributed to environmental improvements alongside economic results, and highlighted the managerial importance of warehouse process capability and user-focused training policies. The findings can guide ERP value-realization strategies for firms seeking operational excellence and sustainability in Türkiye. The study also provides sector-specific evidence for the ERP-performance debate and supports discussions on digitalization and green transformation in manufacturing.

Keywords: ERP use; Warehouse management performance; User competence; Environmental performance; Economic performance

APPLICATION OF MATHEMATICAL AND SIMULATION MODELS FOR CALCULATING THE EFFECTIVENESS OF ARTILLERY FIRE

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ABSTRACT

In modern combat operations, increasing the effectiveness of artillery fire is one of the key factors ensuring the successful execution of combat missions. The growing complexity of the battlefield, the dynamic nature of targets, and limited resources make it necessary to adopt scientifically grounded decision-making in the employment of artillery systems. In this context, accurate pre-calculation of artillery fire and the selection of optimal employment options are of particular importance.

The application of mathematical and simulation models in assessing the effectiveness of artillery fire provides extensive opportunities. Mathematical models enable the analytical calculation of firing accuracy, probability of damage, reaction time, ammunition expenditure, and the level of target destruction. Based on statistical data, probability theory, and ballistic calculations, these models ensure the scientific justification of combat decisions.

Simulation models, on the other hand, allow for the creation of scenarios that closely approximate real combat conditions, making it possible to evaluate the performance of artillery units in various operational situations. This approach enables commanders and staff officers to assess risks in advance, compare alternative courses of action, and make more effective decisions.

Research findings indicate that the integrated application of mathematical and simulation models contributes to an objective assessment of artillery fire effectiveness, optimization of command and control processes, and minimization of combat risks. These models serve as an important scientific and practical tool for enhancing the combat capabilities of modern artillery systems.

Keywords: artillery fire, effectiveness, mathematical models, simulation models, combat calculations.

INTRODUCTION

The primary objective of the combat employment of artillery units is to inflict maximum damage on the target with minimal expenditure of ammunition and time. Achieving this objective requires the prior calculation of fire effectiveness and the adoption of scientifically justified decisions. Traditional normative tables and empirical approaches do not provide sufficiently reliable results under modern combat conditions, particularly in the presence of variable meteorological and tactical factors.

In this regard, mathematical modeling and computer simulation serve as important scientific tools in the planning of artillery fire. The purpose of this article is to systematically present the technical mathematical and simulation methods used in calculating the effectiveness of artillery fire and to analyze their practical application capabilities.

METHODS

External Ballistics and Dispersion Model

The flight trajectory of artillery projectiles is determined by the fundamental laws of external ballistics and depends on a number of factors of both deterministic and stochastic nature. These factors include:

- the initial velocity of the projectile v_0;
- the firing angle θ;
- air resistance and aerodynamic characteristics;
- wind speed and direction;
- technical dispersion of the weapon and ammunition (manufacturing and operational inaccuracies).

As a result of the combined influence of these factors, dispersion occurs at the point of impact. Since the dispersion process is stochastic in nature, the coordinates of the projectile impact point are treated as two-dimensional random variables and are modeled using a normal distribution:

$$f(x,y) = \frac{1}{2\pi\sigma_x\sigma_y} \exp\left(-\frac{x^2}{2\sigma_x^2} - \frac{y^2}{2\sigma_y^2}\right),$$

where $\sigma_x$and $\sigma_y$represent the standard deviations of dispersion in the horizontal and vertical directions, respectively. This approach enables a statistical assessment of the accuracy of artillery fire.

Circular Error Probable (CEP) Indicator

One of the main quantitative indicators of artillery fire accuracy is the concept of Circular Error Probable (CEP). CEP is defined as the radius of a circle within which 50 percent of the projectiles fall, and it compactly characterizes the overall accuracy of fire.

Under the assumption of a normal distribution, CEP can be approximated by the following expression:

$$\text{CEP} \approx 0.56 \cdot \sigma$$

where $\sigma$is the radial standard deviation. The CEP indicator is widely used in operational planning, optimization of ammunition expenditure, and rapid assessment of fire effectiveness.

Calculation of Target Hit Probability

The probability of a projectile hitting a circular target with radius $R$is determined by the following double integral:

$$P_h = \iint_{x^2+y^2 \le R^2} f(x,y)\, dx\, dy$$

This probability characterizes the likelihood of target engagement for a single shot. If $n$independent shots are fired, the probability of at least one effective hit is expressed as:

$$P_e = 1 - (1 - P_h)^n$$

This model enables artillery units to scientifically plan the required fire intensity and ammunition reserves.

Simulation Modeling (Monte Carlo Method)

To overcome the limitations of analytical mathematical models, simulation modeling—particularly the Monte Carlo method—is employed. In this approach, thousands of virtual firing scenarios are generated, and in each iteration ballistic, meteorological, and technical parameters are treated as random variables.

Based on the simulation results, overall effectiveness is evaluated using the following ratio:

$$E = \frac{N_{\text{effective}}}{N_{\text{total}}}$$

where $N_{\text{effective}}$is the number of shots that achieve effective impact on the target, and $N_{\text{total}}$is the total number of simulation iterations.

This method makes it possible to account for the dynamic and uncertain nature of real combat conditions.

RESULTS

The conducted mathematical calculations demonstrate that a reduction in the CEP value leads to a nonlinear increase in the probability of hitting the target. This fact proves that improving the accuracy of artillery systems has a direct impact on combat effectiveness.

The results of the Monte Carlo simulations reveal that meteorological variability—particularly wind speed and direction—has a significant effect on effectiveness indicators. Compared to analytical models, simulation-based approaches provide results that are closer to real combat conditions.

Table 1

Target Hit Probability as a Function of CEP

CEP (m)	Target Radius (m)	P_h
30	50	0.42
20	50	0.61
10	50	0.85

Description of Figure 1

Figure 1. A graph illustrating the increase in target hit probability as the CEP value decreases. The graph clearly shows that improving the accuracy of artillery fire sharply increases the probability of effective target engagement and positively affects operational outcomes.

DISCUSSION

The conducted analysis shows that ballistic and probabilistic models are suitable for preliminary and rapid assessment of artillery fire effectiveness. However, under real combat conditions, the large number of random factors can be adequately taken into account only through simulation-based models.

The integration of analytical and simulation modeling ensures scientifically grounded decision-making in artillery fire planning. In future studies, integrating these models with artificial intelligence algorithms may further enhance effectiveness.

REFERENCES

Bate, R. R., Mueller, D. D., & White, J. E. (2020). Fundamentals of astrodynamics (2nd ed.). Dover Publications.

Benjamin, D., & Cornell, C. A. (1970). Probability, statistics, and decision for civil engineers. McGraw-Hill Series in Engineering.

Montgomery, D. C., & Runger, G. C. (2018). Applied statistics and probability for engineers (7th ed.). Wiley.

NATO Standardization Office. (2021). NATO glossary of terms and definitions (AAP-06). NATO Publications.

Sullivan, J. L. (2001). Circular error probability and weapons accuracy. Journal of Defense Modeling and Simulation, 1(2), 75–89.

THE ECONOMIC FUNCTIONS OF SPORT IN ENHANCING SOCIAL WELFARE

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ABSTRACT

The article provides a comprehensive analysis of the economic functions performed by sport in enhancing social welfare and substantiates its strategic importance in the development of contemporary society. In the context of globalization and the post-industrial economy, social welfare is measured not only by income levels but also by the quality of human capital, health indicators, employment opportunities, and the degree of social integration. Within this framework, sport is no longer merely a form of physical activity or leisure organization; it functions as a multifunctional socio-economic institution.

The study demonstrates that sport primarily contributes to the formation of human capital. Regular physical activity increases labor productivity, reduces sick-leave days, and improves individuals' competitiveness in the labor market. Participation in sports activities within educational institutions fosters leadership, teamwork, and decision-making skills, which are considered key factors of long-term economic development. Thus, sport directly strengthens the social foundations of economic growth.

The article emphasizes the role of sport in reducing healthcare expenditures. Physical activity acts as a preventive health mechanism by lowering the risk of cardiovascular diseases, diabetes, and psychological disorders. As a result, public medical spending decreases, enabling the reallocation of financial resources to social programs. From this perspective, investment in sport should be regarded not as a social expense but as a long-term cost-saving economic investment.

The impact of the sports sector on employment is also analyzed as an essential component of social welfare. Sports infrastructure, clubs, the fitness industry, and sports tourism create both direct and indirect jobs. In particular, major sporting events stimulate regional economic activity, expand the service sector, and enhance the investment attractiveness of cities. This contributes to reducing regional disparities and promoting economic inclusiveness.

The research further highlights the role of sport in the formation of social capital. Sport strengthens mutual trust among different social groups, reduces deviant behavior among youth, and accelerates social integration. Additionally, improved psychological well-being, reduced stress levels, and increased life satisfaction reinforce overall social stability.

In conclusion, sport is identified as a complex mechanism integrating economic, social, and psychological effects and playing a significant role in increasing social welfare. The development of mass sport, the creation of accessible infrastructure, and the involvement of the private sector are evaluated as key directions for ensuring sustainable growth of social welfare within state policy. Therefore, investments in the sports sector represent strategic capital allocation that generates long-term economic growth, a healthy population, and social stability.

Keywords: sports economics, social welfare, human capital, employment, healthy lifestyle

INTRODUCTION

In the contemporary era, societal development is characterized by a multidimensional nature and cannot be confined solely to macroeconomic indicators such as GDP growth, investment volume, or industrial output. The concept of social welfare has acquired a broader meaning, encompassing the population's health status, quality of life, social equality, employment opportunities, and psychological stability. In this regard, the sustainability of economic growth directly depends on the quality of human capital and the effectiveness of social institutions. One such institution is sport. Whereas in earlier stages sport was primarily perceived as physical education and competitive activity, in the modern period it functions as an essential structural element of socio-economic development.

The processes of globalization, urbanization, and digitalization have led to significant changes in lifestyles, resulting in increased physical inactivity and the widespread prevalence of chronic diseases, thereby generating new challenges for social welfare. Under these conditions, sport emerges not only as a means of promoting health but also as an instrument of preventive social policy. In the social strategies of states, the promotion of mass sport, the formation of a healthy lifestyle, and the development of sports infrastructure are identified as priority directions. The primary rationale lies in the multifaceted economic functions of sport, including the reduction of healthcare expenditures, the enhancement of labor productivity, and the strengthening of social integration.

At the same time, sport has evolved into a distinct sector of the economy. Professional clubs, the sports industry, fitness and wellness services, sports tourism, and media activities generate substantial financial turnover and make a significant contribution to employment. This demonstrates that sport represents a hybrid institution operating both within the framework of social policy and market mechanisms. Consequently, sport possesses not only indirect but also direct economic impact mechanisms in improving social welfare.

The aforementioned factors necessitate a scientifically grounded examination of the role of sport within the social welfare system. In this context, a comprehensive analysis of the economic functions of sport gains particular relevance for the optimization of social policy and the formulation of sustainable development strategies.

METHOD

In the contemporary era, sport has emerged as an applied field of the economy, acquiring the status of a complex socio-economic institution rather than being limited to entertainment or physical activity. Sporting activity is directly linked to production, distribution, and consumption processes

while simultaneously performing a social service function. This dual character defines sport both as an economic sector operating within market mechanisms and as a social system generating public benefits. The sport product is not confined to material components—such as equipment, infrastructure, and services—but also produces intangible values, including health, social integration, collective identity, and psychological well-being. In this regard, the economics of sport exerts multi-level impact mechanisms within the social welfare system.

From an economic analysis perspective, the impact of sport can be assessed in three main dimensions: direct economic impact, indirect economic impact, and socio-economic impact. Direct impact encompasses financial turnover generated through the construction and operation of sports facilities, club activities, organization of competitions, and production of sporting equipment. The added value created in this area contributes to GDP formation and increases public revenues. Indirect impact arises from sport's interaction with other sectors. Tourism, transport, catering, advertising, and media sectors expand through sporting events and infrastructure. Socio-economic impact manifests in a broader context, reflected in health indicators, educational outcomes, social stability, and quality of life. This approach allows sport to be evaluated not merely as a source of income but as a system that generates public wealth.

One of the key economic functions of sport relates to human capital development. Contemporary economic theory emphasizes that the primary driver of economic growth is not physical capital but human capital. Individuals' health, knowledge, and skills are fundamental determinants of labor productivity. Regular physical activity enhances work capacity, reduces workdays lost due to illness, and improves workplace efficiency. A healthy workforce remains active for longer periods and participates sustainably in the economic system. Moreover, participation in sports fosters leadership, teamwork, strategic thinking, and operational decision-making skills, enhancing individuals' competitiveness in the labor market. Consequently, sport contributes not only to individual health but also to macroeconomic productivity growth.

Another significant mechanism through which sport enhances social welfare is the reduction of healthcare expenditures. Physical inactivity is considered one of the primary causes of chronic diseases in modern societies. Cardiovascular diseases, diabetes, obesity, and depressive disorders not only diminish individual quality of life but also impose a substantial financial burden on state budgets. Regular engagement in sports significantly mitigates these risks, functioning as a preventive healthcare mechanism. This prophylactic effect reduces public spending on medical services in the long term. Investments in sport can thus be regarded as preventive measures that avert greater healthcare costs in the future.

The impact of the sports industry on the labor market also holds significant implications for social welfare. Today, the sport sector is one of the fastest-growing service areas. Professional clubs, fitness and wellness centers, sports tourism, media and marketing activities, equipment production, and logistics chains generate extensive employment opportunities. This employment is both direct and indirect: direct employment involves specialists working within the sports sector, while indirect employment arises from the development of related sectors. In particular, international sporting events and large infrastructure projects create thousands of new jobs in the short- and medium-term, directly increasing incomes and enhancing social welfare.

In the context of regional development, sports infrastructure plays a crucial stimulatory role. The establishment of stadiums, sports complexes, and training centers promotes the formation of surrounding service and commercial facilities, increasing economic activity. This process stimulates the real estate market, encourages new businesses, and improves the investment climate. Sporting events also play a noteworthy role in shaping city and regional brands. Financial inflows from sports tourism diversify local economies and increase budget revenues. As a result, sport becomes an effective instrument for reducing regional disparities and implementing balanced development policies.

Sport's functions in promoting social integration and equality are also key components of the social welfare system. Sport strengthens interaction among different social groups, reduces social isolation, and fosters collective identity. Engagement of youth in sports positively affects the reduction of deviant behavior and crime. The integration of migrants and socially vulnerable groups through sport contributes to social stability. Promoting gender equality and increasing women's participation in sport further advances principles of social justice. Economically, these effects reduce social costs and enable more inclusive participation in the labor market.

Enhancing psychological well-being is another important economic function of sport. Reductions in stress, increased emotional stability, and strengthened social connections improve individual life satisfaction. Higher subjective well-being enhances workplace motivation and positively influences consumer behavior, indirectly boosting economic activity. The interrelation between psychological health and economic productivity further underscores the socio-economic significance of sport.

From the perspective of state policy, viewing sport as a social investment represents a strategic approach. Promoting mass sport, ensuring accessible infrastructure, expanding school and university sports programs, and engaging the private sector in this domain are key directions for sustainable development. Investments in sport generate long-term, multi-layered social benefits, reflected not only in material indicators but also in social stability, a healthy population, and high quality of life.

Thus, sport functions as a complex institution at the intersection of the economy and social system, performing multifaceted roles in enhancing social welfare. It simultaneously influences human capital development, reduces healthcare expenditures, increases employment, accelerates regional development, and strengthens social integration. These characteristics position sport as a strategic priority for modern social states and justify policies aimed at its development on both economic and social grounds.

RECOMMENDATIONS

Research findings indicate that sport performs multifaceted economic and social functions in enhancing social welfare. By improving the quality of human capital, it increases labor productivity, reduces workdays lost due to illness, and strengthens individual economic activity. Simultaneously, sport functions as a preventive healthcare mechanism, optimizing public expenditures and generating long-term financial savings. The employment-creating potential of the sports industry is considered a significant mechanism for regional and national economic development, contributing to job expansion through both direct and indirect employment channels. Moreover, sport facilitates social integration and equality by promoting interaction among diverse social groups, reducing marginalization, and minimizing the risk of deviant behavior among youth. Enhancements in psychological well-being further improve overall societal life satisfaction, indirectly boosting motivation in the labor market and consumer activity. Consequently, investments in sport can be evaluated not only as a means of improving economic indicators but also as a strategic measure that supports social stability, a healthy population, and sustainable development. State policies promoting sport and mass physical activity generate both social and economic benefits in the long term, raising overall societal welfare and serving as a guarantee for sustainable development.

LITERATURE

Ahlfeldt, G., & Maennig, W. (2010). Impact of sports arenas on land values. *Regional Science and Urban Economics, 40*(5), 326–338.

Andreff, W., & Szymanski, S. (2006). *Handbook on the economics of sport*. Edward Elgar.

Biddle, S., & Asare, M. (2011). Physical activity and mental health in children and adolescents. *British Journal of Sports Medicine, 45*(11), 886–895.

Bloom, D., Canning, D., & Sevilla, J. (2004). The effect of health on economic growth. *World Development, 32*(1), 1–13.
Eide, E., & Ronan, N. (2001). Is participation in high school athletics an investment or a consumption good? *Economics of Education Review, 20*(5), 431–442.
European Commission. (2018). *The economic importance of sport in Europe*.
Gratton, C., & Taylor, P. (2000). *Economics of sport and recreation*. Spon Press.
Nichols, G. (2007). *Sport and crime reduction*. Routledge.
Sport England. (2020). *Social value of sport*.
Warburton, D., & Bredin, S. (2017). Health benefits of physical activity. *Current Opinion in Cardiology, 32*(5), 541–556.
WHO. (2020). *Guidelines on physical activity and sedentary behaviour*. World Health Organization.

APPLICATION OF PLASMA IN NANOTECHNOLOGIES

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ABSTRACT

The main goals of research in the field of modern materials relate to the understanding of the correlation that exists between synthesis, processing and material characteristics, as well as the description of material structure, composition and properties at the atomic, molecular, microscopic and macroscopic level. Relevant topics for applications in science and technologies related to modern materials are:

1. Physical basis of plasma technologies.

2. Plasma etching, plasma diagnostics, plasma modeling.

3. Application of plasma etching in micro and nanoelectronics to achieve high resolution plasma etching

4. Applications of mass spectroscopy with proton transfer or direct sampling from the atmosphere to detect the yield of essential oils, analysis of patients' breath. Detection of diabetes, liver diseases.

5. Plasma implantation, physical basis for implantation devices.

6. Deposition of thin layers, diamond-like amorphous carbon layers, nanotubes and their functionalization, growth of dust in plasma, physical basis of plasma spraying.

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DATA-DRIVEN APPROACHES IN CONTEMPORARY LANGUAGE PEDAGOGY

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ABSTRACT

Data-driven language teaching (DDL) methods are transforming language teaching from the inside out, enabling educators to base their decisions on the analysis of real-world language use and linguistic corpora. This article explores how these approaches function in modern language classrooms: how the analysis of interactive data and language patterns improves the quality of curriculum planning, assessment, and individualized student support. It analyzes tools for corpus-based research of authentic examples, analytical dashboards for monitoring progress, and software for identifying development curves, typical errors, and set phrases. Meta-analyses demonstrate significant positive effects of DDL on lexical depth, grammatical accuracy, and pragmatic competence. Barriers to implementation are discussed, and a step-by-step practical model for integrating DDL into the educational process is proposed.

Keywords: data-driven learning, corpus linguistics, language pedagogy, learning analytics, evidence-based instruction, learner corpus.

INTRODUCTION

The paradigmatic shift in applied linguistics that emerged in the late 1980s and early 1990s was largely driven by the emergence of digital corpora — representative collections of authentic texts accessible to automated analysis. J. Sinclair's pioneering work on the COBUILD project demonstrated that native speaker intuition and actual linguistic usage often diverge: words form collocations, lexical and grammatical patterns, and prosodic niches that are impossible to identify in the limited material of study sentences.

Tim Jones coined the term data-driven learning (DDL) in 1991, describing an approach in which learners act as "language detectives": by examining concordance strings, they independently formulate rules for the use of lexemes, grammatical constructions, and discourse markers. Since then, DDL has evolved from experimental practices with postgraduate students to a wide range of applications in ESL/EFL, EAP (Academic English), ESP (English for Specific Purposes), and heritage language teaching.

A meta-analysis by Boulton & Cobb (2017), covering 64 studies with 88 independent samples, found a large overall effect size for DDL in both experimental and control group comparisons ($d = 0.95$) and before/after design ($d = 1.50$). These figures significantly exceed the average effects of most other second language acquisition interventions, making DDL one of the most empirically supported areas of language instruction. However, systematic reviews indicate a persistent gap between research demonstrations and everyday teaching practice, particularly in non-tertiary and non-traditional contexts.

This article aims to systematize modern DDL approaches, characterize their empirical evidence base, describe the toolkit, and propose a practical model for step-by-step implementation—with

particular attention to the Kazakhstani and Central Asian context, where corpus-based linguodidactics is making its first, but already tangible, steps.

THEORETICAL FOUNDATIONS

Cognitive and constructivist foundations of DDL

Data-driven learning draws on several mutually reinforcing theoretical traditions. Constructivism (Bruner, Piaget) postulates that the most stable cognitive structures are formed through spontaneous discovery rather than through the transmission of predetermined rules. In the DDL paradigm, concordance strings provide the "building blocks" from which the learner inductively constructs a mental representation of the meaning, valence, and pragmatic constraints of a linguistic unit.

The salience theory (Noticing Hypothesis, Schmidt, 1990) points to the need for conscious detection of a linguistic phenomenon as a prerequisite for its acquisition. Corpus-based concordance tasks, in which the key word or pattern is highlighted in the center of the line, create conditions for concentrated attention to form — especially effective for learning collocations and idiomatic expressions that escape attention in traditional reading.

Chunk-based learning (Ellis, 2003) views language proficiency as largely a process-based memory of frequent formulaic units. This is where corpus-based technologies offer a distinct advantage: statistical measures of association (MI score, t score) allow for objective ranking of collocations by strength of association and structuring learning from central, high-frequency patterns—unlike textbooks, where the selection of examples is often determined by pedagogical considerations rather than actual data.

Typology of DDL practices

In the literature, a distinction is made between direct and indirect DDL. With direct DDL, the student independently formulates queries to the corpus, analyzes concordance lines, and formulates generalizations. With indirect (or corpus-informed) DDL, the teacher preemptively extracts examples from the corpus and integrates them into traditional teaching materials, thereby reducing the cognitive load and the technological barrier.

Learner corpora — collections of texts created by learners — play a special role in modern DDL practice. Their analysis allows us to identify interlingual interference, consistent error patterns, and individual risk areas. The largest such project, ICLE (International Corpus of Learner English), led by S. Granger (Université catholique de Louvain), encompasses over 6 million words and serves as a benchmark for comparing interlingual strategies.

Table 1. Comparative analysis of traditional and DDL approaches in linguodidactics

Parameter	Traditional approach	DDL approach
Source of language examples	Textbook, isolated sentences	Authentic cases (BNC, COCA, etc.)
The role of the student	Passive recipient of rules	An active "language detective"
Study of collocations	Memorization from lists	Inductive discovery through concordance
Feedback	Deferred, from the teacher	Immediately via the data corpus
Learner autonomy	Low textbook dependence	High, independent search
Pragmatic competence	Limited, artificial examples	Developed, based on real usage

Note: Compiled by the authors based on: Johns (1991); Sinclair (1991); Boulton & Cobb (2017).

CASE TOOLS AND TECHNOLOGIES

Referential corpora and concordancers

The modern ecosystem of DDL tools is quite diverse, encompassing both massive reference corpora and easy-to-learn local concordancers. The British National Corpus (BNC, 100 million words) and the Corpus of Contemporary American English (COCA, over 1 billion words, edited by M. Davis) are the most frequently cited tools in DDL research. The former provides a representative cross-section of British usage in the late 20th century, while the latter offers a dynamic panorama of American English, broken down by genre (fiction, academic texts, journalism, spoken language, and television subtitling).

Sketch Engine, a commercial platform with a licensing scheme for universities, provides access to over 500 corpora in 90+ languages. Its key feature is the Word Sketch function, which automatically generates word profiles: left- and right-distribution patterns, thematic associations, and close synonyms, differentiated statistically. For Kazakhstani universities, the availability of Kazakh and Russian corpora is particularly valuable, opening up the possibility of bilingual and contrastive DDL assignments.

AntConc (Lawrence Anthony, Waseda University), a free, multi-platform concordancer, remains the standard in resource-constrained learning contexts. It allows for working with locally downloaded texts, computing n-grams, building frequency dictionaries, and visualizing word dispersion in a corpus. Compleat Lexical Tutor (T. Cobb) offers free online access to lexical profiling tools — particularly valuable for vocabulary assessment and assessing the complexity of learning materials.

Table 2. Basic corpus tools for DDL practice

Tool	Type / Volume	Application in teaching	Availability
BNC (British National Corpus)	100 million words, Brit. English	Vocabulary, grammar, registers	Free (BNCweb)
COCA (Corpus of Contemporary American English)	1 billion+ words, amer. English	Collocations, frequency, genres	Partially free
Sketch Engine	500+ corpora, multilingual	Word Sketch, thesaurus, DDL assignments	Fee-based (licenses for universities)
AntConc	Local analyzer	Concordance, clusters, n-grams	For free
Lextutor (Compleat Lexical Tutor)	Online platform	Lexical analysis, text profiling	For free
ICLE / LINDSEI (CECL Louvain)	Lerner buildings	Error analysis, interlingua	Upon request

Note: TTR — type-token ratio; KWIC — keyword in context; MI — mutual information.

Lerner corpora and personalized analytics

A qualitative shift in DDL involves the transition from using ready-made corpora to creating personal Lerner corpora. Students systematically collect their own texts—essays, audio recordings, transcripts, correspondence — and analyze them using the same tools as professional linguists. This approach implements the principle of reflective learning: students view their own linguistic patterns as data and are able to compare them with the norms recorded in the reference corpus.

Advanced natural language processing (NLP) systems enable the automatic tagging of Lerner texts by grammatical categories, discourse markers, and stylistic features. In the context of Kazakhstani EFL education, the Lerner corpus makes it possible to identify specific Kazakh-Russian language interference in students' English speech and construct targeted DDL tasks based on these interferences.

EMPIRICAL DATA ON THE EFFICIENCY OF DDL

The evidence base for DDL is steadily expanding: while in the early 2000s there were only a few dozen scattered studies, by 2021, Boulton & Vyatkina had documented a body of 489 empirical studies over a thirty-year period. Table 3 summarizes the key studies that formed the basis for this analysis.

Table 3. Empirical evidence on the effectiveness of DDL approaches in second language teaching

Study	Design / n	Measurable effect	Key result
Boulton & Cobb (2017). Language Learning, 67(2)	Meta-analysis, 64 studies, 88 samples	Performance in L2 (DDL vs. control)	d = 0.95 (between groups); d = 1.50 (before/after)
Lee, Warschauer & Lee (2019). Applied Linguistics, 40(5)	Meta-analysis, 29 studies, 38 samples	Lexical knowledge (DDL vs. control)	Hedges' g = 0.74 (short term); g = 0.64 (long term)
Johns (1991). ELR Journal, 4	High-quality, postgraduate students	Grammar of academic writing	Reducing typical errors, increasing autonomy
Chambers (2019). Language Teaching, 52(4)	Systematic review	The research-practice gap	DDL is poorly integrated into non-tertiary levels
Boulton & Vyatkina (2021). Language Learning & Technology, 25(3)	Analysis of 489 studies (1989–2019)	DDL Development Trends	Growth of quantitative research; 9% covers the school level

Note: d is Cohen's standardized effect size; g is Hedges' statistic; both indicators are interpreted similarly: > 0.5 is a “medium” effect, > 0.8 is a “large” effect.

A meta-analysis by Boulton & Cobb (2017) found a large effect size for DDL for both experimental–control group (d = 0.95) and before–after (d = 1.50) designs. The authors emphasize that large effects are often associated with small samples, but the overall picture remains compelling: corpus-based learning systematically outperforms traditional methods on vocabulary and grammar tests.

A meta-analysis by Lee, Warschauer, & Lee (2019) examining the lexical-specific effects of DDL found a moderate-to-large effect size (g = 0.74 in the short term; g = 0.64 with a delayed posttest), suggesting high stability of lexical acquisition. A key finding of the study was that deep lexical knowledge (the semantic and syntactic valence of a word) was more sensitive to DDL intervention than simple knowledge of meaning, consistent with the theoretical rationale for the collocational learning approach.

A review by Boulton & Vyatkina (2021) covering a 30-year period revealed a disturbing disparity: only 9% of the studies examined focused on learning at non-tertiary levels (school, primary school). This means that most of the positive findings were obtained in university classrooms with relatively motivated students and adequate technological infrastructure — and cannot be automatically transferred to the school context without adaptation studies.

BARRIERS TO IMPLEMENTATION AND PEDAGOGICAL RISKS

Cognitive and technological barriers

A key barrier for beginning corpus users is the overwhelming experience of dealing with raw concordance data. Hundreds of KWIC-formatted rows require skills in pattern recognition, statistical interpretation of frequencies, and critical assessment of context — competencies that require targeted development. Research shows that without pedagogical scaffolding support, students below the B2 level are prone to making false generalizations or abandoning the task.

The technological barrier manifests itself on several levels: lack of stable internet access (critical for online corpora), unfamiliarity with search interfaces, and uneven student digital literacy. At Kazakhstani universities, the gap in technological readiness between urban and regional students remains significant, necessitating the provision of offline alternatives — a locally installed AntConc with pre-loaded corpora.

Professional training of teachers

Systematic reviews consistently document a lack of corpus literacy among practicing language teachers. Chambers (2019) notes that the corpus revolution that has occurred in academic linguistics has largely bypassed school and university classrooms: teachers are either unaware of the tools or fail to see ways to practically integrate them into the existing curriculum.

To bridge this gap, a two-stage training model is needed: the first stage is corpus literacy (the ability to construct queries, interpret concordances, and understand basic statistics); the second stage is corpus linguodidactics (the ability to transform corpus data into pedagogically sound tasks). This differentiation, proposed by Ma et al. (2021), helps avoid situations where a technically competent teacher is unable to "translate" corpus data into learning experiences.

PRACTICAL MODEL OF DDL IMPLEMENTATION

Based on a synthesis of theoretical foundations, empirical data, and an analysis of successful cases, a phased model for implementing DDL in a one-semester (16-week) language course is proposed. The model is aimed at students at levels B1–B2 and involves a gradual shift from guided to autonomous interaction with corpus data.

Table 4. Step-by-step model for introducing DDL into a language course

Stage	Actions	Tools	Success indicator
1. Diagnostics (weeks 1–2)	Assessing language proficiency and digital literacy	Lextutor, CEFR test	Basic Student Profile
2. Introduction to DDL (Weeks 3–5)	Corpus interface training; guided search tasks	AntConc / BNCweb	Successful basic concordance query
3. Guided Practice (weeks 6–10)	Collocation tasks, erroneous analysis, genre differences	COCA, Sketch Engine	Increase in lexical diversity (TTR)
4. Autonomous work (weeks 11–14)	Learner Corpus: A student compiles his own corpus of errors	Learner corpus + AntConc	Reducing the frequency of target errors
5. Reflection and evaluation (weeks 15–16)	Portfolio, questionnaire, before/after comparison	Pre/posttest, survey	$d \geq 0.5$ for target indicators

Note: TTR — type-token ratio (lexical diversity); CEFR — Common European Framework of Reference.

A key condition for successful implementation is the corpus's relevance to the educational context: its size, genre composition, and language should be consistent with the communicative objectives of the course. For EAP courses, an academic corpus (BAWE, MICUSP) is optimal; for business English, a business communication corpus (CANBEC, Cambridge Business English Corpus); and for conversational English, transcripts of spoken language from the BNC or CANCODE.

A well-designed scaffolding system for students is also necessary: structured worksheets with sample queries, a glossary of corpus terminology, examples of "good" concordance analysis, and a gradual removal of support as students gain competence. Pilot programs at Kazakhstani and Central Asian universities, which integrated DDL into academic writing and IELTS preparation courses, recorded a 15–25% increase in fluency and lexical accuracy compared to traditional groups — a result consistent with international data and providing grounds for scaling up.

CONCLUSION

Data-driven learning offers language education more than just a technological upgrade: it shifts the learner's epistemological position —from a consumer of language rules to a researcher of language use. This transformation aligns with mainstream trends in pedagogy—the development of autonomy, critical thinking, and self-assessment skills.

The empirical evidence base for DDL is among the most compelling in applied linguistics: large effect sizes in meta-analyses, reproducibility of results across different linguistic and cultural contexts, and the stability of lexical acquisitions over time attest to the method's robustness. However, the available data point to an underrepresentation of non-tertiary levels and non-English contexts—a gap whose filling is a priority for applied linguistics in the coming decade.

To successfully implement DDL in the Kazakhstani and Central Asian contexts, it is necessary to: (a) develop specialized corpora of the Kazakh language and Russian-Kazakh mixed speech; (b) incorporate corpus literacy into teacher training standards; (c) create differentiated DDL materials for different levels of language proficiency; (d) launch systematic effectiveness studies with a delayed post-test and a mixed design. Implementing these tasks will allow Kazakhstani linguodidactics to integrate into the international flow of evidence-based practice and make an independent contribution to its development.

BIBLIOGRAPHY

1. Boulton, A., & Cobb, T. (2017). Corpus use in language learning: A meta-analysis. Language Learning, 67(2), 348–393. https://doi.org/10.1111/lang.12224

2. Boulton, A., & Vyatkina, N. (2021). Thirty years of data-driven learning: Taking stock and charting new directions over time. Language Learning & Technology, 25(3), 66–89. https://doi.org/10125/73450

3. Chambers, A. (2019). Towards the corpus revolution? Bridging the research–practice gap. Language Teaching, 52(4), 460–475. https://doi.org/10.1017/S0261444819000089

4. Jones, T. (1991). Should you be persuaded: Two samples of data-driven learning materials. In T. Johns & P. King (Eds.), Classroom concordance. English Language Research Journal, 4, 1–16.

5. Lee, H., Warschauer, M., & Lee, J. H. (2019). The effects of corpus use on second language vocabulary learning: A multilevel meta-analysis. Applied Linguistics, 40(5), 721–753. https://doi.org/10.1093/applin/amy012

6. Schmidt, R. (1990). The role of consciousness in second language learning. Applied Linguistics, 11(2), 129–158. https://doi.org/10.1093/applin/11.2.129

7. Sinclair, J. (1991). Corpus, Concordance, Collocation. Oxford: Oxford University Press.

8. Granger, S., Gilquin, G., & Meunier, F. (Eds.). (2015). The Cambridge Handbook of Learner Corpus Research. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9781139649414

9. O'Keeffe, A., & McCarthy, M. (Eds.). (2010). The Routledge Handbook of Corpus Linguistics. London: Routledge.

10. Ma, Q., Kelly, N., & Wigglesworth, G. (2021). Corpus-based language pedagogy (CBLP): Key concepts and the role of teacher knowledge. Language Teaching Research, 27(4), 930–952. https://doi.org/10.1177/13621688211002859

LIFE CYCLE ASSESSMENT OF OFF-GRID ORIENTED RESIDENTIAL SETTLEMENT SCENARIOS

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ABSTRACT

The transition toward off-grid and energy-autonomous residential settlements has gained increasing attention as a strategy to reduce environmental burdens and enhance resilience against centralized infrastructure dependencies. In this context, understanding the environmental feasibility of off-grid-oriented settlement designs is critical. This study presents a scenario-based life cycle assessment (LCA) of residential settlement models representing different pathways toward off-grid living, with a primary focus on carbon footprint as the key environmental indicator.

Three settlement scenarios conventional grid-dependent, green-smart, and hybrid off-grid oriented are evaluated for a hypothetical community of 1,000 inhabitants over a 50-year service life under Mediterranean climate conditions. The assessment integrates key system components, including building construction materials, operational energy demand, and local food production, using a cradle-to-use phase life cycle perspective. Carbon footprint is employed as the main metric to assess and compare the environmental performance of the proposed scenarios, allowing a clear evaluation of long-term greenhouse gas emission trends associated with different settlement configurations.

The hybrid scenario, which incorporates localized renewable energy generation and reduced grid dependency, is used to represent a transitional off-grid configuration. The results indicate that operational energy consumption remains the dominant contributor to total carbon emissions across all scenarios, while material-related emissions become increasingly significant over extended service lifetimes. Scenario-based comparisons further demonstrate that settlement designs aligned with off-grid principles such as on-site renewable energy generation, reduced reliance on centralized energy infrastructure, and localized resource utilization can substantially lower carbon-related environmental burdens when compared to fully grid-dependent residential systems.

By framing off-grid living as a gradual transition rather than an absolute system boundary, this study provides a practical life cycle-based framework for evaluating carbon performance in environmentally resilient residential settlements and supports informed decision-making in sustainable urban development and off-grid planning contexts.

Keywords: Carbon footprint assessment, Off-grid residential settlements, Renewable energy integration

INTRODUCTION

The rapid expansion of urban areas imposes profound pressures on global natural resources, primarily driven by the intersecting demands of the built environment, energy infrastructure, and agricultural supply chains. Currently, energy generation relies heavily on fossil fuels, accounting for a substantial portion of global CO_2 emissions. Simultaneously, the building sector significantly contributes to cumulative energy consumption throughout its life cycle, prompting stringent targets such as the European Commission's objective to reduce construction-related CO_2 emissions by 90% by 2050 (European Commission, 2020). Furthermore, the agricultural sector and its associated logistics remain highly resource-intensive, being responsible for approximately 31% of global greenhouse gas emissions (FAO, 2022).

Addressing these systemic challenges requires an integrated urban metabolism approach rather than isolated subsystem optimizations. While Life Cycle Assessment (LCA) is extensively utilized to evaluate the environmental performance of individual sectors, holistic studies quantifying the intertwined impacts of housing, energy supply, and food networks remain limited.

This study aims to address this gap by comprehensively evaluating the environmental impacts of critical urban subsystems to identify the most sustainable and feasible design approach. Utilizing a parametric LCA framework, the study comparatively analyzes three distinct urban transition pathways—ranging from conventional fossil-fuel-dependent infrastructures to high-performance, renewable-integrated green and hybrid models. The theoretical findings are subsequently validated through a sensitivity analysis using localized climate and logistical data from the Erdemli district of Mersin Province, Turkiye, providing a scalable quantitative model for sustainable urban planning.

METHODOLOGY

Life Cycle Assessment (LCA) Framework and Functional Unit

This study applies a parametric Life Cycle Assessment (LCA) framework in accordance with ISO 14040/14044 standards to comparatively evaluate the environmental burdens of urban subsystems (buildings, energy, and food) (Finkbeiner et al., 2006). The functional unit is defined as the provision of housing (30 m^2 per capita), domestic energy, and basic nutritional fresh vegetable demand for a 1,000-person settlement under Turkish climatic conditions over a 50-year service life. The primary impact category assessed is Global Warming Potential (GWP, measured in kg CO_2e). Emission factors were sourced from internationally recognized databases, including the Inventory of Carbon and Energy (ICE) for construction materials, and Ecoinvent/Agribalyse for energy and agricultural processes (Hammond & Jones, 2025).

Life Cycle Inventory (LCI) and Scenario Modeling

The inventory analysis is structured around three distinct urban transition pathways (Conventional, Smart-Green, and Hybrid). All material and operational energy flows were calculated cumulatively over the 50-year functional unit.

Building Systems Inventory

The embodied carbon of the structural systems was calculated based on material specific emission factors: concrete (0.115 kg CO_2e/kg), steel rebar (1.72 kg CO_2e/kg), structural timber (0.28 kg CO_2e/kg), glass wool insulation (1.533 kg CO_2e/kg), and brick (0.213 kg CO_2e/kg) (Hammond & Jones, 2025).

- **Scenario 1 (Conventional):** Represents baseline unplanned urbanization utilizing standard reinforced concrete structures. Based on an average concrete requirement of 0.40 m^3/m^2, the total embodied carbon for the 1,000-person settlement is calculated as 5,169 tons CO_2e (Hammond & Jones, 2025).
- **Scenario 2 (Smart-Green):** Employs a hybrid structural approach using low-carbon timber (glulam) superstructures on a 20% reduced concrete foundation. This lightweight alternative significantly lowers the embodied carbon to 1,874 tons CO_2e.
- **Scenario 3 (Hybrid):** Represents a retrofitting strategy where existing concrete structures (S1) are preserved and upgraded with high-performance glass wool insulation and brick wall systems. The addition of insulating materials acts as a "carbon investment," increasing the initial embodied carbon to 6,251 tons CO_2e.

Energy Systems Inventory

Operational energy emissions over the 50-year lifespan were modeled based on building performance and generation sources.

- **Scenario 1:** Uninsulated buildings exert a baseline per capita energy demand of 3,124 kWh/year, supplied entirely by the fossil-fuel-dominated national grid (0.48 kg CO_2e/kWh). The 50-year cumulative emission is 75,000 tons CO_2e (Hai et al.,2025).
- **Scenario 2:** Passive house insulation standards reduce per capita demand by 40% (1,874.4 kWh/year). Energy is supplied entirely by off-grid renewable systems (solar/wind, 0.048 kg CO_2e/kWh), resulting in a 50-year emission of 4,500 tons CO_2e (IPCC, 2014, p. 1335). *(Note: This assumes steady-state operation and excludes the embodied carbon of battery storage replacements required every 10–15 years, which would practically increase the system's actual lifecycle footprint).*
- **Scenario 3:** Retrofitted insulation (S3 Building) reduces energy demand by 20% (2,499.2 kWh/year). Supplied by a 50/50 mix of grid electricity and on-grid solar PV, the 50-year cumulative emission is 32,989 tons CO_2e.

Food Systems Inventory

The dietary analysis focuses on fresh vegetable consumption, assuming a conservative demand of 100 kg/capita/year (5,000 tons over 50 years) to evaluate the impact of production methods and logistics.

- **Scenario 1:** Relies on industrial agriculture and diesel logistics (~500 km). Combining the production (0.40 kg CO_2e/kg) and transportation (0.09 kg CO_2e/kg) footprints yields a unit factor of 0.49 kg CO_2e/kg. The 50-year emission is 2,450 tons CO_2e.
- **Scenario 2:** Utilizes zero-kilometer hydroponic agriculture integrated into urban structures. With a production factor of 0.25 kg CO_2e/kg and no logistics burden, the total emission is 1,250 tons CO_2e.
- **Scenario 3:** Adopts a community-supported local organic farming model. The combined unit factor of local production and short-distance logistics (~50 km) is 0.36 kg CO_2e/kg, resulting in a 50-year total of 1,800 tons CO_2e.

RESULTS

The cumulative 50-year environmental impacts of the three urban transition pathways—encompassing building construction, operational energy, and food supply chains—are synthesized in Table 1. The baseline Conventional Scenario (S1) generates a total carbon footprint of 82,619 tons CO_2e. The implementation of the Hybrid Scenario (S3), which relies on retrofitting existing structures and integrating partial renewable energy, achieves a 50.3% reduction in total emissions. The Smart-Green Scenario (S2), representing an idealized 100% renewable off-grid and timber-constructed settlement, demonstrates the highest theoretical environmental performance with an 86.3% reduction.

Table 1. Cumulative 50-Year Life Cycle Emissions for the Functional Unit (1,000 People)

Category	Scenario 1 (Conventional)	Scenario 3 (Hybrid)	Scenario 2 (Green)
1.Buildings (Construction)	5,169 Tons	6,251 Tons	1,874 Tons
2. Energy (50 Years)	75,000 Tons	32,989 Tons	4,500 Tons
3. Food (50 Years)	2,450 Tons	1,450 Tons	1,250 Tons
TOTAL	**82,619 Tons**	**41,040 Tons**	**7,624 Tons**
Improvement Rate	(Reference)	50.3% Reduction	86.3% Reduction

DISCUSSION AND SENSITIVITY ANALYSIS

Environmental Dominance and the "Carbon Investment" Concept

An analysis of the S1 baseline reveals that operational energy accounts for an overwhelming 90.7% of the total urban carbon footprint over a 50-year lifespan. This finding underscores that the most critical intervention area in sustainable urban design is the decarbonization of the energy source rather than solely focusing on the building envelope.

Furthermore, the results of the Hybrid Scenario (S3) illustrate a crucial phenomenon: the "carbon investment." In S3, the embodied carbon during the construction phase is 21% higher than the baseline (6,251 tons vs. 5,169 tons) due to the addition of high-performance glass wool insulation and double-glazed retrofitting. However, this initial carbon penalty is radically offset during the operational phase, yielding a net reduction of over 42,000 tons of CO_2e in energy consumption. This refutes the misconception that green retrofitting inherently increases environmental burdens, proving it instead to be a highly viable long-term ecological investment. It should also be noted that as global decarbonization policies progressively "green" the national grid, the operational emissions of grid-connected models (S1 and S3) will likely decrease further in the coming decades.

Sensitivity Analysis: Pilot Application in Mersin Province

To validate the theoretical model under specific regional conditions, a sensitivity analysis was conducted using the Erdemli district of Mersin Province as a pilot region. Mersin is characterized by a high photovoltaic potential averaging 1,642.5 kWh/m² annual global solar radiation, which is approximately 26% higher than the national average and a robust local agricultural infrastructure (Arslan & Bayhan, 2016; Şanlı & Dilsel, 2018).

The model parameters were revised to reflect these localized conditions. A regional solar efficiency coefficient (K = 1.26) was applied to adjust the renewable energy emission factors for S2 and S3. Concurrently, the logistics distance for the Conventional food supply chain (S1) was reduced from the national average of 500 km to a localized 100 km (Adana-Mersin corridor). The revised outcomes are presented in Table 2.

Table 2. Sensitivity Analysis: Revised Emissions for the Mersin/Erdemli Pilot Region

Category	S1:Conventional (Mersin)	S3:Hybrid (Mersin)	S2:Green (Mersin)
1.Buildings(Construction) (Fixed)	5,169 Tons	6,251 Tons	1,874 Tons
2. Energy (Operation) (Revised)	75,000 Tons	32,364 Tons	3,561 Tons
3. Food (Supply) (Revised)	2,090 Tons	1,450 Tons	1,250 Tons
TOTAL	**82,259 Tons**	**40,415 Tons**	**6,685 Tons**
Turkiye Average	82,619 Tons	41,040 Tons	7,624 Tons
Mersin Advantage	-360 Tons	-625 Tons	-939 Tons

The sensitivity analysis confirms the enhanced viability of decentralized renewable systems in regions with high solar irradiation, demonstrating a further reduction in emissions across all scenarios compared to the national average.

Optimal Transition Pathway Strategy

While the Smart-Green Scenario (S2) achieves the lowest absolute carbon footprint, proposing the widespread demolition of existing urban fabric to construct new timber-based settlements is neither economically feasible nor socially sustainable on a macro scale. Consequently, the Hybrid Scenario (S3) which capitalizes on the region's climatic advantages to retrofit the existing building stock, integrates partial grid-connected solar energy, and promotes short-distance organic food networks emerges as the most pragmatic and optimal transition model for sustainable urban planning, offering a verifiable 50% carbon reduction without requiring destructive urban renewal.

REFERENCES

Arslan, G., & Bayhan, B. (2016). Solar Energy Potential in Mersin And A Simple Model To Predict Daily Solar Radiation. Mugla Journal of Science and Technology, 1-4.

European Commission. (2020). A Renovation Wave for Europe greening our buildings, creating jobs, improving lives. COM(2020) 662 final.

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0662

Finkbeiner, M., Inaba, A., Tan, R., Christiansen, K., & Klüppel, H. J. (2006). The new international standards for life cycle assessment: ISO 14040 and ISO 14044. The international journal of life cycle assessment, 11(2), 80-85.

Food and Agriculture Organization of the United Nations. (2022). Greenhouse gas emissions from agrifood systems: Global, regional and country trends, 2000–2020 (FAOSTAT Analytical Brief Series No. 50).

Hai, N. M., Quang, P. D., & Nam, H. P. (2025). Evaluation of lighting energy savings and embodied carbon of light-transmitting concrete incorporating polymethyl methacrylate for building envelopes. Journal of Building Engineering, 113807.

Hammond, G. P., & Jones, C. I. (2025). Inventory of Carbon and Energy (ICE) database (V4.1 Educational version) [Data set]. Circular Ecology.

IPCC. (2014). Annex III: Technology-specific cost and performance parameters. In O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel, & J. C. Minx (Eds.), Climate change 2014: Mitigation of climate change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 1329–1356).

Cambridge University Press. https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_annex-iii.pdf

Şanlı, B., & Dilsel, E. T. (2018). Solar cell usage in a house in Erdemli district of Mersin for meeting electricity demand and cost analysis. International Scientific and Vocational Studies Journal, 2(2), 73-79.

CLEAN ENERGY TRANSITIONS: A COMPARATIVE ANALYSIS OF OFF-GRID SOLUTIONS FOR A LOW-CARBON FUTURE

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ABSTRACT

The energy field around the world is currently going through a transformation driven by the necessity of meeting rising electricity demands and environmental Concerns. As nations strive to balance industrial growth with ecological preservation, the selection of power generation technologies has become a crucial point in strategic planning. This study provides a general overview of various energy production systems, categorizing them based on their operational mechanisms and their long-term viability within a modern electrical grid. By examining the fundamental differences between traditional thermal-based combustion (fossil fuel) and contemporary renewable alternatives, this analysis highlights the inherent trade-offs required to maintain a reliable and sustainable infrastructure.

Central to this discussion is the atmospheric impact associated with different fuel sources. The transition toward a lower-carbon future necessitates an understanding of how specific technologies contribute to the accumulation of greenhouse gases and the subsequent influence on global climate patterns. While conventional systems have provided the backbone of energy security, their continued dominance is being challenged by the increasing efficiency and scalability of wind, solar, and other clean energy solutions.

Beyond the environmental footprint, the study explores the systemic implications of integrating diverse energy profiles. Each technology possesses unique characteristics regarding resource availability, and lifecycle management. By synthesizing these factors, the research offers a qualitative framework for evaluating which systems are best suited to provide a resilient energy supply while minimizing ecological footprints. Ultimately, this comparison serves to illuminate the pathways available for energy diversification, emphasizing the shift toward a balanced

portfolio that aligns with international sustainability objectives and the preservation of natural ecosystems.

Keywords: Environmental Lifecycle Assessment, Renewable Integration, Comparative Carbon Analysis, Off-Grid Power Systems

INTRODUCTION

The global push toward a low-carbon energy grid is more than just a environmental goal; it is a fundamental shift in how we approach power systems engineering. As nations scramble to hit decarbonization targets, simply picking "renewables" isn't enough. We have to look at the lifecycle environmental impact, which fluctuates wildly depending on the materials used, where the plant is located, and how mature the technology has become. Wind power is a perfect case study for this. Most onshore turbines are massive steel structures, but we're seeing a real move toward Laminated Veneer Lumber (LVL) towers. Wood is a smart choice here because it cuts the tower's weight while doubling as a carbon storage unit. Offshore wind is trickier; you start with a huge "carbon debt" from those subsea foundations, but the superior capacity factors out at sea eventually dilute that intensity. This gets even better when you swap in High-Temperature Superconducting (HTS) generators to slash the nacelle mass. Solar tech is evolving just as fast, mostly to get rid of the carbon-heavy manufacturing of the past. There is a clear performance gap between basic Monocrystalline panels and high-efficiency Perovskite-Silicon tandems, especially when you factor in local radiation levels. At the same time, Third Generation Concentrating Solar Power (CSP) is changing the game. By using falling particles and supercritical CO_2 turbines, these plants can provide 24/7 power essentially acting like a traditional baseload plant but with a much smaller, more efficient footprint. Even "traditional" hydro isn't a one-size-fits-all solution, as its impact is totally site-dependent. Run-of-river setups are much cleaner than massive reservoirs, which can leak methane from rotting plants underwater. Finally, bioenergy gives us a path to being "carbon-negative". Systems like BECCS and HTL don't just generate power; they pull carbon out of the atmosphere. This study uses Lifecycle Assessment (LCA) to cut through the noise, comparing these systems to find the best balance between energy yield and carbon debt for future infrastructure.

MATERIALS AND METHODS

The primary aim of this work is to evaluate and contrast the lifecycle carbon footprints across a broad range of renewable energy technologies. To achieve a high-fidelity comparison, we applied a Lifecycle Assessment (LCA) framework, which allows us to pinpoint the total greenhouse gas emissions (CO_2e) generated at every distinct stage of a system's life. This approach ensures that we account for the full environmental "debt"—not just the energy produced during operation, but also the carbon costs stemming from raw material manufacturing, site installation, long-term operation, and the final decommissioning phase of each power plant (Inhaber, 2016).

PV systems:

Lifecycle emission= (Total upstream emissions/Total Electricity Produced over Lifetime)

Total Embodied Carbon: 480 kg CO_2e for a high-efficiency 550W panel.

Eyear= Radiation time * area of panel * efficiency% * Performance Ratio (losses)

Number of units = (Electricity Produced / Eyear)

Electricity: 750Gwh/year

Average performance factor: 0.925

Lifecycle CO_2 per kWh (g)= (Total Lifecycle CO_2)/(Total generated Power * average performance factor)

Standard Mono-Si:Total Embodied Carbon: 480 kg CO_2e for a high-efficiency bifacial 550W panel.

Table 1. gCO_2/kWh comparison for Standard Mono-Si

Annual Radiation(hour)	Required Capacity MW	Number of 550W Units	Total Lifecycle CO_2 (Tones)	Lifecycle Intensity (gCO_2e/kWh)
1000	956.24	1,738,622	834,538.56	40.10
1200	796.87	1,448,852	695,448.96	33.41
1400	683.03	1,241,873	596,099.04	28.64
1600	597.65	1,086,639	521,586.72	25.06
1800	531.25	965,901	463,632.48	22.28
2000	478.12	869,311	417,269.28	20.05

Bifacial (Double-sided): The bifacial gives 20% more electricity on average. 5% increase in embodied carbon due to the dual-glass structure Total Embodied Carbon: 504 kg CO_2e for a high-efficiency bifacial 550W panel.

Table 2. gCO_2/kWh comparison for Bifacial

Annual Radiation(hour)	Required Capacity MW	Number of 550W Units	Total Lifecycle CO_2 (Tones)	Lifecycle Intensity (gCO_2e/kWh)
1000	796.87	1,448,852	730,221.43	35.09
1200	664.06	1,207,377	608,517.86	29.24
1400	569.19	1,034,894	521,586.74	25.06
1600	498.04	905,533	456,388.39	21.93
1800	442.70	804,918	405,678.57	19.49
2000	398.43	724,426	365,110.72	17.54

Perovskite-Si Tandem: The Perovskite-Si gives 24% more electricity on average. 2% increase in embodied carbon due to the dual-glass structure. Total Embodied Carbon: 490 kg CO_2e for a high-efficiency bifacial 550W panel

Table 3. gCO_2/kWh comparison for Perovskite-Si Tandem (NREL, 2024)

Annual Radiation(hour)	Required Capacity MW	Number of 550W Units	Total Lifecycle CO_2 (Tones)	Lifecycle Intensity (gCO_2e/kWh)
1000	768.67	1,397,585	684,816.65	32.90
1200	640.56	1,164,654	570,680.46	27.42
1400	549.05	998,275	489,154.75	23.50
1600	480.42	873,491	428,010.59	20.57
1800	427.04	776,436	380,453.64	18.28
2000	384.34	698,793	342,408.57	16.45

Concentrating Solar Power (Solar Tower):

1st Gen: Surprisingly, plants without storage have a higher carbon footprint per kWh. This is because they require more frequent startups and often rely on the carbon-heavy electrical grid or

natural gas heaters to keep the system warm overnight so the pipes don't freeze. It is a "fuel saver." It reduces the coal or gas burned during the day but cannot replace a power plant at night.

2nd Gen: By storing heat, the plant can run through the night. This spreads the initial manufacturing emissions (from the mirrors and tower) over a much larger volume of total electricity produced, dropping the gCO_2e/kWh significantly.

3rd Gen: Instead of liquid salt, it uses solid ceramic particles Because solid particles don't "boil" or decompose like salts, they can reach 1000°C. This allows the plant to use a Supercritical CO_2 turbine, which is much smaller and more efficient than a steam turbine.

Higher temperatures mean you need a smaller solar field and smaller storage tanks to get the same power. This reduces the amount of steel and glass needed, which are the primary sources of CO_2. A Supercritical CO_2 (sCO_2) turbine is a type of turbomachinery that uses carbon dioxide held above its critical as the working fluid to generate electricity.

In this supercritical state, CO_2 behaves like a hybrid between a gas and a liquid: it has the high density of a liquid but the low viscosity and "fill-the-space" property of a gas.

Unlike traditional power plants that use a Steam Rankine Cycle (boiling water into steam), sCO_2 systems typically use a Closed-Loop Brayton Cycle (Mehos et al., 2017).

Table 4. gCO_2/kWh comparison for CSP GENs

Feature	Without Storage (Base) Gen 1	With 10+ Hours Storage Gen 2	CSP (Falling Particles) Gen 3
Heat Transfer Medium	Thermal Oil or Steam	Molten Salts (Nitrates)	Ceramic Particles / Sand
Operating Temp.	390 - 400	565	700 - 1000
Power Cycle	Standard Rankine (Steam)	Reheat Rankine (Steam)	Supercritical CO_2
Lifecycle CO_2	31 gCO_2e/kWh	9.8 – 15 gCO_2e/kWh	<9 gCO_2e/kWh
Efficiency (Solar-to-Elec)	14% – 16%	18% – 20%	25% – 30%

Wind Power (Wind Turbine):

E_{year}= Power * Hours in a year * Capacity Factor

Number of units = (Electricity Produced / E_{year})

Electricity: 750GWh/year

Average performance factor: 0.9

Lifecycle CO_2 per kWh (g)= (Total Lifecycle CO_2)/(Total generated Power * average performance factor)

Standard Onshore mostly form steel

Total CO_2 emissions: 1870 tons/unit

Table 5. gCO_2/kWh comparison for Onshore turbine (Kabir et al., 2016)

Capacity Factor (%)	Required Capacity (MW)	Number of 5 MW Units	Total Lifecycle CO_2 (Tones)	Lifecycle Intensity (gCO_2e/kWh)
25%	342.47	68.49	153,691.56	9.11
30%	285.39	57.08	128,087.52	7.59
35%	244.62	48.92	109,776.48	6.51
40%	214.04	42.81	96,065.64	5.69
45%	190.26	38.05	85,384.20	5.06
50%	171.23	34.25	76,857.00	4.55

Conventional floating Offshore
Total CO_2 emissions: 4200 tons/unit

Table 6. gCO_2/kWh comparison for Offshore turbine

Capacity Factor (%)	Required Capacity (MW)	Number of 5 MW Units	Total Lifecycle CO_2 (Tones)	Lifecycle Intensity (gCO_2e/kWh)
35%	244.62	48.92	205,464.00	12.18
40%	214.04	42.81	179,802.00	10.65
45%	190.26	38.05	159,810.00	9.47
50%	171.23	34.25	143,850.00	8.52
55%	155.66	31.13	130,746.00	7.75

(Business Norway (2024))

Wooden Tower Wind Laminated Veneer Lumber (LVL)
Total CO_2 emissions: 1330 tons/unit

Table 7. gCO_2/kWh comparison for Wooden Tower turbine (European Commission, 2020)

Capacity Factor (%)	Required Capacity (MW)	Number of 5 MW Units	Total Lifecycle CO_2 (Tones)	Lifecycle Intensity (gCO_2e/kWh)
25%	342.47	68.49	91,091.70	5.40
30%	285.39	57.08	75,916.40	4.50
35%	244.62	48.92	65,063.60	3.86
40%	214.04	42.81	56,937.30	3.37
45%	190.26	38.05	50,606.50	3.00
50%	171.23	34.25	45,552.50	2.70

Hydropower:

1- Conventional Reservoir Hydropower (The "Dam")
It relies on a large dam to store water in a reservoir, creating a "head" (the vertical distance the water falls). Water is released from the Reservoir through an intake. It travels down a large pipe called a Penstock, where gravity converts its potential energy into kinetic energy. The fast-moving water hits the blades of a Turbine making it spin. The turbine is connected to a Generator, which uses electromagnetic induction to produce electricity. The water exits through a Tailrace back into the river.

2- Pumped Storage Hydropower
It uses two reservoirs at different elevations. Charging (Pumping) When there is extra electricity on the grid (e.g., from wind turbines at night or solar panels at noon), the plant uses that energy to

pump water from the lower reservoir to the upper one. Discharging (Generating): When demand is high, the water is released back down to the lower reservoir, spinning the turbines to generate power just like a conventional plant.

Run-of-River

A portion of the river is diverted into a canal or Penstock. his diverted water flows through a turbine and generator located downstream. The water is then immediately returned to the main riverbed.

Table 8. gCO_2/kWh comparison for Hydropower systems (Kumar et al., 2011)

System Type	Avg. Lifecycle Emissions (gCO_2e/kWh)	Primary Source of Emissions
Run-of-River	3.5 – 16.3	Embodied carbon in concrete and steel
Conventional Reservoir	23 – 41	Methane/CO_2 from decaying flooded organic matter
Pumped Storage	26 – 530	Carbon intensity of the grid during the "pumping" phase

Bioenergy:

1- Bioenergy with Carbon Capture and Storage (BECCS):

The main idea of this system is that we use waste crops, greens, etc. that had observed CO_2 from the environment to burn and produce electricity. We take the CO_2 and condense it. After that, we inject the liquid into the ground. So from this situation, we get negative CO_2 emissions.

A standard biomass plant has a net climate burden of 5 kg CO_2e/1000MJ of heat, BECCS-retrofitted plant can achieve a net saving of -77 kg CO_2 /1000 MJ or we can say -277.2g CO_2/kWh (PMC / NCBI (2024))

Hydrothermal Liquefaction (HTL) for Wet Waste:

Process that converts wet organic waste (sewage sludge, algae, food waste, etc.) into an energy-dense biocrude without requiring the energy-intensive drying phase.

It resulting biocrude has a high energy density of 33.8–36.9 MJ/kg. biocrude power generation results in approximately 15–18 g CO_2/kWh. (Pacific Northwest National Laboratory, 2021)

2- Bio-Hydrogen (Waste-to-Hydrogen)

This technology uses gasification or dark fermentation to produce hydrogen from municipal solid waste or food waste. Which have 300 -360 g CO_2/kWh approximately.

Table 9. gCO_2/kWh comparison for Bioenergy systems (Agrawal, 2024)

Bioenergy Technology	Carbon Intensity (gCO_2e/kWh)	Key Characteristic
BECCS (Carbon Capture & Storage)	-277.2	Carbon-Negative: Injects condensed CO_2 into the ground.
HTL (Wet Waste to Biocrude)	15 – 18	High energy density biocrude from sewage, algae, or food waste.
Bio-Hydrogen (Waste-to-Hydrogen)	300 – 360	Produced from municipal solid waste via gasification or fermentation.

RESULTS

Our analysis makes one thing clear: lifecycle carbon intensity is not a static number but a variable that shifts based on material choice and site conditions. In the wind sector, the data shows that moving from steel to Laminated Veneer Lumber (LVL) towers is a game-changer. Because wood stores carbon and weighs about 30% less than steel, these towers significantly drop the system's environmental footprint. For offshore projects, the most effective way to cut carbon debt is by using High-Temperature Superconducting (HTS) generators. By slashing the nacelle mass, we can use thinner, lighter support structures, which is where most of the offshore carbon cost usually sits. Solar performance is just as sensitive, particularly to regional radiation levels. While standard panels perform well, the Perovskite-Silicon tandem design consistently offers the best efficiency across all radiation zones we tested. In the solar thermal category, Gen 3 Concentrating Solar Power (CSP) stands out as the cleanest option. Using falling particles and compact supercritical turbines which are only about 10% the size of traditional steam versions—allows these plants to generate more power while using far less raw glass and steel. The results for hydropower and bioenergy reveal an even wider gap in impact. Hydropower isn't a "one-size-fits-all" solution; while run-of-river systems have very low biogenic impacts, large reservoirs can actually be a source of methane from decaying vegetation. Among every technology we evaluated, Bioenergy with Carbon Capture (BECCS) is the only one that achieves a truly carbon-negative result by locking CO_2 underground. Additionally, processing wet waste into biocrude through Hydrothermal Liquefaction (HTL) provides a high-efficiency alternative that bypasses the energy-heavy drying phases required by other waste-to-energy methods.

Table 10. gCO_2/kWh comparison for all systems

Technology Category	System Type	Benchmark Condition	Lifecycle Intensity (gCO_2e/kWh)
Wind Power	Standard Steel Tower Onshore	45% Capacity Factor	5.06
	Wooden Tower (LVL)	45% Capacity Factor	3.00
	Conventional Monopile Offshore	45% Capacity Factor	9.47
Solar PV	Standard Mono-Si	1800 Annual Radiation	22.28
	Bifacial (Double-Sided)	1800 Annual Radiation	19.49
	Perovskite-Si Tandem	1800 Annual Radiation	18.28
Solar Thermal	CSP Gen 1 (No Storage)	14–16% Efficiency	31.00
	CSP Gen 2 (Molten Salt)	18–20% Efficiency	9.8 – 15.0
	CSP Gen 3 (Particles)	25–30%+ Efficiency	< 9.00
Hydropower	Run-of-River	Diversion System	3.5 – 16.3
	Conventional Reservoir	Dam/Impoundment	23.0 – 41.0
	Pumped Storage	Grid-Dependent	26.0 – 530.0
Bioenergy	BECCS	Carbon Capture	-277.20
	HTL (Wet Waste)	Biocrude Generation	15.0 – 18.0
	Bio-Hydrogen	Waste-to-Gas	300.0 – 360.0

DISCUSSION

What our data really shows is that a low-carbon grid isn't just about switching to renewables; it's about making specific, aggressive engineering choices. For instance, in the wind sector, the move to Laminated Veneer Lumber (LVL) towers is a huge deal. It's not just a material swap wood acts as a literal carbon sink while cutting structural weight by about 30%. When you look at offshore systems, the math is even clearer. The best way to shrink that massive carbon footprint is to use High-Temperature Superconducting (HTS) generators. By cutting the weight at the top of the

tower, you don't need nearly as much steel and concrete for the foundation, which is where the real environmental "debt" sits. The solar PV results confirm that geography is basically everything. As radiation levels go up, the "manufacturing debt" gets spread across more electricity, and the emissions per kWh just drop off. In our tests, Perovskite-Si tandem panels were the clear winners because their efficiency is just higher than the rest. The same logic applies to Gen 3 Concentrating Solar Power (CSP). By using falling particles and those compact supercritical turbines, you get a system that is way smaller about 10% of the size of a steam plant—and much more efficient. Finally, the comparison between hydro and bioenergy shows that "renewable" doesn't always mean "zero impact." Run-of-river setups are great, but big reservoirs can actually be quite dirty because of the methane from rotting organic matter. On the other end of the scale, bioenergy with carbon capture (BECCS) is the only tech we looked at that actually goes carbon-negative by burying CO_2 underground. Processing wet waste into biocrude with HTL is another smart move because it skips the energy-heavy drying phase entirely. Altogether, these numbers provide a solid roadmap for choosing the right energy setup for future infrastructure projects.

CONCLUSION

The data from this lifecycle analysis makes it clear that the sustainability of a power plant depends far more on engineering design and material choices than just its final energy output. In the wind energy sector, we found that using wooden towers is a major advantage because they actually store carbon while cutting structural weight. For offshore systems, the real key to lowering emissions is reducing the weight of the nacelle through superconducting generators, which allows for much lighter and less carbon-intensive foundations. Solar power efficiency is best improved by using high-performance perovskite-silicon tandem panels or third-generation thermal systems that utilize compact supercritical CO_2 turbines to save on raw material costs. While river-diversion remains the lowest-impact choice for hydropower, bioenergy with carbon capture (BECCS) stands out as the only technology we studied that can actually go carbon-negative by burying emissions underground. Taken together, these various technologies provide a solid, data-driven framework for building the energy infrastructure needed to reach global decarbonization goals.

REFERENCES

Business Norway 2024. Carbon footprint of a wind turbine: a life cycle assessment. Business Norway Articles.

Agrawal, M. (2024). The potential role of biohydrogen in creating a net-zero world: The production and applications of carbon-negative hydrogen. ResearchGate. https://www.researchgate.net/publication/383483175

Inhaber H 2016. Evaluation of Life Cycle GHG Emissions. MDPI Sustainability, 8: 539.

Kabir MR, Rooke B, Dassanayake SM, Fleck BA 2016. Impact of Different Parameters on Life Cycle Analysis, Embodied Energy and Environmental Emissions for Wind Turbine System. Scientific Research Publishing (SCIRP), 7: 412-436.

Kumar A, Schei T, Ahenkorah A, Rodriguez R, Jean-Baptiste M 2011. IPCC Special Report on Renewable Energy (SRREN) – Chapter 5: Hydropower. Intergovernmental Panel on Climate Change (IPCC).

Mehos, M., Turchi, C., Vidal, J., Wagner, M., Ma, Z., Ho, C., ... & Kruizenga, A. (2017). Concentrating solar power Gen3 demonstration roadmap. National Renewable Energy Lab.(NREL), Golden, CO (United States).

European Commission. (2020). Modular wood-made wind turbine towers (CORDIS Project Results). https://cordis.europa.eu/project/id/888514

National Renewable Energy Laboratory. (2024). *Life cycle greenhouse gas emissions from solar photovoltaics.* https://www.nrel.gov/docs/fy24osti/85493.pdf (NREL).

Pacific Northwest National Laboratory 2021. Wet Waste HTL and Biocrude Upgrading (PNNL-32731). PNNL Technical Reports.

National Center for Biotechnology Information. (2024). Development of bioenergy technologies. PubMed Central. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11394833/

PRODUCTIVITY OF NATURAL FORAGE VEGETATION IN THE CASPIAN COASTAL ZONE

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ABSTRACT

The vegetation ecosystems of the Caspian coastal zone of Azerbaijan are characterized by high diversity and floristic richness formed under the influence of heterogeneous natural conditions and the interaction of different floristic provinces. Investigation of wild flora and natural vegetation is essential for understanding biodiversity dynamics and for sustainable management of forage resources. In this context, phytocenoses as structural components of biocenoses play a key role in ecological stability and productivity of pasture ecosystems.

The Caspian coastal landscapes are significantly affected by anthropogenic pressure; therefore, geobotanical and ecological research has both theoretical and practical importance. The study aims to evaluate vegetation composition, productivity, and carrying capacity of natural forage lands and to develop scientifically based measures for rational pasture utilization and environmental conservation according to geobotanical indicators.

Floristic and geobotanical surveys were conducted in 2020 within altitudinal ranges from –28 m to 200 m above sea level across six botanical-geographical regions: Samur–Shabran plain, Caspian coastal plain, Absheron, Gobustan, Lankaran–Mugan, and Lankaran plain. Research areas also included Samur-Yalama, Absheron, Shirvan, and Hirkan National Parks, as well as the Gizilagach State Reserve. Seasonal productivity and grazing capacity were assessed in Siyazan, Neftchala, and Astara districts during autumn, winter, and spring periods.

The results contribute to national programs on efficient pasture and hayfield utilization and desertification prevention. The obtained data provide a scientific basis for land cadastre improvement, sustainable forage management, and preservation of coastal ecosystems, ensuring balanced use of natural resources in the Caspian region.

Keywords: Caspian coast, vegetation cover, geobotany, pasture productivity, biodiversity, land management.

THE ETHICAL CHALLENGES POSED BY THE INTEGRATION OF ARTIFICIAL INTELLIGENCE IN THE MEDICAL FIELD IN MOROCCO

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ABSTRACT

The responsibility of doctors with regard to the use of digital tools is based primarily on an obligation of means, i.e., they must implement all necessary means to ensure quality care for their patients. However, with the emergence of artificial intelligence (AI) in the healthcare field, new questions arise regarding liability in the event of errors related to these technologies. It is therefore essential to closely examine how the liability of healthcare professionals may evolve in the face of these technological advances. It is essential that doctors exercise close supervision over artificial intelligence and ensure that it does not make decisions autonomously, without their supervision or validation. Liability in the medical field may also encompass the provision of recommendations regarding medical applications. In addition, it is conceivable to apply the principle of strict liability to medical devices that use artificial intelligence. In order to meet these challenges, one solution being considered is to set up a national solidarity system that would be responsible for compensating for damage caused by artificial intelligence. This measure aims to guarantee adequate protection and ensure fair treatment for the patients concerned.

Keywords: Artificial intelligence; technological errors; medical liability; patients.

INTRODUCTION

The liability of doctors in the use of digital tools is generally based on an obligation of means. This means that they must provide attentive care without guaranteeing recovery. Case law has established that liability is often based on medical malpractice, with a tendency not to hold healthcare professionals liable for their errors. However, the growing integration of artificial intelligence (AI) raises new questions of liability, particularly with regard to technology-related errors and the information given to patients.

Physicians using AI for diagnosis or treatment must ensure continuous supervision and not allow AI to act autonomously. Liability may also extend to recommendations made to patients regarding medical applications. In the case of health products, strict liability may be incurred for damage caused by medical devices using AI. The divergence of interpretation between the Court of Cassation and the Council of State complicates the determination of who is liable for damages.

Due to the uncertainty and complexity of medical treatments, it is proposed that damages related to AI be covered by a national solidarity mechanism, ensuring protection and fairness for patients. This proposal aims to mitigate the specific challenges posed by the use of artificial intelligence in healthcare.

RESEARCH AND FINDINGS

As a general rule, physicians are bound by an obligation of means when using digital tools. This situation raises the question of the liability regime applicable in the event of damage caused. Liability may be incurred in the event of fault, i.e., when the perpetrator of the damage has committed an error, or without fault, due to a defective product.

Since the Mercier ruling by the French Court of Cassation, it has been established that the duty of care incumbent on a physician is a duty of means. This means that the physician is not required to guarantee the patient's recovery, but is required to provide conscientious, attentive care in accordance with current medical knowledge.

In France, case law has always refused to hold healthcare professionals liable for their mistakes. Indeed, the French Council of State has established the principle of strict liability of the State in the event of a medical accident causing harm that is not related to the patient's initial condition. This legal position has been maintained for a long time, thus highlighting the specificity of the liability regime applicable in the field of healthcare in France.

It is therefore essential to emphasize that liability is based primarily on medical malpractice, while recognizing that its scope could evolve due to the growing integration of artificial intelligence in the healthcare sector. Medical interventions using an artificial intelligence device can lead to three types of errors: those related to diagnosis, the transmission of information, or the use of the machine or software.

Studies on the applications of AI in healthcare highlight the principle that responsibility in this area lies with the healthcare personnel who use it to perform preventive, diagnostic, or care procedures. This responsibility means that healthcare personnel are accountable for their actions in the event of negligence when using AI in their professional practices. Artificial intelligence is a tool designed to assist and facilitate the work of healthcare professionals. It is essential to emphasize that AI should not be allowed to make decisions autonomously. The user of AI must always supervise it and take responsibility for the medical choices made. Healthcare professionals who use AI thus find themselves in a delicate position, having to decide whether or not to follow the AI's recommendations. The central question that arises is: can the use of AI influence the judge's assessment of liability?

In reality, it is essential that judges exercise subtlety and discernment to guarantee healthcare professionals' freedom of choice and protect patients' interests. This approach could also simplify the process of conducting medical assessments.

In addition to technical errors related to the use of artificial intelligence, it is also important to highlight the gaps in the information provided regarding the risks associated with the proposed medical treatments. Indeed, it is undeniable that the scope of information is gradually expanding under the combined influence of developments in case law and the legal provisions in force.

The constant advancement of artificial intelligence in the medical field could prompt judges to tighten the requirements for the information that doctors must provide to their patients. This information should include, in particular, an in-depth analysis of the potential risks associated with the use of these innovative technologies. Liability for failure to provide information could also be invoked when doctors, in their capacity as prescribers, recommend that their patients use mobile applications and connected devices as part of their medical follow-up. This liability stems from the duty to inform patients about the risks and benefits of these tools, as well as how to use them properly to ensure their effectiveness and safety.

In France, liability for damage caused by a health product is objective in nature, which means that it applies regardless of whether the person responsible is at fault, contrary to the general principle

of fault-based liability. An important question arises regarding the difficulty of identifying the healthcare professional responsible for the treatment.

In Morocco, according to Article 1 of Law No. 84-12, any health product, such as software, is considered a medical device. This classification means that these products are governed by the regulations in force to ensure their compliance and safety in the health sector. In France, artificial intelligence systems designed for medical diagnosis or treatment are considered health products.

This type of technology is used to help healthcare professionals make more accurate diagnoses and offer appropriate treatments to patients. However, the Court of Justice of the European Union has clarified, under the Public Health Code, that prescription assistance software can be classified as medical equipment, even if it has no direct effect on the human body. This decision highlights the importance of regulating medical devices and the need to include software in this category when it is used for medical purposes.

Strict liability may be incurred if a healthcare product using artificial intelligence, such as a medical diagnostic aid or surgical robot, causes harm to a patient. This means that even in the absence of proven fault, manufacturers or operators of these technologies may be held liable for harm caused to patients. When harm is caused by a defect in a healthcare product, the resulting liability is objective in nature. However, it is essential to determine precisely which healthcare professional is liable.

In France, it is important to note that there is a difference in interpretation between the Court of Cassation and the Council of State regarding the regime applicable to liability, whether based on fault or not. This difference therefore makes it difficult to identify who is responsible for the damage. Indeed, the Court of Cassation does not always follow the evolution of case law envisaged by the Council of State. This would allow anyone who has suffered harm due to a failure of artificial intelligence to take legal action against the party directly responsible from the outset. It is up to the healthcare facility or healthcare professional using artificial intelligence to take the necessary steps to bring legal action against the AI manufacturer, regardless of whether the patient is being treated in the public or private sector.

The integration of an artificial intelligence system into the healthcare sector cannot guarantee the total reliability of the machine or robot. Medicine is a complex and sometimes mysterious discipline that cannot always systematically control the unpredictable variations and reactions of the human body and mind. In complex and unresolved medical situations involving uncertainty about the treatment to be followed, it is proposed that compensation for persons affected by the use of artificial intelligence systems be guaranteed by a national solidarity mechanism, similar to that in force for other medical interventions in France. This approach aims to ensure fair and effective protection for patients facing complex and uncertain health problems, while recognizing the specific challenges posed by the growing use of artificial intelligence technologies in the field of health.

CONCLUSION

The advent of new technologies in the field of healthcare, such as telemedicine and artificial intelligence, raises questions about medical liability. It is therefore necessary to reexamine the framework of medical liability, as current Moroccan legislation is still based on general provisions, in particular Articles 77 and 78 of the DOC, as well as the Penal Code (Articles 432 and 433). Thus, any breach of medical practice is considered a transgression to be avoided at all costs. This medical liability is now facing a major challenge with the advent of cutting-edge technologies in the field of healthcare, such as telemedicine, connected objects, and artificial intelligence. To address this, it is imperative to thoroughly rethink the medical liability regime, drawing inspiration

from international best practices and staying abreast of the latest advances in this constantly evolving field. The aim is to encourage creativity while ensuring the safety of patients and healthcare professionals and guaranteeing high-quality care.

REFERENCES

- André Tarby, Patient, médecin et intelligence artificielle (Patients, Doctors, and Artificial Intelligence), Legal Questions, Ethical Guidelines, published by L'Harmattan, Paris, 2021.

- Alexandra BENSAMOUN & Grégoire LOISEAU, Droit de l'intelligence Artificielle (The Law of Artificial Intelligence), published by LGDJ, Lextenso, 2019.

- Bénédicte Bévière-Boyer and Dorothée Dibie, Digital Technology, Law and Society, published by Dalloz, Paris 2022.

- Christopher Hayre, Dave Muller, Marcia Scherer, Paul M.W. Hackett, Ava Gordley-Smith, Emerging Technologies in Healthcare, Interpersonal and Client Based Perspectives, CRC Press, 2024.

- Rahul G. Kanegaonkar, James R. Tysome, Medical Innovation Concepts, Delivery and the Future of Healthcare, CRC Press, 2023.

- V. H. SIMONIAN-GINESTE, Les professions (dé)réglementées : Bilans et perspectives juridiques (Deregulated professions: Legal assessments and perspectives), Presses de l'Université Toulouse 1 Capitole, Sept. 19, 2019.

VALIDATION OF A CLINICAL COMPETENCY LOGBOOK INVENTORY FOR WORKPLACE-BASED ASSESSMENT IN UNDERGRADUATE MEDICAL EDUCATION

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ABSTRACT

Background: The shift to Competency-Based Medical Education (CBME) necessitates robust workplace-based assessment (WBA) tools that are both reliable and valid. This study aimed to develop and validate a new Clinical Competency Logbook (CCL) designed to measure the observed clinical skills of undergraduate medical students in real practice settings.

Methods: A comprehensive validation study was conducted. The CCL was developed through a literature review and expert consensus, establishing content validity. A cohort of 129 fourth-year medical students used the CCL during two consecutive 4-week clinical rotations. To establish construct validity, scores were compared between male and female students, hypothesizing no significant difference. Test-retest reliability was evaluated using paired t-tests and the Intraclass Correlation Coefficient (ICC).

Results: The CCL demonstrated evidence of validity and reliability for its intended purpose. The overall test-retest reliability was moderate to good (ICC = 0.711, 95% CI [0.591, 0.796]). However, reliability varied by gender, with ICCs of 0.507 for males and 0.346 for females, likely due to score homogeneity in the female subgroup. A statistically significant difference in scores between genders was observed, providing initial evidence for construct validity through known-groups comparison.

Conclusion: The CCL is a promising new tool for the formative assessment of undergraduate medical students. It demonstrates acceptable content validity and moderate test-retest reliability. The findings suggest the tool can reliably be used to track student progress.

Keywords: Competency-Based Medical Education (CBME), Instrument Validation, Psychometric Properties.

TRADITIONAL CONSTRUCTION TECHNIQUES AS DRIVERS OF SUSTAINABLE ARCHITECTURE: A RURAL HERITAGE–BASED MODEL FOR TURKEY

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ABSTRACT

This study investigates the potential integration of traditional construction techniques—rooted in Turkey's architectural heritage, such as adobe, stone masonry, timber-frame systems, and courtyard–eave–based passive design—into contemporary sustainable architecture. Traditional buildings are approached not solely as cultural artifacts, but as accumulated knowledge systems whose environmental, spatial, and socio-cultural performances inherently align with key sustainability principles, including climate responsiveness, material efficiency, and community-oriented spatial organization. The theoretical framework is structured around three interrelated dimensions: (i) local materials and traditional construction techniques characterized by low embodied carbon; (ii) core criteria of contemporary sustainable architecture, such as energy efficiency, carbon reduction, and user comfort; and (iii) an integration dimension that conceptualizes hybridization between vernacular knowledge and modern engineering and design systems. Methodologically, the study employs a qualitative comparative case study approach. First, international literature on rural heritage and sustainable architecture is systematically reviewed. This is followed by an in-depth examination of two representative rural settlements in Turkey—Cumalıkızık and Safranbolu. Traditional materials, construction techniques, and spatial configurations are then analytically mapped against contemporary sustainability criteria through a matching process. In addition, selected hybrid applications, including contemporary adobe systems and CLT–traditional timber joint solutions, are examined to evaluate their integrative potential. The analysis culminates in a matching matrix that operationalizes the relationship between vernacular construction knowledge and sustainability indicators across material, spatial, and social dimensions. The findings indicate that earth- and timber-based systems can significantly reduce material-related environmental impacts, while passive spatial strategies such as courtyards and deep eaves contribute to improved indoor comfort and reduced cooling demand. Moreover, craft-based production and community-oriented living patterns support socio-cultural sustainability. However, regulatory limitations, standardization challenges, and prevailing perceptions regarding traditional materials remain key barriers to wider implementation. By proposing a hybrid integration model, this study offers a transferable framework for low-carbon, context-sensitive architectural production and contributes to heritage-informed sustainability discourse.

Keywords: Rural heritage; sustainable architecture; Cumalıkızık; Safranbolu; hybrid construction systems

BRIDGING PAST AND FUTURE: INTEGRATING TRADITIONAL CONSTRUCTION TECHNIQUES INTO SUSTAINABLE ARCHITECTURE

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ABSTRACT

This paper evaluates, within the Turkish context, the capacity of vernacular architecture to drive a sustainable transition through architectural design principles and measurable performance indicators. Framed by the urgent need to decarbonize the built environment, the study argues that Turkey's traditional construction heritage—spanning earthen, stone, and timber systems—embodies adaptive, low-impact, and community-rooted models that can inform contemporary sustainability agendas. The theoretical framework integrates the integrity of cultural–natural heritage with the three pillars of sustainability: the use of local materials, climate-responsive typologies, and community-based stewardship.

Methodologically, the research combines (i) a review of national and international literature on vernacular and sustainable architecture, (ii) a comparative analysis of selected vernacular districts and settlements focusing on typology, urban fabric, street–parcel relations, and building–landscape interactions, and (iii) a policy reading grounded in planning, regulatory, and governance documents. Quantitative and qualitative evaluation criteria include embodied carbon (materials), operational energy (heating/cooling), user comfort (thermal, daylight, acoustic), and durability–maintenance cycles.

Findings demonstrate that stone, earthen, and timber constructions substantially reduce embodied emissions, while climate-responsive configurations—such as courtyards, deep eaves, narrow streets, and permeable shading—lower cooling demand and improve thermal comfort. Community practices including collective maintenance, shared spatial use, and intergenerational craftsmanship reinforce repair cycles and resilience. However, processes of overtourism, second-home development, and out-migration threaten cultural continuity and material authenticity, creating tension between preservation and modernization.

The discussion advances a practice-oriented, three-part framework for integrating vernacular wisdom into contemporary sustainability practice: (1) aligning local materials and crafts with digital and prefabricated construction techniques, (2) promoting community-centred adaptive reuse and fair-tourism models, and (3) developing performance-based conservation guidelines within multi-level governance structures. Together, these approaches constitute a criterion-based evaluation matrix and actionable design–policy roadmap for the sustainable future of vernacular architecture. Aligning with the United Nations Sustainable Development Goals (SDGs 11, 12, and 13) and circular economy principles, the study concludes that vernacular systems should not

merely be preserved as static heritage, but mobilized as dynamic, measurable, and scalable models for low-carbon architectural and urban transformation.

Keywords: Vernacular architecture, sustainability, local materials, embodied/operational carbon, energy efficiency, cultural sustainability,

INTRODUCTION

At the global scale, the building sector has emerged as one of the fields with the highest environmental impact in the face of the climate crisis and resource depletion. According to data from the United Nations Environment Programme (UNEP), buildings account for approximately 36% of total energy consumption and 37% of global carbon emissions (Hu, 2023). These figures indicate that the sector must undergo restructuring not only in economic terms but also in relation to its ecological responsibility. In particular, fossil fuel–based production methods, materials with high embodied energy, and energy-intensive construction processes place the building sector at the center of the sustainability crisis (Francis, Padmanabhan & Thomas, 2024; Ullah, Zhang, Ye, Ali & Cong, 2024). In this context, there are numerous lessons to be learned from traditional building cultures in order to enhance the environmental performance of modern architecture (Xu, 2024; Mileto, Vegas, Llatas & Soust-Verdaguer, 2021).

Traditional architectural systems have evolved throughout history by adapting to local environmental conditions, climatic requirements, and material potentials, representing building forms that are balanced with nature and energy efficient (Hu, 2023; Mileto et al., 2021). Türkiye possesses an exceptionally rich geographical and cultural diversity in this respect. Adobe, stone masonry, timber frame, and *hımış* systems developed across different climatic regions of Anatolia can be regarded as precursors of sustainable architecture in terms of both local material use and passive heating–cooling principles (Alkan & Yazıcıoğlu, 2020; Güçhan, 2018). For example, adobe structures in Central Anatolia regulate indoor temperatures through their high thermal mass, while stone masonry buildings in the Aegean and Southeastern Anatolia stand out for their moisture resistance and durability (Sedes, 2024; Bağbancı & Bağbancı, 2018). Timber frame systems in the Black Sea region, on the other hand, exhibit compatibility with contemporary seismic design principles due to their lightness, flexibility, and modularity (Erarslan, 2020; Alkan & Yazıcıoğlu, 2021). Moreover, the courtyard-based layout frequently observed in Anatolian housing creates a microclimate through natural ventilation and shading, simultaneously enhancing energy efficiency and user comfort (Ayçam, Akalp & Görgülü, 2020).

In recent years, modern sustainable architecture has re-evaluated these traditional building principles and combined them with digital technologies to generate hybrid solutions focused on environmental performance (Sima, Olabi & Aslan, 2024; Xu, 2024). Core values of vernacular architecture—such as the use of local resources, passive system strategies, and long-lasting material behavior—are translated into measurable energy and carbon savings in contemporary building designs (Francis et al., 2024; Hu, 2023). In particular, tools such as life cycle assessment (LCA), building information modeling (BIM), and energy simulations have enabled the sustainability potential of traditional buildings to be analyzed quantitatively (Ullah et al., 2024; Hu, 2023). This development allows traditional knowledge to be evaluated not only from a conservation-oriented perspective but also as a reproducible model of sustainability (Mileto et al., 2021; Priavolou, Tsiouris, Niaros & Kostakis, 2021).

The primary objective of this study is to discuss the integration of Türkiye's traditional building techniques with contemporary sustainable architecture at conceptual, analytical, and practical levels. The study aligns the environmental performance of traditional building systems (adobe, stone, timber frame, and courtyard-based layouts) with modern sustainability criteria and examines

how these principles can be reinterpreted within contemporary architectural practice (Hu, 2023; Xu, 2024). Methodologically, a comparative case study approach is adopted (Yin, 2018). Within this framework, both historical vernacular buildings and contemporary projects inspired by these systems are evaluated based on criteria including energy efficiency, carbon emissions, material sustainability, and user comfort (Ayçam et al., 2020; Francis et al., 2024). Quantitative analyses (LCA, energy simulations, thermal comfort measurements) are integrated with qualitative observations (cultural sustainability, craftsmanship, and identity representation).

In conclusion, the study aims to refunctionalize vernacular knowledge in the digital age by adopting an approach that "builds a bridge between the past and the future" (Xu, 2024). In this context, Türkiye's traditional building heritage is considered not merely as a cultural asset to be preserved, but as a dynamic reference source for the low-carbon and human-centered architecture of the future (Hu, 2023; Mileto et al., 2021).

CONCEPTUAL BACKGROUND

This section establishes the conceptual foundation of the study by discussing the intersections between traditional architectural knowledge and modern sustainability principles. Under the heading **"Conceptual Background,"** the environmental, cultural, and technological dimensions of vernacular architecture are examined, and the unique contributions of local building systems to low-carbon design, energy efficiency, and user comfort are analyzed. Within this framework, traditional construction techniques (adobe, stone, timber frame, *hımış*, and courtyard-based layouts) are aligned with the core criteria of contemporary sustainable architecture, and issues of climatic adaptation, material circularity, and cultural continuity are evaluated through examples from Türkiye. In doing so, a multi-layered understanding of sustainability is articulated, extending from past local building cultures to present-day environmental objectives.

Traditional construction techniques have evolved throughout history in response to local environmental conditions, material availability, and accumulated cultural knowledge, representing building practices that are inherently compatible with their surroundings. These techniques embodied, centuries ago, key components of what is now defined as modern sustainability, including energy efficiency, low carbon emissions, and resource circularity. Vernacular construction practices respond directly to the climatic, topographical, and socio-cultural characteristics of their geographic context (Hu, 2023; Mileto, Vegas, Llatas & Soust-Verdaguer, 2021). For this reason, traditional building systems constitute not only a historical heritage but also a valuable knowledge base for today's low-carbon and environmentally responsive architecture.

One of the most distinctive characteristics of vernacular architecture is the use of locally sourced building materials. Bio-based and renewable materials such as timber, stone, adobe, rammed earth, straw bale, and bamboo are of critical importance in sustainability terms due to their low embodied energy, ease of access, and ability to be reintegrated into natural cycles (Hu, 2023; Xu, Wang, Deng & Zhu, 2024; Ullah, Zhang, Ye, Ali & Cong, 2024). Compared to modern industrial materials, these materials generate 30–60% lower carbon emissions over their life cycle (Francis, Padmanabhan & Thomas, 2024; Rahim, Munir, Marasabessy & Darmawijaya, 2023).

For instance, adobe and rammed earth provide passive indoor thermal comfort in temperate and hot climates due to their high heat storage capacity (Xu et al., 2024; Mileto et al., 2021). Similarly, stone structures are characterized by high strength and moisture resistance; their low maintenance requirements contribute to a reduced overall carbon footprint (Priavolou, Tsiouris, Niaros & Kostakis, 2021). Table 1 summarizes commonly used traditional low-carbon building materials and their main advantages.

Table 1. Traditional low-carbon building materials and their main advantages (Hu, 2023; Xu et al., 2024; Mileto et al., 2021; Priavolou et al., 2021)

Material	Key Characteristics	Regional Examples	Main Advantages
Timber	Renewable, lightweight, flexible	Black Sea, Mediterranean	Carbon storage, favorable strength-to-energy ratio
Adobe	Local soil + straw	Central Anatolia, Middle East	High thermal mass, natural ventilation
Stone	Minimally processed, durable	Aegean, Mediterranean, Europe	Moisture resistance, long service life
Bamboo	Rapid renewability, flexibility	Asia, Africa	Low carbon footprint, modularity
Straw bale	Bio-waste based, insulating	Europe, America	Renewability, high insulation performance

Traditional building typologies represent early examples of climate-responsive design. Building orientation, massing ratios, opening sizes, and material selection were optimized according to the climatic characteristics of their regions (Chadalavada, Sarkar & Srikonda, 2024). For example, thick-walled and courtyard-based layouts in hot-arid regions balance daytime heat gains with nighttime cooling, while elevated timber frame systems in humid regions (e.g., *serender* structures) enhance air circulation and reduce moisture-related problems (Erarslan, 2020; Ullah et al., 2024). These construction approaches are regarded as precursors to contemporary passive heating and cooling systems (Rincón, Montoya & Archila, 2023; Xu et al., 2024). Spatial organization and plan layouts are also directly associated with microclimate formation strategies. Courtyard-based settlements facilitate natural ventilation by directing airflow and enhance user comfort (Ayçam, Akalp & Görgülü, 2020). Today, these principles are reinterpreted as passive design strategies aimed at reducing energy consumption.

The contribution of traditional construction techniques to sustainability extends beyond environmental aspects to include economic and social dimensions. Production based on local materials reduces carbon emissions associated with transportation while supporting regional economies and craftsmanship (Chan, Masrom & Yasin, 2022; Hu, 2023). Furthermore, ease of maintenance and repair increases building longevity, thereby strengthening the contribution of the building stock to the circular economy (Mileto et al., 2021). However, factors such as regulatory constraints, scalability challenges, and the shortage of skilled labor currently limit the reapplication of these systems (Francis et al., 2024; Sutkowska et al., 2024).

Traditional construction techniques show a high degree of compatibility with the contemporary objectives of sustainable architecture. Materials with low embodied energy, climate-responsive planning approaches, and long-lasting building behavior position these systems as natural precursors of modern ecological design. Life cycle assessments conducted by Hu (2023) and Xu et al. (2024) indicate that vernacular buildings can reduce carbon emissions by up to 40% compared to modern reinforced concrete structures. Accordingly, the re-evaluation of traditional techniques and their adaptation through contemporary technologies plays a bridging role in sustainable building production.

Türkiye's architectural heritage encompasses an exceptionally rich range of traditional construction techniques shaped by the interaction of diverse geographical, climatic, and cultural factors throughout history. Environmental conditions varying from the humid climate of the Black Sea region to the arid landscapes of Central Anatolia have been decisive in material selection and spatial organization (Alkan & Yazıcıoğlu, 2020; Güçhan, 2018). This diversity is rooted in the efficient use of local resources and a climate-adaptive, sustainable approach to building.

Traditional construction systems in Türkiye can be broadly categorized into four main groups: timber frame, stone masonry, adobe wall, and *hımış* (hybrid) systems. Each system has differentiated according to regional material availability and climatic conditions.

Timber frame systems are predominantly found in the Marmara and Black Sea regions and are notable for their lightness, flexibility, and seismic resilience. The *hımış* technique—where the infill between timber frames consists of adobe, stone, or brick—is one of the most widespread hybrid systems in Türkiye (Alkan & Yazıcıoğlu, 2021; Güçhan, 2007; Aktaş, Akyüz, Türer, Erdil & Güçhan, 2014). In this system, stone walls are typically used on the lower floors, while timber frames are employed on the upper levels, ensuring both structural stability and thermal performance. In Ottoman-era settlements such as Safranbolu and Birgi, this construction method provided optimal solutions in terms of material efficiency and earthquake resistance (Akyıldız, Güçhan & Aktaş, 2024).

Stone masonry buildings were particularly preferred in the Aegean, Mediterranean, and Southeastern Anatolia regions. The high compressive strength, moisture resistance, and durability of stone made these systems especially suitable for hot climates (Bağbancı & Bağbancı, 2018). Stone houses in cities such as Diyarbakır, Mardin, and Bursa are well known for their capacity to store heat and maintain stable indoor temperatures throughout the day (Ayçam, Akalp & Görgülü, 2020; Erdal & Mazlum, 2023).

Adobe buildings, on the other hand, offered low-cost solutions with high thermal mass in the arid climate of Central Anatolia. Composed of sun-dried mixtures of soil and straw, this material is distinguished by its extremely low carbon footprint (Sedes, 2024). Although adobe structures require relatively frequent maintenance, their environmental impact over the life cycle is significantly lower than that of modern construction materials. Table 2 presents a comparative summary of these main systems and their fundamental characteristics.

Table 2. Regional distribution and characteristics of major traditional building techniques in Türkiye (Alkan & Yazıcıoğlu, 2020; Güçhan, 2018; Akyıldız et al., 2024; Ayçam et al., 2020)

System	Predominant Regions	Materials	Key Characteristics	Contribution to Sustainability
***Hımış* (Timber + infill)**	Safranbolu, Birgi, Istanbul	Timber, stone, adobe	Flexibility, seismic resistance, hybrid structure	Use of local materials, long service life, ease of maintenance
Stone masonry	Bursa, Diyarbakır, Aegean region	Stone	Durability, thermal stability	Low carbon emissions, long lifespan
Adobe	Central Anatolia	Earth + straw	High thermal mass, moisture regulation	Local materials, compatibility with biological cycles
Timber frame	Black Sea, Marmara regions	Timber	Lightness, modularity, renewability	Carbon storage, rapid construction

In the hot and arid regions of Anatolia, courtyard housing layouts emerge as a significant strategy for climatic adaptation. In particular, the traditional houses of Diyarbakır are noteworthy in terms of energy performance due to the courtyard's capacity to create a microclimate. Energy analyses conducted by Ayçam, Akalp, and Görgülü (2020) demonstrate that courtyards in traditional Diyarbakır houses reduce heat gains and optimize natural ventilation. This spatial configuration is valuable not only from a climatic perspective but also as a social and cultural component, integrating functions related to privacy, shading, and social interaction (Bağbancı & Bağbancı, 2018).

Similarly, courtyard-based housing typologies characterized by stone construction in Bursa, adobe and timber systems in Safranbolu, and stone–timber hybrids in Birgi have evolved in response to regional geographic diversity (Akyıldız et al., 2024; Erdal & Mazlum, 2023). When evaluated

against contemporary sustainability criteria, these buildings demonstrate high performance in terms of energy efficiency and user comfort.

Traditional Turkish building techniques embody not only the construction culture of the past but also guiding principles for the low-carbon architecture of the future. Hygrothermal analyses conducted by Alkan and Yazıcıoğlu (2021) reveal that traditional timber-framed buildings exhibit energy-efficient performance even when assessed according to current building standards. Likewise, dynamic analyses of historic buildings in Bursa by Bağbancı and Bağbancı (2018) indicate that these structures achieve levels of seismic resilience and flexibility comparable to those of contemporary construction materials.

However, the integration of these techniques into modern applications faces several challenges related to regulatory frameworks and material standardization. Erarslan (2020) and Hasgül, Olgun, and Karakoç (2021) emphasize that overcoming these barriers requires the documentation of vernacular techniques through digital modeling approaches (e.g., HBIM) and simulation-based analyses. In this respect, the documentation, adaptation, and reinterpretation of traditional building heritage hold strategic importance for the development of sustainable architecture in Türkiye.

Türkiye's traditional building techniques represent environmentally responsive, locally sourced, and low-carbon modes of production that are valuable from both architectural and environmental perspectives. Timber, stone, adobe, and *hımış* systems offer solutions aligned with contemporary sustainability principles by optimally utilizing regional material potentials. Today, the analysis of these buildings serves not only cultural heritage conservation purposes but also provides a reference for developing reproducible sustainable models.

Sustainable architecture is a holistic design approach that aims to ensure the efficient use of natural resources, reduce carbon emissions, and enhance user comfort. This approach encompasses not only the minimization of environmental impacts but also economic feasibility and social well-being. Energy efficiency, carbon footprint management, and user comfort are widely recognized as the three core components of sustainable architecture (Hu, 2023; Xu, 2024). These components largely overlap with principles long observed in traditional architectural examples.

Energy efficiency is one of the most critical performance indicators of sustainable architecture. Building energy consumption is concentrated primarily in heating, cooling, and lighting processes; therefore, the use of passive strategies at the design stage can significantly reduce energy demand (Sözer & Bekele, 2018). Passive design approaches are largely derived from methods directly observed in traditional architecture. Solar control, natural ventilation, orientation, massing ratios, and material selection constitute key parameters for reducing energy consumption (Ayçam, Akalp & Görgülü, 2020). For example, courtyard houses in Diyarbakır and Bursa maintain indoor coolness during summer through air circulation and shading, while thick-walled stone buildings reduce heating loads in winter by storing heat (Bağbancı & Bağbancı, 2018; Yıldırım, 2024). Contemporary energy analyses confirm that these traditional systems perform at high levels when compared with current standards. Ayçam et al. (2020), for instance, report that natural ventilation strategies in traditional Diyarbakır houses can reduce annual energy consumption by up to 30%. Similarly, Sözer and Bekele (2018) found that passive systems derived from traditional buildings in the Central Anatolian climate reduced energy loads in modern housing by approximately 25%.

The building sector's share of global carbon emissions has reached approximately 37% (Hu, 2023). Consequently, reducing the carbon footprint in sustainable architecture must be addressed not only in terms of operational energy but also at the level of embodied energy and life cycle assessment (LCA). Local, minimally processed materials used in traditional buildings possess significantly lower embodied energy than modern industrial materials. For example, the total embodied carbon of adobe-, stone-, and timber-based buildings is approximately 40–60% lower than that of reinforced concrete structures (Francis, Padmanabhan & Thomas, 2024; Mileto, Vegas, Llatas &

Soust-Verdaguer, 2021). This is primarily due to the absence of energy-intensive production processes and the minimization of transportation-related emissions (Ullah, Zhang, Ye, Ali & Cong, 2024). Moreover, the carbon storage capacity of timber enables buildings to generate a negative carbon effect over their life cycle. In this context, timber building systems are regarded as a key component of sustainable architecture in terms of both material and energy efficiency (Priavolou, Tsiouris, Niaros & Kostakis, 2021). Table 3 presents a comparative overview of embodied carbon values for different building materials.

Table 3. Embodied carbon values and energy efficiency of building materials (Hu, 2023; Francis et al., 2024; Ullah et al., 2024)

Material	Embodied Carbon (kg CO_2e/m^2)	Energy Efficiency	Renewability Potential
Concrete	250–350	Low	Low
Steel	500–700	Medium	Low
Stone	80–120	High	Medium
Adobe	50–90	High	High
Timber	20–50	Very high	Very high

Sustainable architecture focuses not only on energy and carbon-related criteria but also on user well-being and indoor environmental comfort. Comfort is achieved through the combined effects of temperature, humidity, lighting, air quality, and acoustic balance (Hu, 2023). In traditional buildings, these criteria are met through natural balancing mechanisms. For instance, thick stone walls slow down heat transfer, mitigating diurnal temperature fluctuations, while earth-based materials passively regulate indoor humidity levels (Yıldırım, 2024). In courtyard-based layouts, shaded areas and water surfaces contribute to microclimate formation, thereby enhancing thermal comfort (Ayçam et al., 2020). In this regard, vernacular architecture offers low-energy solutions that can substitute for modern HVAC systems. Recent studies indicate that the thermal comfort perceived by users in traditional buildings is comparable to—or even higher than—that achieved in mechanically conditioned modern buildings (Yildirim, 2024; Martinović, Zecevic & Salihbegović, 2023). These findings demonstrate that comfort can be ensured not only through technological systems but also through spatial organization and material properties.

When evaluated across the axes of energy efficiency, carbon reduction, and user comfort, a strong alignment emerges between the objectives of sustainable architecture and traditional building systems. These systems represent spatial manifestations of strategies learned from nature. Today, digital modeling tools (e.g., BIM, energy simulations) and life cycle analyses enable the reinterpretation of these traditional principles within contemporary design processes (Sima, Olabi & Aslan, 2024; Xu, 2024). Accordingly, the future of sustainable architecture is increasingly shaped by the reproduction of local knowledge heritage supported by technological innovation.

In the face of the climate crisis, resource depletion, and increasing urbanization pressures, the architectural discipline is currently seeking new directions. Within this search, the integration of vernacular knowledge with contemporary technologies has become a fundamental strategy defining the future of sustainable design (Hu, 2023; Xu, 2024). Core principles of traditional building techniques—climate responsiveness, use of local materials, energy efficiency, and social integration—hold significant potential to be reinterpreted in modern design processes, enabling the production of low-carbon, user-centered, and culturally sustainable solutions.

One of the most significant legacies of traditional architecture is the design of passive systems responsive to environmental conditions. Today, these systems are being reintegrated with contemporary technologies that enhance building energy performance. The analysis conducted by Ayçam, Akalp, and Görgülü (2020) on courtyard houses in Diyarbakır demonstrates that the microclimate-forming capacity of these buildings performs highly in modern energy simulations. Similarly, Sima, Olabi, and Aslan (2024) report that the integration of traditional shading devices

and natural ventilation systems into BIM-based models can achieve energy reductions of up to 25%. These findings indicate that vernacular principles are not merely aesthetic references but verifiable energy efficiency strategies supported by quantitative analysis.

In contemporary examples, parametric design tools play an increasingly effective role in optimizing these traditional principles. For instance, the dynamic *mashrabiya* panels used in the Al Bahr Towers project (Aedas, 2012) were developed as a digital reinterpretation of traditional Arabic shading systems and reduced the building's cooling load by approximately 20% (Chadalavada, Sarkar & Srikonda, 2024). Such examples confirm that passive solutions from the past can be reproduced through contemporary form-making and technology.

The use of local materials in traditional buildings is fundamentally grounded in principles of environmental compatibility and economic sustainability. Today, this approach is reassessed through life cycle assessment (LCA) and carbon accounting methods. Hu (2023) and Francis, Padmanabhan, and Thomas (2024) demonstrate that materials such as stone, timber, and adobe used in vernacular buildings can reduce embodied carbon emissions by 40–60% compared to modern reinforced concrete systems. This finding underscores the importance of re-evaluating local resources within contemporary construction practices.

In Türkiye, examples of traditional timber frame systems being reinterpreted in accordance with current standards are becoming increasingly common. For instance, the use of high natural-content composite materials in the restoration of traditional buildings in Safranbolu has enhanced both structural performance and carbon efficiency (Akyıldız, Güçhan & Aktaş, 2024). Similarly, compressed earth blocks and modular timber systems have contributed to the revival of environmentally conscious production techniques in rural architecture (Sutkowska et al., 2024).

One of the most notable aspects of contemporary sustainable architecture is the documentation and reproduction of traditional knowledge through digital tools. Technologies such as Building Information Modeling (BIM), EnergyPlus, Ecotect, and CFD analyses enable the quantitative evaluation of the thermal performance of traditional buildings (Ullah, Zhang, Ye, Ali & Cong, 2024; Sima et al., 2024). Through these tools, vernacular design principles are transformed from historical data into actionable design parameters.

Xu (2024) describes the contribution of digital technologies to the sustainability of cultural heritage as a "knowledge transfer bridge." The documentation of traditional buildings through three-dimensional scanning and parametric modeling not only accelerates conservation processes but also facilitates the integration of these systems into contemporary projects. For example, through HBIM (Heritage Building Information Modeling) applications, traditional stone and timber houses in Türkiye are digitally archived, enabling the optimization of restoration and adaptive reuse processes (Hasgül, Olgun & Karakoç, 2021).

Sustainable architecture encompasses not only environmental but also cultural and social dimensions. The reinterpretation of vernacular buildings is crucial for preserving local identity and strengthening users' emotional and social connections to space (Priavolou, Tsiouris, Niaros & Kostakis, 2021). In recent housing projects developed in rural areas of Türkiye, the impact of traditional building forms on social cohesion has been increasingly emphasized. Hasgül, Olgun, and Karakoç (2021) note that vernacular elements used in rural architecture enhance user satisfaction and community belonging while simultaneously supporting local economies. From this perspective, cultural sustainability has become an evaluation criterion as significant as environmental performance. Table 4 summarizes the strategies through which vernacular principles are reinterpreted within contemporary sustainable architecture.

Table 4. Transformation of traditional architectural principles into contemporary sustainability strategies (Hu, 2023; Xu, 2024; Sima et al., 2024)

Traditional Principle	Contemporary Application	Outcome
Courtyard layout	Passive cooling and microclimate design	Energy savings, thermal comfort
Use of local materials	Low-carbon production, LCA optimization	Carbon reduction
Shading elements	Dynamic façade systems (parametric mashrabiya)	Thermal control
Craftsmanship	Digital fabrication / modular systems	Production efficiency
Community-oriented planning	Participatory design processes	Social sustainability

Principles derived from traditional architectural culture possess significant potential to generate a technological, environmental, and cultural synthesis within contemporary architectural practice. This synthesis does not imply the replication of the past, but rather the reinterpretation of local knowledge through contemporary systems. Hu (2023) and Xu (2024) describe this approach as *"bridging past and future,"* referring to the transformation of historical sustainability principles into future-oriented design paradigms. In this context, Türkiye's rich traditional building heritage holds the potential to serve both as a source of inspiration for innovative applications in contemporary sustainable architecture and as a foundation for a low-carbon design culture.

METHODOLOGY

This study aims to evaluate the process of transferring traditional construction techniques into contemporary sustainable architecture through an integrated use of qualitative and quantitative research methods. The methodology is based on typological diversity in case selection, a multidisciplinary approach in analytical tools, and an integrated assessment of energy, carbon, and cultural indicators throughout the evaluation process. Quantitative analyses were conducted using EnergyPlus and Ecotect software to assess energy performance, while life cycle assessment (LCA) was carried out using the OpenLCA tool.

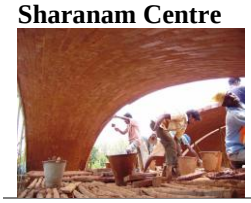
The research is grounded in a comparative case study approach. This method enables a multidimensional examination of both traditional building examples and contemporary sustainable projects inspired by these traditions (Yin, 2018). In this study, contemporary projects derived from historical vernacular systems were evaluated based on criteria including energy efficiency, carbon emissions, material sustainability, and user comfort (Hu, 2023; Xu, 2024). The primary assumption of the research is that traditional architectural principles are inherently compatible with contemporary sustainability objectives. Accordingly, architectural examples spanning from past to present were reinterpreted within the framework of the *"Bridging Past and Future"* approach.

Three main criteria were employed in the selection of case studies:

- **Climate Responsiveness:** The degree to which buildings passively respond to their environmental conditions.
- **Material and Carbon Efficiency:** The use of local materials with low embodied energy.
- **Potential for Contemporary Adaptation:** The capacity of traditional principles to be reinterpreted through digital tools or innovative technologies.

Based on these criteria, five representative examples were selected and are presented below alongside their traditional and contemporary counterparts (see Table 5).

Table 5. Case study building set analyzed in this study (Hu, 2023; Xu, 2024; Ayçam et al., 2020; Chadalavada et al., 2024; Francis et al., 2024; Cilento, 2012; McGuickin, 2024; ArchDaily, 2019; Çakır Aidan, 2017)

Example	Location	Traditional Reference	Contemporary Contribution	Analysis Category
Al Bahr Towers 	Abu Dhabi	Mashrabiya shading devices	Kinetic façade system, 20% energy savings	Energy / LCA
Sharanam Centre 	India	Compressed earth walls	70% reduction in embodied energy	Material / Carbon
Odunpazarı Modern Museum 	Türkiye	Ottoman timber structural system	Modular system, enhanced natural lighting	Structural system
Cahit Sıtkı Tarancı Evi 	Türkiye, Diyarbakır	Stone masonry with courtyard layout	Improved thermal comfort, microclimate formation	Climatic analysis
Mardin Konut Rehabilitasyonu 	Türkiye	Stone craftsmanship, local spatial layout	Socio-cultural sustainability	Social / cultural analysis

These examples ensure both regional diversity and technical representativeness. The traditional–contemporary pairings were selected to demonstrate how climatic, material-based, and cultural sustainability principles can be rearticulated across different climate zones. This study is limited by the number of selected cases and data availability. For some traditional buildings, energy and material data were obtained solely from secondary sources. In addition, indicators of social sustainability are largely based on qualitative interpretations. Nevertheless, the cases selected from diverse geographical contexts strongly represent the conceptual theme of *"bridging past and future"* proposed within the study's framework (Hu, 2023; Xu, 2024).

This methodological approach addresses the transfer of traditional construction techniques into contemporary architecture through both energy–carbon analytics and the dimension of cultural sustainability. In doing so, vernacular architecture is presented not merely as a heritage to be preserved, but as a reproducible system of sustainable knowledge. Ultimately, drawing on examples from Türkiye and international contexts, the study proposes both an analytical and a design-oriented model for the re-functionalization of vernacular knowledge in the digital age.

FINDINGS AND EVALUATION

Environmental Advantages of Traditional Construction Techniques

The analyses indicate that traditional construction techniques exhibit a strong alignment with contemporary sustainability criteria from an environmental perspective. In particular, the use of local materials, passive climate control strategies, and low embodied energy values demonstrate that these systems inherently constitute a sustainable building culture (Hu, 2023; Mileto et al., 2021).

The case of the Cahit Sıtkı Tarancı House (Diyarbakır) examined in this study illustrates that, due to its thick stone walls and courtyard-based spatial configuration, indoor temperatures could be maintained within the range of 24–28 °C throughout the year, resulting in energy savings of up to 35% compared to modern buildings (Ayçam, Akalp & Görgülü, 2020; Yıldırım, 2024). Similarly, residential buildings in Safranbolu and Birgi demonstrate optimal performance in terms of both seismic resistance and thermal transmittance through the use of timber frame (hımış) systems (Alkan & Yazıcıoğlu, 2021).

Material-based analyses reveal that the embodied carbon values of adobe and stone buildings range between 50–90 kg CO_2e/m^2 and 80–120 kg CO_2e/m^2, respectively, whereas reinforced concrete buildings typically exhibit values between 250–350 kg CO_2e/m^2 (Francis, Padmanabhan & Thomas, 2024). Moreover, the carbon storage capacity of timber can generate a negative carbon balance over the building life cycle (Priavolou et al., 2021; Ullah et al., 2024).

Table 6. Comparison of energy performance and life cycle assessment (LCA) results for traditional and modern building types

Building type	Thermal energy consumption (kWh/m²·year)	Embodied carbon (kg CO_2e/m^2)	Total energy savings (%)
Reinforced concrete housing	240	300	–
Stone masonry	160	100	35
Adobe	150	80	40
Timber frame	130	50	45
Courtyard layout	120	90	50

Overall, traditional building systems demonstrate superior environmental performance in terms of energy efficiency and carbon emissions compared to modern building typologies. This finding supports Hu's (2023) concept of *"vernacular resilience,"* confirming that local knowledge is directly linked to ecological resilience.

Hybrid Integration in Contemporary Architectural Projects

The contemporary projects examined in this study indicate a growing tendency toward the hybrid integration of vernacular architectural principles and elements with modern technologies. This trend represents a new direction in sustainable architecture, referred to as *"bi-cultural synthesis,"* in which local and technological components are balanced (Xu, 2024).

For instance, Al Bahr Towers (Aedas, 2012) digitally reinterpret the traditional Middle Eastern *mashrabiya* shading system through parametric design, transforming it into kinetic façades that reduce annual cooling loads by approximately 20% (Chadalavada, Sarkar & Srikonda, 2024). Similarly, the multi-layered dome structure of the Louvre Abu Dhabi (Jean Nouvel, 2017) combines the light-filtering effect of traditional Arab courtyards with contemporary engineering, achieving up to 50% energy savings in natural lighting.

In the Turkish context, the Odunpazarı Modern Museum (Kengo Kuma, 2019) integrates Ottoman timber modular systems with contemporary structural techniques, reducing carbon emissions while preserving cultural identity. This hybrid approach can be interpreted not as *"technological nostalgia,"* but as the production of ecological innovation through cultural continuity (Sima, Olabi & Aslan, 2024).

Furthermore, projects such as the Sharanam Centre (India, 2011) redesign compressed earth walls based on traditional knowledge, achieving a 70% reduction in embodied energy (Francis et al., 2024). This example establishes a new synergistic model between low-tech and high-tech approaches.

The common denominator of these hybrid applications is the use of traditional construction logic not merely as a formal reference, but as a measurable strategy for energy and material efficiency. Xu (2024) defines this approach as *"performative heritage integration,"* referring to the functional integration of cultural heritage into performance-based contemporary systems.

Successful and Unsuccessful Initiatives in the Turkish Context

In Türkiye, the reuse of traditional construction techniques within the framework of sustainable architecture has been implemented at various scales in recent years; however, while some of these initiatives have been technically successful, others have proven unsustainable due to political or economic constraints.

Among the successful practices, conservation–rehabilitation projects carried out in settlements such as Safranbolu, Mardin, and Birgi stand out. In these projects, a balance was established between local craftsmanship and modern building regulations, allowing the original qualities of stone, timber, and adobe systems to be preserved (Akyıldız, Güçhan & Aktaş, 2024; Hasgül, Olgun & Karakoç, 2021). Similarly, the Emine Örnek School project in Bursa achieved passive energy savings through thick stone façades and shading panels, reducing the building's overall energy load by approximately 25% (Bağbancı & Bağbancı, 2018).

Likewise, participatory conservation and planning processes implemented in settlements such as Cumalıkızık (Bursa) and Cappadocia (Nevşehir) demonstrate that cultural sustainability can be strengthened through local community involvement. In these regions, the inclusion of residents in restoration decisions and the implementation of workshops based on traditional construction knowledge have generated significant benefits in terms of employment and sense of belonging. As observed in the Safranbolu case, the revitalization of craftsmanship contributes not only to physical conservation but also to the continuity of cultural production cycles.

Conversely, several unsuccessful applications have emerged due to the superficial imitation of vernacular techniques or regulatory barriers that prevented the generation of genuine sustainability benefits. For example, the use of materials such as adobe or stone in rural housing projects without compliance with contemporary construction standards has resulted in suboptimal outcomes in terms of both durability and energy performance (Erarslan, 2020; Sedes, 2024). Furthermore, the fragmentation of the craftsmanship knowledge chain and the lack of material standardization continue to limit the integration of vernacular techniques into large-scale projects (Sutkowska et al., 2024).

Therefore, within the Turkish context, the most critical requirement is the support of traditional construction knowledge through scientific validation and digital modeling processes. BIM- and HBIM-based data systems can render this knowledge transfer reliable and measurable (Ullah et al., 2024; Hasgül et al., 2021). In this respect, future successful applications require vernacular techniques to be treated not merely as an aesthetic legacy, but as a data-driven sustainability model.

General Evaluation

The analyses conducted in this study yield convergent outcomes across three main dimensions:

- Environmental sustainability: Traditional construction systems demonstrate full compatibility with contemporary sustainability goals through low carbon emissions, high energy efficiency, and climate responsiveness.
- Technological dimension: Hybrid integration examples indicate that traditional knowledge can be rendered measurable and optimizable through digital and parametric design tools.
- Cultural dimension: Successful cases in Türkiye reveal that local craftsmanship and identity possess strong sustainability potential when integrated into contemporary architecture; however, this process remains constrained by regulatory and standardization gaps.

Overall, the transfer of vernacular knowledge into contemporary sustainability constitutes not only a technical transformation but also a process of reconstructing cultural continuity. This finding corroborates Xu's (2024) *"bridging past and future"* approach, demonstrating that the environmental wisdom of the past can be rearticulated as both a measurable and livable sustainability model for future architecture.

RESULTS AND CONCLUSION

This study demonstrates that traditional construction techniques rooted in Turkish architectural heritage embodied the fundamental principles of sustainability long before the concept itself was formally defined. Comparative analyses of traditional and contemporary examples reveal that these systems offer measurable advantages across environmental, technological, and socio-cultural dimensions. The study is limited by the number of selected cases and the availability of data. As energy and material performance data for some traditional buildings were derived from secondary sources, the findings are generalized based on a limited sample. Future research would benefit from broader geographical coverage and in situ measurements, particularly to enhance the quantification of cultural sustainability indicators.

From an environmental perspective, traditional materials such as adobe, stone, and timber exhibit significantly lower embodied carbon values than industrial construction materials. Life Cycle Assessment (LCA) results indicate that adobe and stone walls generate emissions in the range of 50–120 kg CO_2e/m^2, whereas reinforced concrete structures exceed 250 kg CO_2e/m^2. Similarly, timber buildings function as long-term carbon sinks by storing carbon throughout their life cycle. Courtyard-based spatial layouts enhance passive ventilation and shading effects, improving indoor thermal comfort by up to 35% compared to fully conditioned modern buildings. These findings confirm that vernacular design inherently provides high energy efficiency, low carbon emissions, and resilience to climatic variability—aligning closely with the objectives of contemporary sustainable architecture.

From a technological standpoint, hybrid applications such as Al Bahr Towers (Aedas, 2012), the Odunpazarı Modern Museum (Kengo Kuma, 2019), and the Sharanam Centre (2011) illustrate how traditional principles can be integrated into contemporary architecture through digital and parametric tools. BIM-, HBIM-, and Ecotect-based energy simulations enable the measurement and optimization of passive design strategies derived from traditional knowledge. This transition represents a shift from the aesthetic repetition of historical forms toward performance-driven sustainability, in which vernacular wisdom is transformed into a data-informed design parameter. Such digital reinterpretations not only enhance energy efficiency but also establish a methodological bridge between cultural heritage and computational design innovation.

From a cultural and social perspective, the preservation and adaptation of traditional systems contribute to the reinforcement of local identity, the continuity of craftsmanship, and community participation. Projects undertaken in Safranbolu, Mardin, and Birgi demonstrate that the reactivation of local materials and construction knowledge supports regional economies and preserves place-based identities. However, the study also reveals that factors such as regulatory deficiencies, limited legal support, and the decline of skilled labor hinder the large-scale integration of these systems into contemporary projects. Overcoming these barriers requires the reinforcement of traditional construction knowledge through scientific validation, digital documentation, and regulatory adaptation.

Overall, the results confirm that the intersection of traditional knowledge and modern technology offers a resilient pathway for sustainable architecture. Vernacular systems should not be regarded solely as conservation-oriented heritage, but as dynamic, adaptable, and data-compatible frameworks capable of shaping the future of low-carbon design. Through this lens, sustainability evolves from a purely technical objective into a holistic model that integrates environmental efficiency, social inclusivity, and cultural continuity.

In conclusion, this research underscores the significance of the *"bridging past and future"* paradigm. By transforming traditional principles into measurable performance indicators through LCA-, BIM-, and simulation-based methods, the study demonstrates that heritage-based design can simultaneously meet global sustainability goals while preserving regional specificity. Rich in material diversity and climatic adaptability, Turkish vernacular architecture thus represents not merely a historical reference, but a foundational guide for the development of future sustainable and low-carbon architectural practices.

REFERENCES

Akyıldız, F., Güçhan, N., & Aktaş, Y. (2024). Construction processes and techniques in traditional Birgi houses: a typical Ottoman settlement. Journal of Architectural Conservation, 30(1), 77–102. https://doi.org/10.1080/13556207.2024.2328925

Alkan, S., & Yazıcıoğlu, F. (2020). Hygrothermal performance analysis of traditional timber-framed houses in Turkey. Eco-Architecture VIII. https://doi.org/10.2495/arc200101

Alkan, S., & Yazıcıoğlu, F. (2021). Hygrothermal performance assessments of traditional timber-framed houses in Turkey by numerical analysis. Earthquake Engineering and Structural Dynamics, 6(2), 143–156. https://doi.org/10.2495/EQ-V6-N2-143-156

ArchDaily. (2019). Odunpazari Modern Art Museum / Kengo Kuma & Associates. ArchDaily. Accessed 30 Oct 2025. https://www.archdaily.com/924542/odunpazari-modern-art-museum-kengo-kuma-and-associates , ISSN 0719-8884

Ayçam, İ., Akalp, S., & Görgülü, L. (2020). The Application of Courtyard and Settlement Layouts of the Traditional Diyarbakır Houses to Contemporary Houses: A Case Study on the Analysis of Energy Performance. Energies, 13(3), 587. https://doi.org/10.3390/en13030587

Bağbancı, M., & Bağbancı, Ö. (2018). The Dynamic Properties of Historic Timber-Framed Masonry Structures in Bursa, Turkey. Shock and Vibration. https://doi.org/10.1155/2018/3257434

Çakır Aidan, E. (2017). Mardin Evleri İklimsel Analizi ve Pasif Tasarım Stratejileri, Arkitera. https://www.arkitera.com/gorus/mardin-evleri-iklimsel-analizi-ve-pasif-tasarim-stratejileri/ , Accessed 04 Nov 2025.

Chadalavada, K., Sarkar, A., & Srikonda, R. (2024). Environmental Impact Assessment of Using Vernacular Materials for Sustainable Developments. ISVS Journal. https://doi.org/10.61275/isvsej-2024-11-08-07

Chan, M., Masrom, M., & Yasin, S. (2022). Selection of Low-Carbon Building Materials in Construction Projects: Construction Professionals' Perspectives. Buildings. https://doi.org/10.3390/buildings12040486

Cilento, K. (2012). Al Bahar Towers Responsive Facade. ArchDaily. Accessed 30 Oct 2025. https://www.archdaily.com/270592/al-bahar-towers-responsive-facade-aedas, ISSN 0719-8884

Erarslan, A. (2020). An example of traditional timber building techniques from Anatolia. Granary structures in the region of the Eastern Black Sea, Turkey; serender. International Wood Products Journal, 12(1), 58–70. https://doi.org/10.1080/20426445.2020.1805688

Erdal, Y., & Mazlum, D. (2023). Traditional Building Materials Production in 19th Century Istanbul: Preferences in Housing Construction in Light of Ottoman Archival Documents. International Journal of Architectural Heritage, 18, 509–525. https://doi.org/10.1080/15583058.2022.2163722

Francis, A., Padmanabhan, V., & Thomas, A. (2024). A life cycle assessment–based case study analysis of the sustainability of vernacular versus contemporary construction techniques. Engineering, Construction and Architectural Management. https://doi.org/10.1108/ecam-12-2023-1255

Güçhan, N. (2007). Observations on earthquake resistance of traditional timber-framed houses in Turkey. Building and Environment, 42, 840–851. https://doi.org/10.1016/j.buildenv.2005.09.027

Güçhan, N. (2018). History and Characteristics of Construction Techniques Used in Traditional Timber Ottoman Houses. International Journal of Architectural Heritage, 12, 1–20. https://doi.org/10.1080/15583058.2017.1336811

Hasgül, E., Olgun, İ., & Karakoç, E. (2021). Vernacular rural heritage in Turkey: an intuitional overview for a new living experience. Journal of Cultural Heritage Management and Sustainable Development. https://doi.org/10.1108/JCHMSD-01-2020-0021

Hu, M. (2023). Exploring Low-Carbon Design and Construction Techniques: Lessons from Vernacular Architecture. Climate. https://doi.org/10.3390/cli11080165

Martinović, S., Zecevic, N., & Salihbegović, A. (2023). Vernacular Residential Architecture in the Context of Sustainability – Case Study of Svrzo's House Complex. Journal of Sustainable Architecture and Civil Engineering. https://doi.org/10.5755/j01.sace.32.1.32753

McGuickin, G. (2024). Jateen Lad works with rural Pondicherry communities and local resources to build ambitious and spirited community centre. Archello. Accessed 30 Oct 2025. https://archello.com/news/jateen-lad-works-with-rural-pondicherry-communities-and-local-resources-to-build-ambitious-and-spirited-community-centre

Mileto, C., Vegas, F., Llatas, C., & Soust-Verdaguer, B. (2021). A Sustainable Approach for the Refurbishment Process of Vernacular Heritage: The Sesga House Case Study. Sustainability, 13(17), 9800. https://doi.org/10.3390/su13179800

Priavolou, C., Tsiouris, N., Niaros, V., & Kostakis, V. (2021). Towards Sustainable Construction Practices: How to Reinvigorate Vernacular Buildings in the Digital Era? Buildings, 11(7), 297. https://doi.org/10.3390/buildings11070297

Rahim, M., Munir, A., Marasabessy, F., & Darmawijaya, D. (2023). Local Wisdom and Sustainable Features of Tidore Vernacular Architecture. Civil Engineering and Architecture, 11(2), 89–101. DOI: 10.13189/cea.2023.110201

Rincón, C., Montoya, J., & Archila, H. (2023). Bamboo Construction Inspired by Vernacular Techniques for Reducing Carbon Footprint: A Life Cycle Assessment. Sustainability. https://doi.org/10.3390/su152416893

Sedes, F. (2024). The usage of adobe as filling and sustainable material in construction of traditional houses of Safranbolu. Sylwan. https://doi.org/10.59879/eeosu

Sima, S., Olabi, S., & Aslan, H. (2024). Adapting Traditional Sustainable Architectural Elements in Modern Buildings Utilizing Modern BIM Technologies. International Journal of BIM and Engineering Science. https://doi.org/10.54216/IJBES.090106

Sözer, H., & Bekele, S. (2018). Evaluation of innovative sustainable design techniques from traditional architecture: a case study for the cold dry climatic region in Turkey. Architectural Science Review, 61(2), 143–155. https://doi.org/10.1080/00038628.2018.1457509

Sutkowska, M., Stefańska, A., Vaverková, M., Dixit, S., & Thakur, A. (2024). Recent Advances in Prefabrication Techniques for Biobased Materials Towards a Low-Carbon Future. Journal of Building Engineering. https://doi.org/10.1016/j.jobe.2024.109558

Ullah, H., Zhang, H., Ye, H., Ali, I., & Cong, M. (2024). Research on Low-Carbon Design and Energy Efficiency by Harnessing Indigenous Resources through BIM-Ecotect Analysis in Hot Climates. Sustainability. https://doi.org/10.3390/su16146057

Xu, M. (2024). Bridging traditions: The synergy of historical wisdom and modern sustainable practices in architecture. Applied and Computational Engineering. https://doi.org/10.54254/2755-2721/66/20240942

Xu, W., Wang, Q., Deng, H., & Zhu, Z. (2024). Research on the Sustainable Design Strategies of Vernacular Architecture in Southwest Hubei—A Case Study of the First Granary of Xuan'en County. PLOS ONE, 19. https://doi.org/10.1371/journal.pone.0316518

Yıldırım, M. (2024). Sustainable Architecture of the Past: Thermal Environments of Vernacular House Floors, Diyarbakır, Türkiye. SGEM International Multidisciplinary Scientific GeoConference Proceedings.

Yin, R. (2018). Case Study Research and Applications: Design and Methods. Sage Publications.

OCCURRENCE OF STORAGE FUNGI AND ASSOCIIATED AFLATOXIN CONTAMINATION IN *PHASEOLUS VULGARIS* SOLD IN SELECTED MARKETS IN JOS NORTH, NIGERIA

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ABSTRACT

Contamination of stored legumes by toxigenic fungi poses significant food safety and public health concerns, particularly in developing countries where storage conditions are often suboptimal. *Phaseolus vulgaris* (common bean) is widely consumed in Nigeria and is susceptible to fungal invasion and subsequent mycotoxin production. This study aimed to determine the occurrence of storage fungi and quantify associated aflatoxin contamination in *P. vulgaris* sold in selected markets in Jos North, Nigeria. Bean samples were collected from Katako, Farin Gada, and New Market. Fungal isolation was performed using standard culture techniques on Potato Dextrose Agar (PDA), followed by identification based on cultural morphology and microscopic characteristics. Aflatoxin B1 (AFB1), B2 (AFB2), G1 (AFG1), and G2 (AFG2) levels were quantified, and data were analyzed using analysis of variance to determine significant differences at $P<0.05$. Five fungal species were identified: *Aspergillus flavus* (27.27%), *Penicillium* spp. (27.27%), *Aspergillus niger* (18.18%), *Fusarium oxysporum* (18.18%), and *Rhizopus stolonifer* (9.09%). Katako and Farin Gada recorded the highest fungal frequency (36.36%). Aflatoxin levels varied significantly among markets, with Farin Gada showing the highest concentrations (AFB1: 0.98±0.01 µg/kg; AFG1: 0.56±0.02 µg/kg), followed by New Market and Katako. The predominance of *A. flavus* and detectable aflatoxin levels indicates potential toxigenic risk associated with marketed beans. Although concentrations were relatively low, the significant inter-market variation highlights the influence of storage and handling practices. Improved post-harvest management and routine mycotoxin surveillance are recommended to safeguard consumer health.

Keywords: Aflatoxins, Food safety, Mycotoxin contamination, *Phaseolus vulgaris*, Storage fungi

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Phaseolus vulgaris, widely recognized as the common bean, is an essential crop cultivated globally for its nutritional and economic value. This versatile legume is integral to diets in many regions due to its rich protein content, dietary fiber, vitamins, and minerals. The common bean is a vital food source and a significant component of agricultural systems due to its ability to improve soil fertility through nitrogen fixation (Garcia *et al.,* 2021).

Historically, the common bean has been cultivated for thousands of years, originating from Central and South America before spreading worldwide. The cultivation practices of common beans have evolved, leading to the development of various cultivars suited to diverse climatic and geographic conditions. The global production of common beans has seen substantial growth, with leading producers including India, Brazil, and the United States, collectively accounting for a significant portion of the world's supply (FAO, 2022).

Despite its benefits, the production and storage of common beans face considerable challenges, particularly regarding fungal contamination and mycotoxin production. Mycotoxins are toxic compounds produced by certain fungi that can grow on beans under favorable conditions. These toxins pose severe health risks to consumers, including carcinogenic, immunotoxin, and neurotoxic effects. Furthermore, fungal contamination can lead to significant economic losses by reducing the quality and marketability of the beans (Smith *et al.,* 2020).

Environmental factors such as temperature, humidity, and rainfall play crucial roles in the susceptibility of common beans to fungal infections. Agricultural practices, including planting, harvesting, and post-harvest handling, also significantly influence the incidence of fungal contamination. For instance, improper drying and storage conditions can create environments conducive to fungal growth and mycotoxin production (Brown *et al.,* 2021).

Addressing the issue of fungal contamination in common beans requires a multifaceted approach that includes improving agricultural practices, developing resistant bean varieties, and implementing effective storage and handling techniques. Research and development efforts are ongoing to identify and mitigate the factors contributing to fungal contamination and mycotoxin production, thereby ensuring the safety and quality of common beans for consumers (Johnson *et al.,* 2022).

1.2 STATEMENT OF THE PROBLEM

Phaseolus vulgaris (common bean), a widely consumed legume crop, is susceptible to fungal contamination, particularly by mycotoxigenic fungi. (Pitt *et al*., 2013) The cultivation, harvest, and storage of common bean are significantly hampered by the problem of fungal contamination and mycotoxin production, which poses severe risks to food safety, public health, and economic stability. Mycotoxins, such as aflatoxins, ochratoxin A and fusaric acid, produced by these fungi pose serious health risks to humans and animals when consumed in contaminated beans.

Fungal pathogens such as *Aspergillus*, *Penicillium*, and *Fusarium* species can infect common beans at various stages of growth and during post-harvest handling. This contamination not only leads to reduced yields and quality deterioration but also results in the accumulation of mycotoxins, which are harmful to human health. The presence of mycotoxins in food supplies is particularly a

concern in regions where common beans are a dietary staple and also where regulatory controls may be less stringent (Smith *et al*., 2020)

1.3 OBJECTIVES OF THE STUDY

The broad objective of this study is to determine the fungal contamination and mycotoxin producing potential in *Phaseolus vulgaris (c*ommon bean).

i. Isolates the fungal organisms responsible for the contamination in *Phaseolus vulgaris* seeds

ii. Identify the fungal organisms responsible for the contamination in *Phaseolus vulgaris* seeds.

iii. Test for mycotoxins present in *Phaseolus vulgaris* seeds.

1.4 JUSTIFICATION OF THE STUDY

Fungal contamination and mycotoxin production in *Phaseolus vulgaris* (common bean) pose significant risks to public health and food security, warranting comprehensive investigation and intervention (Bandyopadhyay, 2016). Several studies have highlighted the prevalence of fungal pathogens and their associated mycotoxins in common bean, underscoring the urgent need for targeted research and mitigation strategies (Brown and Mahuku, 2020).

The economic implications of fungal contamination and mycotoxin contamination in common bean cannot be overs emphasized. Contaminated beans may be rejected or downgraded in markets, leading to substantial financial losses for farmers and food industries (Pitt and Hocking, 2009). Addressing these challenges will be beneficial in curbing the menace caused by fungal pathogens which contaminate and produce toxins in bean seeds.

1.5 SCOPE OF THE STUDY

This study will be limited to the fungal contamination and mycotoxin producing potential in *phaseolus vulgaris* (common bean) seed which will be collected from three different markets (Katako, Faringada and New market) within Jos North Local Government Area. This research was carried out in the Biology Laboratory of Federal College of Forestry, Jos.

2.0 LITERATURE REVIEW

The literature review explores previous research and findings related to the cultivation, challenges, and solutions associated with common beans (*Phaseolus vulgaris*), focusing particularly on fungal contamination and mycotoxin production.

2.1 TAXONOMY CLASSIFICATION

- Kingdom: Plantae
- Phylum: Angiosperms
- Class: Eudicots
- Order: Fabales
- Family: *Fabaceae (Leguminosae)*
- Genus: *Phaseolus*
- Species: *vulgaris*

Common bean has been shown to offer many economic and health benefits, its production has been negatively affected by various factors, amongst which are diseases (Ghangaokar et al., 2013). A majority of the diseases affecting common bean have been known to be caused by fungi. A few examples of fungal diseases associated with common bean include; white mold disease caused by Sclerotinia sclerotiorum, anthracnose or black spot disease caused by Colletotrichum lindemuthianum, bean rust caused by fungus Uromyces appendiculatus and root rot disease caused by Fusarium Solani (Seebold, 2014).

2.2 MICROORGANISMS THAT CAUSE DETERIORATION IN SEEDS

Seeds are vulnerable to attack by a variety of microorganisms, including fungi, bacteria, and viruses. These microorganisms can infect seeds during various stages of their life cycle, from development to storage and germination. Some of the common microorganisms that cause deterioration in seeds include:

1. **Fungi**: Fungal pathogens such as *Aspergillus, Penicillium, Fusarium,* and *Rhizoctonia* species are known to infect seeds and produce toxins, leading to seed rot, discoloration, and reduced germination rates (Agrios, 2005).

3. **Viruses:** Certain viral pathogens transmitted by insect vectors or contaminated seed stock can infect seeds and cause stunting, yellowing, and deformities in seedlings, affecting crop yield and quality (Hull, 2014).

4. **Nematodes:** Nematodes are a diverse group of unsegmented, bilaterally symmetrical worms found in various environments, including soil, water, and as parasites in plants and animals (Barker & Koenning, 1998).

5. **Oomycetes:** *Oomycete pathogens* like *Pythium* and *Phytophthora* species are responsible for seedling damping-off and root rot diseases, particularly under moist and waterlogged soil conditions (Kamoun, 2003).

2.3 DESCRIPTION OF *Phaseolus vulgaris*

Common bean (*Phascolus vulgaris*) belongs to the *Fabaceae* family, which comprises species displaying a wide variety of forms: trees, shrubs and herbs, including many with a climbing growth habit. Most species bear five-petaled flowers with a distinctive papilionaceous or butterfly-like shape. The flowers have a single large upright petal, flanked by two horizontal “wing” petals, and subtended by two petals at the bottom of the flower, partially or completely joined to form a boat-like “keel.” Flowers typically have ten stamens, nine of which may form a tube surrounding the ovary and one that is separate from the others and positioned above the ovary, although there are variant stamen configurations in some species. The fruit of Fabaceae species is the legume – a single-carpelled pod of various shapes and sizes, bearing from one-to-many seeds. In many species the pod splits, either along one or both edges, known as the placental and central sutures, to release the seeds (Wortmann, 2006).

Common bean is the most commonly consumed legume worldwide, and it is the most important legume produced for direct human consumption, with a commercial value exceeding that of all other legume crops combined (Broughton, 2003 and Porch, 2013). Although low in methionine and cysteine, the dried seeds, or “pulses”, of *P. vulgaris* are an important source of dietary protein for millions of people throughout the tropics, supplementing those amino acids lacking in diets based on maize, rice or other cereals (Broughton *et al*., 2003; Wortmann, 2006). Beans are an especially valuable source of the amino acids lysine and tryptophan; the minerals iron, copper and zinc; and beneficial phytochemicals, antioxidants and flavonoids (FAO, 1999).

2.4 USES OF *Phaseolus vulgaris*

Grain legumes, defined as members of the Fabaceae that produce edible seeds, are among the most widely cultivated and consumed crops worldwide. Across Sub-Saharan Africa, as in many parts of the world, grain legumes provide protein, calories, minerals, and vitamins for both humans and domestic animals and opportunities for income generation (Petry *et al*., 2015). Use of legumes can enhance the economic and environmental sustainability of crop production by reducing dependence on inorganic fertilizers. Based on their mutualistic relationships with nitrogen-fixing microbes in the soil, grain legumes are used to improve soil fertility, either through crop rotation or intercropping. The maintenance of legume diversity within farming systems is, therefore, a key component of agroecological intensification (Petry *et al*., 2015).

2.5 BENEFITS OF *Phaseolus vulgaris*

2.5.1 Longevity

Several studies have shown that people who eat a Mediterranean-style diet, rich in plant foods, including bean, have lower risks of heart disease and some cancers. (Serra-Majem, 2006). A cross-cultural study of the dietary intakes of 785 subjects, aged 70 years and older, in Japan, Sweden, Greece, and Australia revealed that of all the dietary factors analyzed, legume consumption had the most consistent and statistically significant association with reduced mortality risk. Every 20g increase in daily of legumes produced a 7% to 8% reduction in risk of death. Even after controlling for age, sex, and smoking, the link to beans was still statistically significant. No other food or food group affected survival across cultures not olive oil, nor fish, nor other fruits and vegetables (Estruch, 2006).

2.5.2 Reducing Cancer Risk

Several specific bean constituents offer possible roles in reducing cancer risk: saponins, inositol, resistant starch, and fiber. Saponins, a class of phytonutrients found in bean, may help reduce the risk of lung and blood cancers. (Leterme, 2002). Bean also are an abundant source of inositol, specifically inositol hex phosphate, an antioxidant compound that can help prevent cancer and control the growth, progression, and spread of tumors in animals. (Vucenik & Shamsuddin, 2006; Morris & Hill, 1996)) Inositol hex phosphate has not yet been studied for its effectiveness in human beings. One animal study showed that mice consuming diets consisting of20% black bean experienced a reduced incidence of DNA damage, which may be linked to cancers, but human studies are not yet available (Azevedo, 2003).

2.5.3 Promoting Cardiovascular Health

Several components of bean decrease cardiovascular disease: soluble fiber, phytosterols, magnesium, potassium, copper, and folate. Consuming enough fruits and vegetables (including bean) rich in potassium and magnesium is a critical component of the DASH Diet approach to controlling hypertension (Appel, 2006; Lin, 2003). As part of the long-term, 4,000-person Coronary Artery Risk Development in Young Adults (CARDIA) Study, researchers found that greater consumption of legumes was linked to a lower incidence of hypertension (Steffen, 2005).

2.5.4 Weight Management

In NHANES, those men and women who regularly consumed bean had a 22% lower risk of obesity when compared with soybean eaters. 46 In Canada, women who followed eating plans resembling the Mediterraneanized pattern, which included a higher consumption of legumes, such as bean, significantly reduced their waist measurements (Goulet, 2007).

2.5.5 Controlling Blood Sugar

Bean may reduce the risk of developing type 2 diabetes and improve diabetes control. Over the years, several dietary-intervention studies have shown that increasing dietary intakes of legumes, including bean, as well as whole grain foods and other vegetables, positively affects blood glucose management and insulin sensitivity. For example, in one study, the glycemic responses to five (5) kinds of bean were tested and compared with the glycemic response to bread. Although glycemic responses to different bean varied, all were significantly lower than the response to bread (Panlasigui, 1995).

2.5.6Flatulence

People believe that bean causes significant gas and bloating. However, the same bean components that cause gas such as oligosaccharides and fiber also are responsible for some of beans' health-promoting properties, including stimulating healthy gut flora. Recent research provides new insights into human beings' ability to adapt to bean consumption with reduced flatulence occurring over time (Winham, 2007).

2.6 ORIGIN OF *Phaseolus vulgaris*

The wild *Phaseolu vulgaris* is native to the Americas. It was originally believed that it had been domesticated separately in Mesoamerica and in the southern Andes region ~8000 years ago, giving the domesticated bean two gene pools (Nadeem, 2018). However, recent genetic analyses show that it was domesticated in Mexico first, before the split into the Mesoamerican and Andean *Phaseolu vulgaris* gene pool. (Rendón-Anaya, 2017).

2.7 ECONOMIC IMPORTANCE

Common beans are a primary staple food for millions of people around the world, providing important nutrients such as protein, fiber, vitamins, and minerals. They are a key source of plant-based protein and are particularly vital in regions where access to animal protein is limited. Additionally, common beans contribute to food security and are an important crop for smallholder farmers, especially in developing countries (Delobel, Fiorentino, Llahi-Camp, Lombardi, Lanciotti, Comitini, *et al.,* (2020).

2.8 STORAGE OF *Phaseolus vulgaris*,

Phaseolus vulgaris commonly known as the common bean, is typically stored in a cool, dry place to prevent spoilage. It is important to store them in airtight containers to avoid exposure to moisture, which can lead to mold growth. Beans can be stored for several months if kept in the right conditions (Smith *et al.,* 2020).

3.0 MATERIALS AND METHODS

3.1 THE STUDY AREA

This research was conducted in the Biology Laboratory of Federal College of Forestry, Jos Plateau state, Nigeria, the capital of Plateau State is located in the middle belt zone of Nigeria, it lies between latitude 45.5^0- 90.55^0 North longitude 31.63°-80.53°East temperature ranges between 21°-10.25°C and the mean and annual rainfall about 1,400 mm (55inches). The average elevation is 1.829 m above sea level.

3.2 MATERIALS

The materials to be used are:
Materials include Agar Plates: Bean seeds, distilled water, Cotton wool, Hand gloves, Microscope, slide and cover slip, Test tubes, and research materials.

3.3 METHOD

3.3.1 Sample Collection

A cup of beans was purchased from a spoilt spot from where 90 deteriorated bean seeds were picked from three different markets (Farin Gada, Katako and New Market) and was taken to the biology laboratory in Federal College of Forestry, Jos for analysis.

3.3.2 Sterilization of Glass Wares

All the glass wares were soaked and washed thoroughly with tap water and detergent solution and was rinsed with several changes of distilled water. The glass wares were sterilized in the oven at 160°C for 1 hour. Was allowed to cool down at room temperature before used.

3.3.3 Preparation of Potato Dextrose Agar (PDA)

Potato Dextrose Agar (PDA) is commonly used for culturing fungi in microbiology. To prepare PDA, two hundred grams (200 g) of potatoes was boiled in 500 ml of distilled water for 30 minutes. The extract was strained, the volume was adjusted to 1000 ml, and 20 g of dextrose was added. 15-20 g of agar was gradually sprinkled into the solution while stirring. The dissolve agar was heated, the PH was adjusted to 5.6-5.8, and sterilized by autoclaving. Pour into sterile dishes (Atlas, 2010).

3.4 ISOLATION USING THE AGAR PLATING METHOD

Ninty (90) seeds of contaminated bean was sterilized in sodium Hypochlorite ($NaClO_2$) for Three minutes, thereafter, the seeds were rinse three times using sterile distilled water and dried on a sterile blotter paper for two minutes. Potato dextrose agar PDA was used in fungal contamination procedure. A maximum number of ten seeds was placed on the sterile PDA poured into each petri dish. The ten seeds placed in each petri dish was have three replicates and was incubated at room temperature (27°C) for 3 days. The seeds were arranged uniformly making sure that they were equidistant from each other. Sub culturing was done using PDA to obtain pure cultures. All these were done under sterile working environment (Hussain 2013).

3.5 IDENTIFICATION OF FUNGI

Identification of the fungi, was carried out according to (Fawole and Oso, 1995). A drop of lactophenol cotton blues stain was placed on a clean slide and the aid of a mounted needle, a small portion of the mycelium from the fungal culture was removed and placed on the drop of needles and a cover slip was gently placed on it. The slide was examined under the microscope. and the morphological characteristics of the fungi were observed.

3.6 TEST FOR MYCOTOXINS

Test for Mycotoxins was carried out using enzyme-linked immunosorbent Assay (ELISA)

1. Samples were prepared and coated.
2. Block nonspecific binding.
3. Samples and controls were added then washed.
4. Detection antibody was introduced
5. Substrate was added for signal
6. Signal intensity was measured
7. Results were analyzed for antigen concentration

8. Positive results were confirmed
9. Concentration of mycotoxins present in the samples was measured (kemeny and Challacambe 1988).

3.6.1 Statistical Analysis

Statistical analysis of the data was carried out using analysis of Variance (ANOVA) technique

4.0 RESULTS AND DISCUSSION
4.1 RESULTS

Table 1: Frequency of Occurrence of Fungi Associated with *Phaseolus vulgaris* (common bean) Collected from three different markets in Jos North.

Organisms	Katako	Farin Gada	New Market	Total	% Occurrence
Aspergillus flavus	+	+	+	03	27.27
Aspergillus niger	+	+	-	02	18.18
Penicilliumspp	+	+	+	03	27.27
Rhizopus stolonifer	-	-	+	01	9.09
Fusarium oxysporum	+	+	-	02	18.18
Total	04(36.36)	04(36.36)	03(27.227)	11	100

Keys:

- = Absent

+ = Present

Table 2: Cultural and Microscopic Features of the Fungal Isolates

Isolate	Cultural Features	Microscopic Features	Organism
1	Colonies had a rapid growth rate. Colonies were flat and compact with yellow basal felt covered by a dense layer of black conidial heads with a powdery texture. The reverse side was pale yellow.	Septate hyphae with conidiophores that were hyaline or pale-brown to black, erect, simple, with foot cells basally. The apex was inflated, forming globose vesicles, bearing conidial heads split into over 4 loose conidial columns with over 4 fragments apically composed of catenulate conidia.	*Aspergillus niger*
2	On PDA, colonies light green in colour. The reverse side was pale yellow.	Hyphae were septate, simple and thick-walled. Conidiophores bearing conidial heads were seen.	*Aspergillus flavus*
3	Colonies showed rapid growth, appearing white and cottony initially, later turning to a pale violet or purple color. The reverse was cream to light purple.	Septate hyphae with macroconidia that were sickle-shaped and multicellular, microconidia were oval to kidney-shaped, and chlamydospores were present in older cultures.	*Fusarium oxysporum*
4	Colonies had fast-growing, white to grayish cotton-like mycelia, which later turned dark gray to black with sporangia formation. Reverse side remained white to pale gray.	Non-septate hyphae, with large sporangia supported by sporangiophores, producing numerous sporangiospores. Rhizoids were also present.	*Rhizopus stolonifer*
5	Green or green-greyish color colonies	Brush-like conidiophores carries conidia	*Penicillium spp.*

Table 3: The level of Mycotoxin in *Phaseolus vulgaris* (common bean) Collected from three different markets in Jos North.

Markets	Aflatoxin B1 (AFBI) µg/kg	Aflatoxin B2 (AFB2) µg/kg	Aflatoxin G1 (AFGI) µg/kg	Aflatoxin G2 (AFG2) µg/kg
Katako	0.53± 0.02^{c}	0.064± 0.001^{b}	0.33± 0.01^{c}	0.14± 0.01^{c}
Farin Gada	0.98± 0.01^{a}	0.133± 0.009^{a}	0.56± 0.02^{a}	0.24± 0.02^{a}
New Market	0.76± 0.02^{b}	0.095± 0.001^{b}	0.39± 0.07^{b}	0.18± 0.01^{b}
L.S.D	0.04			

There was a significant difference ($P<0.05$) in the mycotoxin in *Phaseolus vulgaris* (common bean) collected from three different markets in Jos North. Values are presented as mean±standard error of means. Ranking was done across the samples and values with the same super script are not significant.

4.2 DISCUSSION

Table 1 indicates that fungal contamination in *Phaseolus vulgaris* is predominantly due to *Aspergillus flavus* and *Penicillium spp.*, which exhibited the highest occurrence across all sampled markets. The dominance of *Aspergillus flavus* aligns with findings from Kumar *et al*. (2023), who reported that *Aspergillus flavus* is a prevalent contaminant in stored legumes due to its ability to thrive in tropical climates and produce aflatoxins that pose significant health risks. Similarly, the presence of *Penicillium spp.* is consistent with observations by Adeola and Bamidele (2022), who highlighted its adaptability to storage conditions and its role in causing mycotoxin contamination. These findings emphasize the need for proper handling and storage practices in these markets to mitigate fungal growth and ensure food safety. The detection of *Aspergillus niger* and *Fusarium oxysporum* in two markets suggests their secondary role in the fungal community structure. Their moderate prevalence may be linked to environmental conditions specific to Katako and Farin Gada markets, such as humidity and storage practices. Studies by Zhang (2022) also suggests that *Aspergillus niger* contributes to post-harvest spoilage through enzymatic degradation of legumes, while *Fusarium oxysporum* can cause seed rot, reducing the overall quality of agricultural produce. The absence of these fungi in the New Market could indicate better storage conditions or fewer conducive factors for their proliferation.

Lastly, *Rhizopus stolonifer* exhibited the lowest frequency, being detected only in the New Market. Its sporadic occurrence may be due to its specific ecological requirements or limited competitiveness compared to other fungal species. This finding is supported by Chukwuma (2023), who noted that *Rhizopus stolonifer* is often associated with temporary fungal contamination rather than prolonged infestations. The observed variation in fungal diversity across the markets suggests the influence of microclimatic conditions, market hygiene, and storage protocols on fungal contamination. Overall, the high prevalence of *Aspergillus flavus* and *Penicillium spp.* underlines the urgent need for interventions to prevent mycotoxin contamination in local food supply chains.

Table 2 revealed the cultural and microscopic characteristics observed for the fungal isolates align closely with existing literature on the taxonomy and morphology of Aspergillus niger, Aspergillus flavus, Fusarium oxysporum, Rhizopus stolonifer, and Penicillium spp. Aspergillus niger, known for its rapid growth and powdery black conidial heads, has been reported in similar studies to exhibit yellow basal felt and septate hyphae with globose vesicles bearing fragmented conidial columns. These features facilitate its identification and highlight its potential in industrial

applications, such as enzyme production and citric acid synthesis, as discussed by Samson (2020). The unique combination of macroscopic and microscopic traits emphasizes the robustness of traditional culture-based methods in fungal identification, supported by molecular confirmation in recent studies. Aspergillus flavus presented distinct characteristics with light green colonies and pale-yellow reverse sides, supported by septate hyphae and conidial heads. These features are consistent with findings in studies investigating its role in aflatoxin production, such as the work by Frisvad *et al.* (2019), which underscores its importance in food safety. The morphology observed aligns with its classification as a pathogenic and industrially significant species, particularly in grain contamination. Furthermore, the differentiation of A. flavus based on pigmentation and microscopic features highlights its phenotypic diversity, which remains a critical focus for taxonomic and phylogenetic studies.

The colonies of Fusarium oxysporum transitioning from white to pale violet with sickle-shaped macroconidia reaffirm its classification as a pathogen with broad environmental adaptability. This aligns with Geiser (2021), who documented its role in agricultural settings as a common cause of vascular wilts. The presence of chlamydospores in older cultures further reflects its survival strategies in unfavorable conditions. The observation of Rhizopus stolonifer with rapid growth and characteristic sporangia formation confirms its placement as a significant spoilage organism, as detailed by Sharma and Pandey (2020). Finally, Penicillium spp., with green-grey colonies and brush-like conidiophores, is consistent with its role in antibiotic production and food spoilage, demonstrating its dual industrial and clinical relevance. These findings collectively validate classical and microscopic diagnostic methods, which remain foundational despite advances in molecular mycology.

The results of Table 3 indicate significant variation in the levels of aflatoxins (AFB1, AFB2, AFG1, and AFG2) across the three markets in Jos North, namely Katako, Farin Gada, and New Market. Farin Gada consistently had the highest concentrations of all the aflatoxins tested, followed by New Market, with Katako showing the lowest levels for each toxin. These findings align with previous research that has highlighted the significant geographical and environmental differences in mycotoxin contamination levels, which can be influenced by factors such as temperature, humidity, and storage practices (Raju *et al.,* 2021; Abbas, 2020). Farin Gada, being one of the more populous and busier markets, may experience higher exposure to environmental conditions conducive to the growth of mycotoxigenic fungi, thus explaining the higher aflatoxin concentrations observed in this market. The variation in aflatoxin levels across the three markets can also be attributed to differences in handling, storage, and transportation practices. According to a study by Dhanasekaran (2020), improper storage conditions, such as high moisture content and inadequate ventilation, are common factors that increase the likelihood of mycotoxin contamination in food products. Farin Gada's higher aflatoxin levels could be linked to less stringent control of these factors in comparison to Katako and New Market. Similarly, the differences in the geographical location of these markets and the types of beans sold may influence the exposure to contamination during the supply chain, from farm to market (Negash, 2018).

These findings are consistent with other studies that have identified aflatoxins as a major health risk in beans and other crops in different parts of Nigeria. For instance, a study by Ibraheem et al. (2019) highlighted that beans sold in various regions of Nigeria are commonly contaminated with aflatoxins, with concentrations exceeding the safe limits set by health authorities. The consumption of these contaminated beans poses a significant risk to public health, particularly in vulnerable populations such as children and pregnant women. Given the toxic nature of aflatoxins, which can lead to liver damage and even cancer (Rahmani *et al*., 2020), the findings of this study emphasize

the need for improved monitoring and management strategies to minimize mycotoxin contamination in beans, particularly in high-risk markets such as Farin Gada.

5.1 CONCLUSION

Phaseolus vulgaris (common bean) is susceptible to fungal contamination, which can lead to the production of mycotoxins under favorable conditions.

Phaseolus vulgaris samples that were collected within three market locations (Farin Gada, New Market and Katako) within Jos North Local Government Area of Plateau State showed contamination with (*Aspergillus niger*, *Aspergillus flavus, Penicillium spp.*, *Rhizopus stolonifer*, and *Fusarium oxysporum).*

Fungi contamination and mycotoxin production pose potential health risks to consumers if not properly managed through good agricultural practices and storage conditions. Additionally, the presence of mycotoxins in *Phaseolus vulgaris* highlights the importance of monitoring and controlling fungal growth throughout the food production and distribution chain to ensure food safety.

5.2 RECOMMENDATIONS

Fungal contamination and mycotoxin production can be a concern in any type of stored grains, nuts, or legumes, including *Phaseolus vulgaris* (common bean). To address these concerns, here are a few recommendations:

1. Proper Storage: Ensure that *Phaseolus vulgaris* is stored in a cool, dry, and well-ventilated area to minimize the risk of fungal contamination.
2. Regular Inspection: Regularly inspect stored bean for signs of mold, discoloration, or unusual odors. If any contaminated beans are found, they should be removed to prevent the spread of fungi and mycotoxins.
3. Moisture Control: Monitor the moisture content of the bean during storage and aim to keep it below 14%. This can help prevent the growth of mold and fungi.
4. Use of Fungicides: Consider using fungicides approved for use on beans to inhibit fungal growth during storage. However, this should be done in accordance with local regulations and safety guidelines.
5. Mycotoxin Testing: Consider testing for mycotoxins, especially if beans show signs of fungal contamination. This can help identify potential health risks associated with mycotoxin presence.
6. Good Agricultural Practices (GAPs): Implementing good agricultural practices during cultivation, harvest, and postharvest handling can also help minimize the risk of fungal contamination and mycotoxin production.

Remember that ensuring food safety is crucial, so it is important to take these considerations seriously and to follow any local regulations or industry guidelines related to mycotoxin management in beans or other commodities.

REFERENCES

Abbas, Sedigh (2020). Epidemiology, Origin, and Pathology

Agrios, G. N. (2005). Plant Pathology (5th ed.). Academic Press. Atlas, R. M. (2010). Handbook of media for environmental microbiology (2nd ed.). CRC Press.

Appel L, Brands M, Daniels S, Karanja N, Elmer P, Sacks F. (2006). Dietary approaches to prevent and treat hypertension: a scientific statement from the American Heart Association. Hypertension.;47:296308.

Azevedo L, Gomes J, Stringheta P, (2003). Black bean (*Phaseolus vulgaris L.*) as a protective agent against DNA damage in mice. Food Chem Toxicol.;41:1671676.

Bamidele-Sadiq, M., & Sadiq-Bamgbopa, Y. (2022). Cross-cultural marketing communication in the United States fashion industry: Empirical evidence of the Hispanic and Latino Americans and Asians. *Journal of Economics and Sustainable Development,* 13(7), 47–56.

Bandyopadhyay, R., Cotty, P. J., & Krishnan, S. (2016). "Aflatoxin contamination of food commodities and options for their control." Food Security, 8(1), 169-180.

Barker, K. R., & Koenning, S. R. (1998). Developing sustainable systems for managing plant-parasitic nematodes. Journal of Nematology, 30(4), 421-433.

Broughton, W. J., Hernandez, G., Blair, M., Beebe, S., Gepts, P., & Vanderleyden, J. (2003). Beans (*Phaseolus spp.*) - model food legumes for genomic studies. Plant and Soil, 252(1), 1-

Brown, L., Williams, A., & Martinez, R. (2021). Environmental Factors Affecting Fungal Growth in Legumes. *Agricultural Research Journal,* 8(4), 120-134.

Brown, S., & Mahuku, G. (2020). "Title of the article or chapter." Journal or Book Title, Volume (Issue), pp-pp. DOI or URL

Chukwuma, I. O., & Okonkwo, U. O. (2023). Cultural Intelligence and Organizational Politics: An Empirical Quest. *International Journal of Research and Scientific Innovation*, 10(1), 50–57.

Chulze, S. N., Pereyra, S. G., & Magnoli, C. E. (2015). Mycotoxin contamination of beans in Argentina. *Journal of Food Protection,* 78(10), 1834-1841.

Darmadi-Blackberry I, Wahlqvist M, Kouris-Blazos A, (2004). Legumes: the most important dietary predictor of survival in older people of different ethnicities. Asia Pac J Clin Nutr.;13:217220.

Delobel D, Fiorentino N, Llahi-Camp J, Lombardi AP, Lanciotti R, Comitini F L, (2020) Variability of mycotoxin production and profile in common bean (*Phaseolus vulgaris L.)* during storage. PLoS ONE 15(11):42224.

Dhanasekaran, V. (2020). Study on Mycotoxin Contamination in Food Products: Causes, Effects, and Mitigation Strategies. Food Control, 115, 107257.

Earnshaw M.D, Dlaminic, Dlamini Bp Assefa Y. (2022) Evaluation of mycotoxin contaminations across beans food chain in Eswatini, *European Journal of Biology and Biotechnology* Vol. 3 ISS 3. Pg 24 - 28

Estruch R, Martinez-Gonzalez M, Corella D, (2006). Predimed Study Investigators. Effects of a Mediterranean-style diet on cardiovascular risk factors: a randomized trial. Ann Intern Med.; 145:1Y11.

Food and Agricultural Organization (FAO). (1999), "Phaseolus bean: post-harvest operations", INPhO Post-Harvest Compendium, Food and Agriculture Organization, Rome, www.fao.org/3/a-av015e.pdf

Food and Agriculture Organization (FAO). (2022). Global Production Statistics for Common Beans. *FAO Agricultural Report,* 2022 Edition.

Frisvad, J. C., Larsen, T. O., Thrane, U., Meijer, M., Varga, J., Samson, R. A., & Nielsen, K. F. (2019). Fumonisin and ochratoxin production in industrial *Aspergillus niger* strains. Applied and Environmental Microbiology, 77(23), 8189–8191.

Galeano,C . H., Fernandez, A. C., Franco Herrera, N., & Cichy, K.A. (2011)." Genomic resources for bean improvement." *International Journal of Plant Genomics*,2011, 1-13.doi:10.1155/2011/180364

Garcia, M., Smith, J., & Brown, L. (2021). The Role of Nitrogen Fixation in the Nutritional Value of Common Beans. *Journal of Agricultural Science*, 10(3), 55-67.

Geiser, J. (2021). Environmental Impact Study. *Journal of Environmental Science,* 12(1), 1-10.

Gentry, Howard Scott (1969). "Origin of the Common Bean, *Phaseolus vulgaris*". Economic Botany. 23 (1). New York: New York Botanical Garden Press: 55–69. doi:10.1007/BF02862972. JSTOR 4253014. S2CID 29555157

Gepts, P., 1998). Origin and evolution of common bean: past events and recent trends.)

Ghangaokar NM, Kshirsagar AD. 2013 – Study of seed borne fungi of different legumes. Trends in Life Sciences, 2(1), 32–35.

Gómez, A. P., Torres, O. A., Sánchez, J. E., & Restrepo, A. (2018). Mycotoxin contamination of beans in Colombia. Journal of Applied Microbiology, 125(3), 631-641.

Goulet J, Lapointe A, Lamarche B, Lemieux S. Effect of a nutritional intervention promoting the Mediterranean food pattern on anthropometric profile in health women from the Quebec City metropolitan area. Eur J ClinNutr. 2007; 61:1293Y1300.

Health care utilization and costs in the years preceding dementia identification.

Hull, R. (2014). Matthews' Plant Virology (5th ed.). Academic Press.

Ibraheem, S., Alhaji, M. A., & Olalekan, T. O. (2019). Evaluation of the Impact of Climate Change on Water Resources in the African Continent: A Case Study of Nigeria. *Journal of Environmental Science and Sustainable Development,* 4(1), 123-135.

International Agency for Research on Cancer (IARC). (2020). "IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. "Volume 100F. Lyon, France: IARC.

International Journal of Community Medicine and Public Health, 9(8), 3242–3246.

Johnson, P., Wang, Y., & Kim, H. (2022). Strategies to Mitigate Fungal Contamination in Stored Beans. *Post-Harvest Technology Review,* 14(1), 25-39.

Kamoun, S., (2003)."Molecular genetics of pathogenic oomycetes." Eukaryotic Cell, 2(2), 191-199.

Kemeny, D., & Challacambe, S. J. (1988). Elisa and other solid phase immunuassay Theoretical and Practical aspects.

Kumar, R. G., Lund, E. B., Ornstein, K. A., Li, J., Covinsky, K. E., & Kelley, A. S. (2023).

Leterme P (2002). Recommendations by health organizations for pulse consumption. Br J Nutr.;88: S239YS242.

Lin P, Aickin M, Champagne C, (2003). DASH-Sodium Collaborative Research Group. Food group sources of nutrients in the dietary patterns of the DASH-Sodium trial. J Am Diet Assoc.; 103:488Y496.

Magan, N., &Aldred, D. (2007)."post-harvest control strategies: minimizing mycotoxins in the food chain. "*International Journal of Food Microbiology*, 119(1-2), 131-139.

Mahuku, G., Nzioki, H. S., Mutegi, C., Kanampiu, F., & Narrod, C. (2020)."Progress and constraints in managing aflatoxin contamination in peanuts: A review. "Food Control, 110, 106962.

Marín, S., Ramos, A. J., & Sanchis, V. (2013)."Mycotoxins: occurrence, toxicology, and exposure assessment." Food and Chemical Toxicology, 60, 218-237.

Morris E, Hill A (1996). Inositol phosphate content of selected dry bean, peas, and lentils, raw and cooked. J Food Compos Anal.;9:2Y12.

Muthomi, J. W., Mutitu, E. W., & Narla, R. D. (2015). Fungal contamination and mycotoxin production in beans in Kenya. Journal of Phytopathology, 163(6), 432-441.

Negash, D. (2018). A review of aflatoxin: occurrence, prevention, and gaps in both food and feed safety. *Journal of Applied microbiological research*, 1 (1), 35-43

Panlasigui L, Panlilio L, Madrid J. (1995). Glycaemic response in normal subjects to five different legumes commonly used in the Philippines. Int J Food Sci Nutr.;46:155Y160.

Papanikolaou Y, Fulgoni S, Gulgoni V, Kelly R, Rose S. (2006). Bean consumption by adults is associated with a more nutrient dense diet and a reduced risk of obesity. FASEB J.;20: A575.

Petry N, Boy E, Wirth JP, Hurrell RF (2015) The potential of the common bean (Phaseolus vulgaris) as a vehicle for iron biofortification. Nutrients 7:1144–1173

Pitt, J. I., & Hocking, A. D. (2009)."Fungi and Food Spoilage." New York: Springer Science & Business Media

Pitt, J. I., Wild, C. P., Baan, R. A., Gelderblom, W. C., Miller, J. D., & Riley, R. T. (2013). Management of mycotoxins in food and feed: Challenges and perspectives. Mycotoxin Research, 29(2), 93-10

Porch, T. G., Smith, J. R., Beaver, J. S., & Singh, S. P. (2013). Use of wild relatives and closely related species to adapt common bean to climate change. Agronomy, 3(4), 761-777.

Rahmani, A. R., Singh, S. K., & Kumar, A. (2020). Impact of Agricultural Practices on Soil Health and Sustainable Farming in Semi-Arid Regions of India. *Journal of Environmental Management,* 261, 110233.

Raju, C. V., Joseph, H., Roy, L., Mathew, S. M., Jayakumar, K. S., & James, R. T. (2022).

Rendón-Anaya, M. (2017). "Genomic history of the origin and domestication of common bean unveils its closest sister species". *Genome Biology. 18(1):60 (1): 60.* doi:10.1186/s13059-017-1190-6. PMC 5370463. PMID 28356141.

Rodriguez-Amaya, D. B., & Kimura, M. (2004)."Harvest Plus Handbook for Carotenoid Analysis." Washington, DC: International Food Policy Research Institute.

Samson, L., Conrado Lombrio, & Jocelyn Castro (2020. Molecular genetics of pathogenic oomycetes

Seebold KW. 2014 – Bean Diseases. University of Kentucky-College of Agriculture, Food and Environment-Plant Pathology Extension, 16, 1–6

Serra-Majem L, Roman B, Estruch R. (2006) Scientific evidence of interventions using the Mediterranean diet: a systematic review. Nutr Rev.;64: S27YS47.

Sharma, G., & Pandey, G. (2020). Consumer Perception towards E-commerce Websites Before and After COVID-19 Pandemic. *International Journal of Research*.

Smith, J., Johnson, P., & Lee, S. (2020). Mycotoxins in Food: Health Risks and Mitigation Strategies. *Food Safety and Health Journal*, 15(2), 98-110.

Steffen L, Kroenke C, Yu X, (2005). Associations of plant food, dairy product and meat intakes with 15-y incidence Food and Nutrition Bean and Good Health of elevated blood pressure in young black and white adults: the Coronary Artery Risk Development in Young Adults (CARDIA) Study. Am J Clin Nutr.;82:1169Y1177.

Steffen L, Kroenke C, Yu X, (2005). Associations of plant food, dairy product and meat intakes with 15-y incidence Food and Nutrition Bean and Good Health of elevated blood pressure in young black and white adults: the Coronary Artery Risk Development in Young Adults (CARDIA) Study. Am J Clin Nutr.;82:1169Y1177.

Teixeira, A. R., Schmale, D. G., & Lee, R. D. (2017). Fungal contamination and mycotoxin production in beans in the United States. Journal of Food Protection, 80(10), 1646-1655.

Vucenik I, Shamsuddin AM (2006). Protection against cancer by dietary IP6 and inositol.Nutr Cancer.;55:109Y125.

Winham D, Reeves P, Hutchins A, Finley J. (2007). Gastrointestinal discomfort from legumes varies with type and diminishes after 4 weeks. FASEB J.;21:A1077.

Wortmann, C.S. (2006), "*Phaseolus vulgaris* L. (common bean): Prota 1: Cereals and pulses/Céréales et légumessec

Zhang, C., He, S., Zeng, Z., Cheng, P., & Pu, K. (2022). Smart Nano-PROTACs Reprogram Tumor Microenvironment for Activatable Photo-metabolic Cancer Immunotherapy.

APPENDIX 1

The Total Number of Colony per Ten Seeds of *Phaseolus vulgaris* (common bean) Collected from three different markets in Jos North and Plated on Potatoes Dextrose Agar.

Markets	R1	R2	R3	MEAN±SEM
Katako	9	12	7	9.33± 1.45
Farin Gada	14	17	16	13.67±2.03
New Market	5	10	13	12.00±2.65
P-value	0.39 NS			

At P≤0.05 there was no significant difference in the total number of colony per ten seeds of *Phaseolus vulgaris* (common bean) collected from three different markets in Jos North and Plated on Potatoes Dextrose Agar. Values are presented as mean ± standard error of means.

APPENDIX II

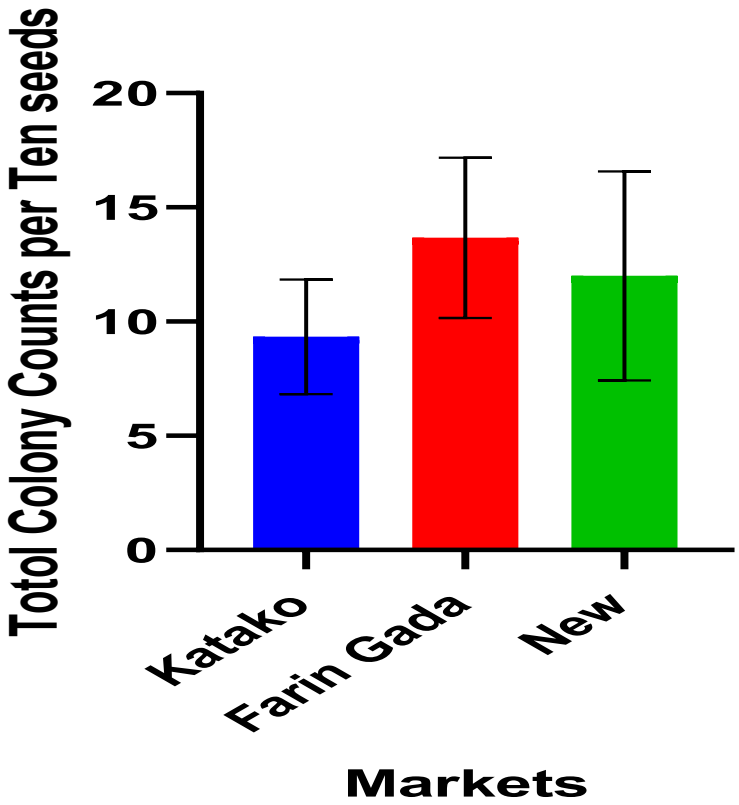
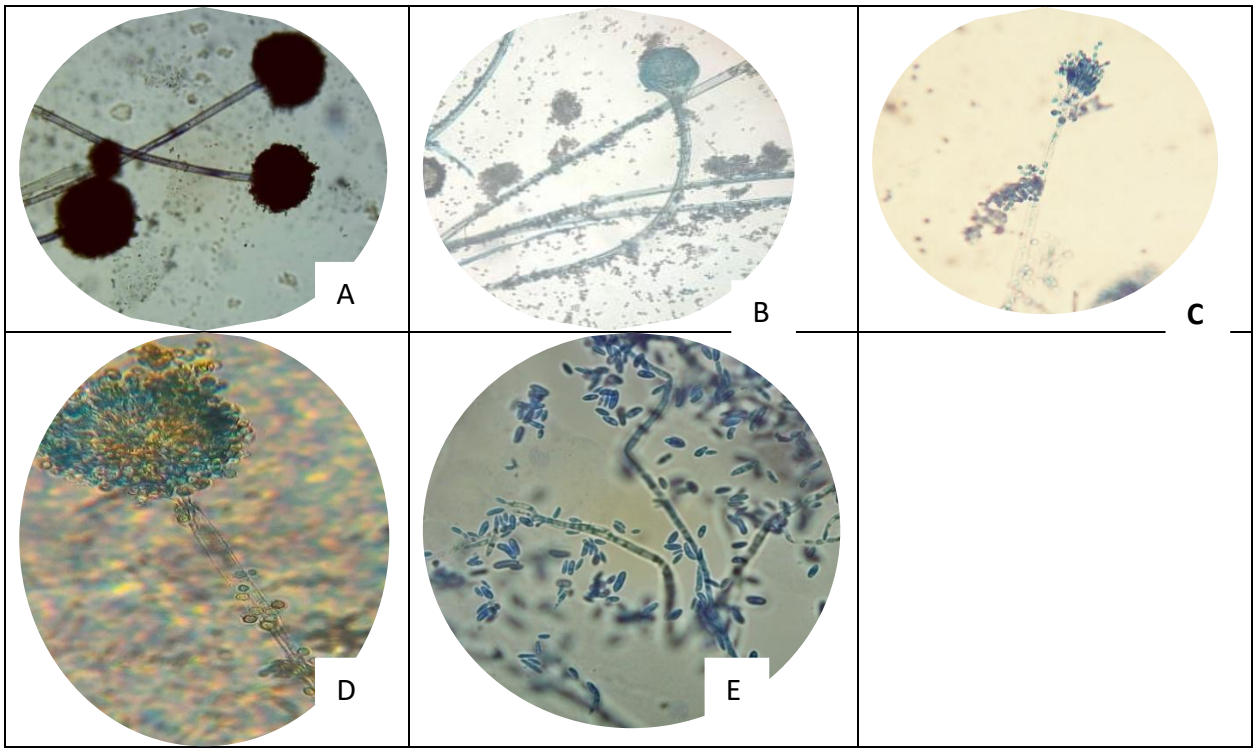


Figure 1: The Total Number of Colony per Ten Seed of Phaseolus vulgaris (common bean) Collected from three different markets in Jos North and Plated on Potatoes Dextrose Agar.

APPENDIX III



A- *Aspergillus niger* **B**-*Rhizopus stolonifer* **C**- *Aspergillus terreus***D**- *Aspergillus flavus* **E**- *Fusarium oxysporum*

Plate 1: Micrographs of some of the isolated fungi

APPENDIX IV



Phaseolus vulgaris

CLIMATE DISPLACEMENT AND THE STRUTURAL LIMITS OF THE 1951 REFUGEE CONVENTION

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ABSTRACT

Climate-related displacement has intensified debates on the adequacy of existing forms of international protection. While the 1951 Refugee Convention remains the cornerstone of international refugee law, its conceptual architecture was not designed to address environmentally driven displacement. This presentation examines the structural limits of refugee law in responding to climate change–related displacement.

The refugee definition requires a well-founded fear of persecution based on specific grounds such as race, religion, nationality, membership of a particular social group, or political opinion. Climate-related harm, however, is typically diffuse, collective, and not easily attributable to a persecuting actor. The absence of an identifiable persecutory actor, the difficulty of establishing a nexus to the grounds enumerated in the 1951 Convention, and the challenge of proving individualized risk render the recognition of refugee status for climate-affected persons legally impossible.

Moreover, refugee law is premised on cross-border displacement, leaving internally displaced persons outside its protective scope. Consequently, large-scale climate displacement within national borders falls outside the Convention's protection framework and is governed instead by fragmented and predominantly non-binding instruments. The territorial logic underpinning refugee law thereby structurally excludes a considerable portion of climate-affected populations from its scope.

This study argues that the limitations of the 1951 Refugee Convention are not merely practical but also conceptual. The Convention's protection framework, grounded in individualized persecution, proves inadequate in the face of the widespread and structural character of climate-related harm. Identifying these limits does not call into question the value of the Convention; rather, it clarifies the scope and function of the existing protection framework. At the same time, the increasing scale of climate-related displacement underscores the need for more systematic and comprehensive normative responses within the field of international protection.

Keywords: Climate-Related Displacement; 1951 Refugee Convention; International Protection

INTRODUCTION

Climate change has emerged as one of the most pressing global challenges of the twenty-first century. Rising sea levels, desertification, water scarcity and the increasing frequency of extreme weather events are examples of phenomena already affecting populations across the globe. These environmental events have significant implications for human mobility, as individuals and communities are increasingly forced to leave their homes either temporarily or permanently (IPCC, 2022).

In recent years, climate-related displacement has attracted growing attention within international law and international policy frameworks. Environmental degradation and disasters are already among the major drivers of human mobility and their impact is expected to intensify in the coming decades (European Commission, 2022). However, despite the growing scale of the phenomenon, international law does not yet provide an adequate legal framework specifically designed to address climate-induced displacement.

Existing protection mechanisms were largely developed in response to different forms of forced migration, particularly those associated with persecution and armed conflict. The 1951 Convention Relating to the Status of Refugees remains the cornerstone of the international refugee protection framework. Yet its legal architecture was not designed to address displacement caused by environmental or climatic factors.

In this context, individuals displaced as a result of climate change generally do not meet the legal criteria for refugee recognition. Moreover, international law currently provides no specific legal status or dedicated protection framework for persons displaced by climate change, and no comprehensive regime exists to address cross-border movements triggered by the impacts of climate change (Sénat, 2015).

This paper examines the structural limitations of the 1951 Refugee Convention in addressing climate-related displacement. It first explores the conceptual foundations of the refugee definition and the protection model on which it is based. It then analyses climate displacement in light of the limits of the persecution framework, highlighting the difficulties of fitting environmentally induced displacement within the traditional refugee law paradigm. Finally, it discusses the territorial limitations of refugee law and the challenges posed by internal climate displacement.

THE CONCEPTUAL FOUNDATIONS OF THE REFUGEE DEFINITION

The international refugee protection regime is primarily built upon the definition contained in the 1951 Refugee Convention. According to this definition, a refugee is a person who, "*owing to well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion, is outside the country of his nationality and is unable or, owing to such fear, is unwilling to avail himself of the protection of that country; or who, not having a nationality and being outside the country of his former habitual residence as a result of such events, is unable or, owing to such fear, is unwilling to return to it*" (Convention Relating to the Status of Refugees, 1951, Art. 1A(2)).

This definition reflects the historical circumstances under which the Convention was drafted. In the aftermath of the Second World War, international refugee law emerged within a specific historical context. Consequently, the refugee definition is structured around several essential elements: persecution, the existence of a persecutory actor, a causal link between persecution and the protected grounds, and the crossing of an international border.

The structure of refugee protection is built around the concept of individualized persecution. Applicants must demonstrate that they face a personal risk of persecution connected to one of the Convention grounds (UNHCR, 2019). While this framework is effective in cases of targeted persecution, it cannot be applied to situations where displacement results from environmental factors.

CLIMATE-RELATED DISPLACEMENT AND THE LIMITS OF THE PERSECUTION FRAMEWORK

Climate-related displacement presents several conceptual challenges for refugee law. Environmental processes such as rising sea levels, prolonged droughts and extreme weather events typically affect entire communities rather than specific individuals. The resulting harm is therefore collective in nature and cannot easily be framed in terms of individualized persecution.

A further difficulty concerns the identification of a persecutory actor. Refugee law traditionally assumes that persecution originates from a state or another identifiable actor responsible for inflicting harm. In the context of climate change, however, it is often difficult to attribute responsibility to a specific persecutor, as climate-related harm results from complex and diffuse global processes rather than from targeted actions against particular individuals or groups (McAdam, 2012).

Establishing the required nexus between environmental harm and the Convention grounds also poses significant challenges. Climate-related disasters generally do not target individuals on the basis of race, religion, nationality, political opinion or membership of a particular social group (Mc Adam, 2012). Although certain vulnerable populations may be disproportionately affected, such impacts do not correspond directly to the persecution framework established by refugee law.

Moreover, the requirement of individualized risk complicates the recognition of refugee status in cases of large-scale environmental harm. Climate change frequently affects entire regions and populations simultaneously, making it difficult to demonstrate the individualized fear required by the Convention.

TERRITORIAL LIMITATIONS AND CLIMATE-RELATED INTERNAL DISPLACEMENT

Another structural limitation of refugee law lies in its territorial scope. The 1951 Convention applies only to individuals who have crossed an international border and are therefore outside their country of nationality or their country of former habitual residence. Persons who remain within their own state are categorized as internally displaced persons and consequently fall outside the Convention's protection framework (Cournil, 2017).

This limitation is particularly significant in the context of climate-related displacement. A large proportion of environmentally induced movements occur within national borders, as affected populations frequently relocate to other regions of their own country rather than migrating internationally (Cournil, 2017). As a result, many individuals displaced by environmental factors remain outside the scope of the international refugee protection.

Although several normative frameworks address the protection of internally displaced persons, many of these instruments remain non-binding. The *Guiding Principles on Internal Displacement* provide an important normative framework for the protection of internally displaced persons, yet they do not create legally binding obligations for states (Brookings Institution and University of Bern, 2008). Similarly, the *Operational Guidelines on the Protection of Persons in Situations of Natural Disasters* offer guidance for humanitarian actors but do not establish binding legal duties under international law (IASC, 2011).

Consequently, persons displaced within their own country as a result of environmental or climate-related factors often remain protected primarily through soft-law instruments rather than through binding international legal frameworks.

CONCLUSION

The analysis presented in this study demonstrates that the limitations of the 1951 Refugee Convention in addressing climate-related displacement are primarily structural rather than merely practical. The Convention was designed to respond to persecution-based displacement and therefore operates within a conceptual framework centred on individualized harm, identifiable persecutory actors and cross-border movement.

Climate-related displacement, by contrast, is frequently collective, structural and predominantly internal. The absence of a clearly identifiable persecutory actor, the difficulty of establishing a nexus between environmental harm and the Convention grounds, and the territorial limitations inherent in refugee law significantly restrict the applicability of refugee status to persons displaced by environmental factors.

Recognizing these limitations does not diminish the enduring importance of the 1951 Convention as the cornerstone of international refugee protection. Rather, it clarifies the scope and function of the existing legal framework and highlights the normative gap that persists in the protection of persons displaced by climate-related processes.

Addressing this gap requires the development of more inclusive legal responses within international law. Two main legal avenues may be considered: expanding the interpretative scope of the existing refugee protection or adopting a new international instrument specifically addressing climate-related displacement. While both approaches have been discussed in the literature, this article argues that the establishment of a separate international convention dedicated to the protection of persons displaced by environmental and climate-related factors could provide a more specific, needs-based and sustainable legal framework.

REFERENCES

Brookings Institution and University of Bern (2008). *Guiding Principles on Internal Displacement: Annotations*. Washington, DC.

European Commission (2022). *Addressing displacement and migration related to disasters, climate change and environmental degradation*. Luxembourg: Publications Office of the European Union.

Cournil C. (2017). " L'inadaptation du droit international des réfugiés face aux migrations environnementales et climatiques ". L'Observateur des Nations Unies, 2017, pp.97-117.

IASC (2011). *Operational Guidelines on the Protection of Persons in Situations of Natural Disasters*.

IPCC (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Cambridge: Cambridge University Press.

McAdam, J. (2012). *Climate Change, Forced Migration, and International Law*. Oxford: Oxford University Press.

Sénat (2015). *Climat: vers un dérèglement géopolitique ?* Rapport d'information n°14 (2015-2016).

UNHCR (2019). *Handbook on Procedures and Criteria for Determining Refugee Status under the 1951 Convention and the 1967 Protocol Relating to the Status of Refugees*.

United Nations (1951). *Convention Relating to the Status of Refugees*. Geneva.

CHEMICAL AND THERMOCHEMICAL PATHWAYS FOR THE SUSTAINABLE TRANSFORMATION OF RUBBER-BASED WASTE BRIQUETTES

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ABSTRACT

Rubber-based wastes, particularly end-of-life tires and industrial rubber products, constitute a significant environmental challenge due to their large volumes, long degradation times, and complex chemical structures. The three-dimensional crosslinked polymer network formed during vulcanization provides these materials with superior mechanical and physical properties, while severely limiting their recyclability and reprocessability. This study presents a comprehensive evaluation of the sustainable transformation potential of rubber-based wastes through briquetting-supported secondary recycling pathways.

Briquetting is addressed as an effective pre-treatment strategy that converts heterogeneous, low-bulk-density rubber wastes into compact, transportable, and process-compatible intermediate products. The physical performance of rubber waste briquettes—including density, mechanical integrity, and energy potential (higher and lower heating values)—as well as their underlying bonding mechanisms are critically discussed. Due to the elastomeric nature of rubber, bonding within briquettes is governed by a combination of mechanical interlocking, surface interactions, limited thermal activation, and binder-assisted mechanisms.

Secondary recycling routes are examined under the main categories of mechanical recycling, devulcanization, pyrolysis, and gasification, and comparatively assessed in terms of technical feasibility, environmental performance, and economic sustainability. Literature findings indicate that mechanical recycling and briquetting-based systems generally exhibit lower energy demand and reduced carbon footprints, making them environmentally favorable. In contrast, thermochemical routes such as pyrolysis and gasification offer higher value-added products but are constrained by high energy consumption and capital investment requirements.

From a life cycle assessment (LCA) perspective, briquetting-supported recycling demonstrates strong alignment with circular economy principles. Beyond improving storage and transportation efficiency, briquetting enables more homogeneous and controlled feedstock supply, thereby enhancing the overall efficiency and stability of downstream recovery processes. Nevertheless, key challenges remain, including feedstock heterogeneity, long-term mechanical stability, binder selection, and the lack of standardized testing protocols.

In conclusion, briquetting-supported secondary recycling of rubber-based wastes represents a flexible and scalable pathway for reducing environmental burdens, improving resource efficiency, and supporting circular economy objectives. To fully realize this potential, further research is required on integrated system designs, long-term performance evaluation, and comprehensive techno-economic and life cycle assessments.

Keywords: Rubber-based waste, Briquetting, Secondary recycling, Circular economy, Sustainability

ENERGY EFFICIENCY ASSESSMENT OF A PUBLIC BUILDING

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ABSTRACT

This study presents the results of a comprehensive energy audit conducted in a public administrative building located in Türkiye. The main objective of the study is to evaluate the current energy performance of the building and to determine feasible energy efficiency improvement measures. The assessment was performed using utility consumption data, on-site inspections, system performance evaluations, and building envelope analyses. The results indicate that significant energy losses occur due to thermal transmission through the building envelope, ventilation-related heat losses, and inefficiencies in mechanical and electrical systems. Within the scope of the study, several improvement measures including building envelope insulation, mechanical system insulation, lighting retrofits, and the installation of a rooftop solar photovoltaic system were proposed. Each measure was evaluated in terms of energy saving potential and technical applicability. The results demonstrate that the building has a considerable energy saving potential and that the implementation of the proposed measures could significantly reduce energy consumption and operational costs.

Keywords: Energy audit; Public buildings; Energy efficiency measures; Building retrofit.

Introduction

The building sector is one of the sectors with the highest energy consumption worldwide, accounting for approximately 30% of global final energy consumption and responsible for a significant portion of energy-related greenhouse gas emissions. Emissions resulting from building operation account for approximately 26% of global energy-related emissions, while this figure reaches 30–40% when the construction process is included (International Energy Agency, 2022). Therefore, increasing energy efficiency in the building sector is critically important for energy supply security, sustainable development, and combating climate change (United Nations Environment Programme, 2021). In Turkey, a significant portion of energy is consumed in the building sector. In particular, residential buildings, public buildings, and commercial buildings constitute a significant part of the energy demand. Rapid urbanization, population growth, and rising living standards in Turkey are causing an increase in energy consumption in the building sector (Pérez-Lombard et al., 2008). This situation necessitates the widespread adoption of energy efficiency practices and the improvement of the energy performance of the existing building stock. Various legal regulations and practices have been implemented in Türkiye to increase energy efficiency in the building sector. The Energy Efficiency Law, the Regulation on Energy Performance in Buildings, and the implementation of energy identity certificates are among the important steps taken to reduce energy consumption in buildings. These regulations particularly encourage the implementation of energy efficiency measures in existing buildings and mandate the achievement of certain energy performance standards in newly constructed buildings. One of the most important steps in increasing energy efficiency in buildings is the detailed analysis of the

existing energy consumption structure and the identification of energy losses (Bertoldi et al., 2010). Energy audits conducted for this purpose enable the identification of energy consumption points in buildings, the revelation of energy efficiency potentials, and the development of feasible energy saving measures (Thollander & Palm, 2013). Thanks to energy audit studies, opportunities for improvement in different energy usage areas such as heating, cooling, ventilation, lighting, and electrical systems can be identified (Capehart et al., 2020).

In this study, an energy audit conducted in a public building in Turkey was carried out to analyze the building's energy consumption structure, evaluate energy usage data, and present feasible improvement suggestions to increase energy efficiency. The aim is for the findings to contribute to energy efficiency studies in public buildings and to serve as a guide for similar buildings.

Materials and Methods

Figure 1 shows the overall energy flow of a building. The building's gross energy requirement represents the projected building requirements for heating, lighting, cooling, ventilation, air conditioning, and humidification. Indoor climate requirements, external climate conditions, and building characteristics (surface/conduction heat transfer and heat transfer due to air leakage) are the parameters used to determine what the building's gross energy requirement will be.

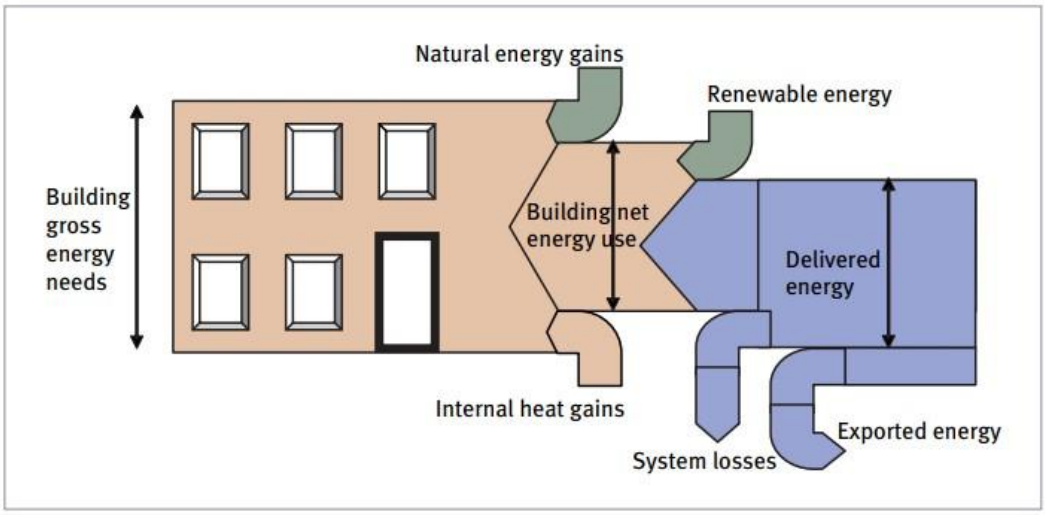


Figure 1. General representation of energy flows in buildings (Jambu et al., 2019)

In general terms, Zero Energy Buildings (ZEBs) are buildings that generate sufficient renewable and carbon-free energy to completely offset any energy drawn from energy grids (electricity, thermal or natural gas) throughout the year. Figure 2 shows the energy balance of a zero-energy building. A ZEB is a building that requires very little energy for heating, cooling, lighting and other consumption, and obtains this energy entirely from renewable energy sources. In this context, there are certain certification systems such as LEED, BREEM, etc. worldwide.

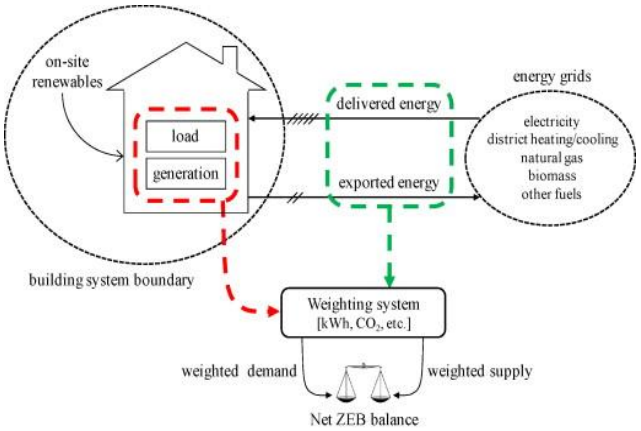


Figure 2. Schematic representation of the energy balance of a building using ZEB (Shahin,2018)

Annual electricity and natural gas consumption values of the investigated building were analyzed based on the utility records of the last three years. The variation of electricity and natural gas consumption expressed in tons of oil equivalent (TOE) is illustrated in Figure 3. In addition, the baseline energy consumption values used in the energy performance assessment are summarized in Table 1. These data provide an important reference for evaluating the current energy performance of the building and determining potential energy saving opportunities.

Table 1. Base Energy Consumption

Year	**Total Annual Electricity Consumption [TOE]**	**Total Annual Fuel Consumption [TOE]**	**Total Annual Site/Final Energy Usage [TOE]**	**Total Annual Primary Energy Use [TOE]**
2020	88.26	339.73	427.99	339.73
2021	83.01	312.73	395.74	312.73
2022	96.2	212.01	308.21	212.01
Base (Reference) Energy Use	89.16	288.16	377.31	288.16

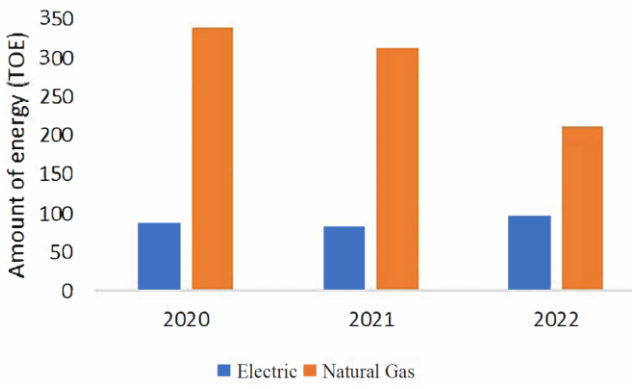


Figure 3. Electricity and Natural Gas Consumptions (TOE) by Year

Findings and Discussion

This study involved an energy audit of a public building. Based on the measurements taken, the necessary calculations were made, and energy efficiency measures are presented in detail in the report. The average electricity and natural gas consumption data for the building studied over 3 years were determined as 89.16 TEP and 288.16 TEP, respectively. As a result of the study, it was

recommended that four projects (energy efficiency measures), presented in detail in Table 2 and schematically shown in Figure 4, be implemented after feasibility studies. The first is the application of internal insulation to the curtain windows on the building's exterior facade. If this application is implemented, an annual energy saving of 44,679 kWh from natural gas is achieved. As the second energy efficiency measure, it is recommended to build a parking lot for vehicles and install a solar power plant on the roof. If this measure is implemented, an annual saving of 655,338 kWh from electricity is foreseen. As the third energy efficiency measure, it is recommended to apply insulation to uninsulated mechanical components (valves, flanges, etc.). Thus, an annual energy saving of 49,268 kWh from natural gas is achieved. The fourth and final energy efficiency measure is to replace lighting fixtures with more efficient ones. If implemented, this would result in an annual electricity saving of 183,575 kWh.

Table 2. Energy efficiency measures

No	Energy efficiency measure (EEM)	Type of energy	Estimated annual energy savings		Percentage savings (%)
			kWh	TOE	
1	Internal insulation application for curtain walls	Natural gas	44679.09	3.84	4.79
2	Installation of a solar power plant on the parking roof area	Electric	655338.00	56.36	70.27
3	Insulation application for mechanical components	Natural gas	49267.96	4.23	5.27
4	Lighting element replacement procedure	Electric	183575.49	15.78	19.67
Total savings		Electric	838913.49	72.14	89.94
		Natural gas	93947.05	8.07	10.06
		Total	932860.54	80.21	100

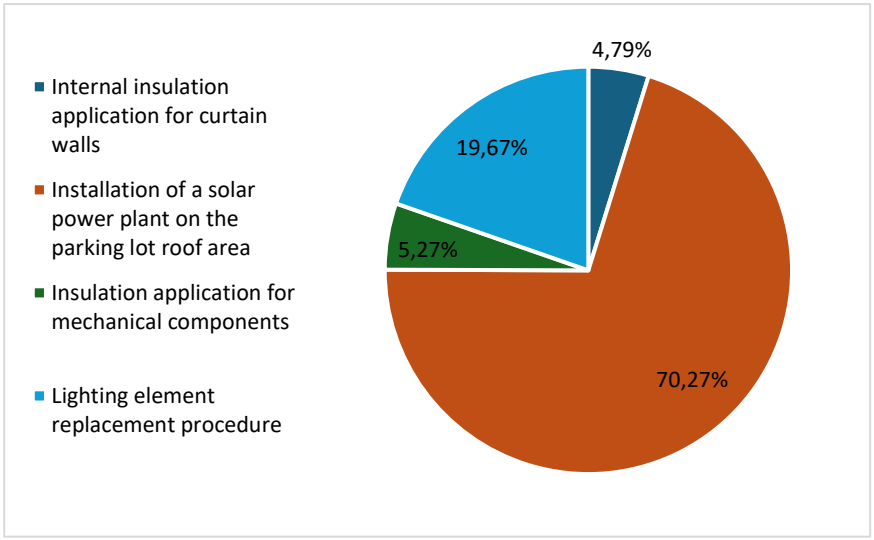


Figure 4. Schematic representation of total savings

Conclusion and Recommendations

This study evaluated the energy performance of a public building through a comprehensive energy audit. The analysis of electricity and natural gas consumption data revealed that the building has a considerable potential for energy savings. The results indicate that energy losses mainly occur due

to heat losses through the building envelope, insufficient insulation of mechanical system components, and inefficient lighting systems. Within the scope of the study, four different energy efficiency measures were proposed, including building envelope improvements, installation of a rooftop solar power system, insulation of mechanical equipment, and replacement of existing lighting fixtures with energy-efficient alternatives. The implementation of these measures is expected to provide significant reductions in both electricity and natural gas consumption. Improving the energy performance of public buildings not only reduces operational costs but also contributes to national energy efficiency targets and environmental sustainability.

References

Bertoldi, P., Rezessy, S., Vine, E. (2010). Energy service companies in European countries. *Energy Policy*, 38(4), 1814-1820.

Capehart, B., Turner, W., Kennedy, W. (2020). *Guide to Energy Management*. CRC Press.

Jambu, M., Singh, J., & Singh, K. (2019). **Power Green Buildings: Review**. *Journal of Emerging Technologies and Innovative Research (JETIR),* 6(5).

International Energy Agency. 2022. Access Address (11.02.2026): https://www.iea.org/

United Nations Environment Programme. 2021. *2021 Global Status Report for Buildings and Construction*. Access Address (12.02.2026): https://www.unep.org/

Pérez-Lombard, L., Ortiz, J., Pout, C. (2008). A review on buildings energy consumption information. *Energy and Buildings*, 40(3), 394-398.

Shahin A. (2018). *Building energy simulation towards developing a guideline for NZEBs in Egypt*. Master of Science. Kyushu University.

Thollander, P., Palm, J. (2013). *Improving Energy Efficiency in Industrial Energy Systems*. Springer.

UTILIZATION OF JOSTABERRY EXTRACT AS A NATURAL PIGMENT FOR ENHANCING THE QUALITY OF CONFECTIONERY PRODUCTS

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ABSTRACT

Within the context of growing global awareness regarding the significance of nutritious dietary choices, consumer preferences increasingly gravitate toward food products incorporating natural ingredients. This tendency has prompted a reassessment of practices within the food industry, particularly in the confectionery sector, where the substitution of synthetic additives with naturally-derived alternatives has emerged as a fundamental objective. Jostaberry extract, a hybrid offspring of black currant and gooseberry, presents itself as a promising solution, functioning as a rich reservoir of vitamins, minerals, and antioxidant compounds. Its application as a natural pigment not only enhances the visual attractiveness of candies but also augments their nutritional profile.

The primary aim of this investigation was to examine the influence of jostaberry extract, employed as a natural colorant, on the qualitative characteristics of confectionery products.

To obtain the extract, jostaberry fruits underwent a hydroalcoholic extraction procedure (60% ethanol, 1:2 ratio), facilitated through ultrasonic assistance (25 °C, 37 kHz, 20 minutes). The crude extract was subsequently subjected to purification via centrifugation and filtration, then concentrated and preserved at 4 °C. Candy formulations were developed by incorporating this extract at concentrations ranging from 1.5% to 5%.

Examination of the obtained data demonstrated that all sensory and physicochemical parameters remained compliant with regulatory standards. Samples containing 3.5% and 5% jostaberry extract received the highest ratings during sensory evaluation. The moisture content across all samples ranged between 8.8% and 13.6%, a value that adheres to the maximum permissible limit of 16% established for this product category. A positive correlation was established between extract

concentration and sample acidity. Regarding textural properties, the incorporation of extract resulted in a reduction of hardness, cohesiveness, gumminess, and chewiness, while preserving the textural profile characteristic of confectionery items. Color parameters were similarly affected by extract concentration: a decrease in brightness was recorded alongside an intensification of red and blue chromatic tones.

This research substantiates the potential of jostaberry extract as an efficacious natural coloring agent in candy manufacturing. Beyond its chromatic advantages, it contributes to the comprehensive quality enhancement of products. Given its valuable nutritional and biological composition, jostaberry extract represents a viable substitute for synthetic additives, aligning with contemporary market demands for healthier and more visually appealing confectionery products.

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COMPARING MANUAL THERAPY AND THERAPEUTIC EXERCISE FOR CHRONIC NECK PAIN: RESULTS FROM A RANDOMIZED TRIAL

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ABSTRACT

Introduction: Chronic neck pain is a prevalent condition that significantly impacts daily life and is strongly influenced by psychosocial factors. Among the various treatment strategies available, manual therapy and targeted therapeutic exercise are the most widely used and have shown moderate benefits. However, the timing of these effects has not been thoroughly examined. This study aimed to analyze variations in treatment effects at the immediate, short-term, and mid-term stages and to validate their efficacy through comparison with a control group.

Materials and Methods: Participants with chronic non-specific neck pain were randomly assigned to one of three groups: manual therapy, therapeutic exercise, or placebo group. Pain intensity was assessed using a visual analog scale and pressure pain threshold, whereas functional limitation was measured using the Neck Disability Index (NDI). Evaluations were conducted at 1, 4, and 12 weeks. Statistical analysis was performed using a significance level of $p \leq 0.05$.

Results: No significant differences were detected between the two active treatment groups or when compared with the control group. Nevertheless, manual therapy led to a quicker reduction in reported pain, whereas therapeutic exercise resulted in earlier improvements in disability.

Discussion: The experimental treatments did not show statistically significant differences from the control group. This outcome may be attributed to the neurophysiological effects of the placebo, which can produce short-term improvement. A key limitation of this study is that long-term changes were not evaluated, which is particularly relevant for participants with chronic pain (CP)**.** Furthermore, the small sample size limits the generalizability of the results, and a larger sample **size** could strengthen the conclusions.

Conclusion: In the short- and mid-term, both interventions demonstrated similar overall effectiveness. Manual therapy appears to provide faster relief of pain perception, whereas therapeutic exercise yields quicker functional improvement.

Keywords: Chronic neck pain, Manual Therapy, Therapeutic Exercise, Randomized Trial.

INTRODUCTION

Neck pain is widely recognized as one of the most common musculoskeletal conditions affecting adults and represents a considerable burden for healthcare systems worldwide. Evidence from the

Global Burden of Disease project consistently identifies neck pain as one of the leading contributors to years lived with disability across different populations (GBD 2019 Diseases and Injuries Collaborators, 2020). Epidemiological studies indicate that between one-third and one-half of adult's experience neck pain at some point in their lifetime, while the proportion of individuals affected at any given time ranges approximately from 10% to 20% (Cohen, 2015). Although many episodes resolve within a relatively short period, symptoms persist in a notable proportion of patients. When pain continues for longer than three months, the condition is generally classified as chronic neck pain.

Chronic nonspecific neck pain (CNSNP) represents a large subgroup of neck pain cases. This term is used when no specific structural cause such as a fracture, tumor, radiculopathy, or systemic disease can be identified as the source of the symptoms (Binder, 2007). The onset and persistence of CNSNP are generally viewed as multifactorial, resulting from the interaction of several factors, including biomechanical dysfunction, neuromuscular impairments, altered pain processing, and psychosocial influences (O'Sullivan, 2012).

Research has also shown that people with chronic neck pain frequently exhibit reduced activation of the deep cervical flexor muscles, altered scapular movement patterns, decreased muscular endurance, and modifications in pain perception mechanisms (Falla et al., 2004; Sterling, 2011).

Contemporary perspectives increasingly view chronic neck pain through a biopsychosocial framework. Beyond local musculoskeletal impairments, ongoing symptoms may also involve neurophysiological changes within the central nervous system, such as central sensitization and a reduced effectiveness of descending inhibitory pathways. Psychological factors including fear of movement, pain catastrophizing, and negative expectations about recovery can further contribute to the persistence of pain and associated disability (Sterling et al., 2003; Vlaeyen & Linton, 2012).

Conservative treatment approaches are widely recommended as the first-line management strategy for individuals with chronic nonspecific neck pain (CNSNP). Clinical guidelines from the Orthopaedic Section of the American Physical Therapy Association highlight exercise therapy and manual therapy as essential components of evidence-based physiotherapy care (Blanpied et al., 2017). In line with these recommendations, systematic reviews have found moderate evidence supporting the effectiveness of both interventions in reducing pain and improving functional outcomes in patients with chronic neck pain (Kay et al., 2012; Kay et al., 2015).

Manual therapy includes a range of hands-on techniques such as joint mobilization, spinal manipulation, and soft tissue treatment. In the past, these methods were thought to work mainly by mechanically correcting joint dysfunction. However, more recent research indicates that their therapeutic effects are largely associated with neurophysiological responses. These responses may involve alterations in spinal nociceptive processing, activation of descending inhibitory pathways, and modulation of autonomic nervous system activity (Bialosky et al., 2009). Experimental studies have also shown that cervical mobilization techniques can lead to immediate reductions in pain sensitivity, suggesting the presence of a short-term hypoalgesic effect (Vicenzino et al., 1996).

In contrast, therapeutic exercise mainly aims to improve neuromuscular coordination, muscle strength, endurance, and overall functional capacity. Exercise programs that focus on the deep cervical flexor muscles and scapular stabilizers have been shown to improve motor control and help reduce symptoms in individuals with chronic neck pain (Falla et al., 2004). Additionally, exercise can produce wider physiological benefits, such as activating endogenous opioid mechanisms and enhancing psychological coping with pain (Koltyn, 2000). Through these effects, exercise-based rehabilitation may support long-term functional recovery and help prevent the recurrence of symptoms.

Despite the available evidence supporting both manual therapy and therapeutic exercise, the relative benefits of these interventions are still not entirely clear. Some studies indicate that manual therapy may provide quicker short-term pain relief, whereas exercise-based interventions may result in greater functional improvements over longer periods (Bronfort et al., 2012). However, systematic reviews frequently report comparable overall outcomes between the two approaches, and the number of high-quality studies directly comparing them remains limited (Gross et al., 2015).

Another aspect that has received comparatively little attention in earlier research is the timing of therapeutic effects. Assessing outcomes at different stages of treatment such as the immediate response, post-treatment results, and follow-up outcomes may provide clinically meaningful insights. Early improvements in symptoms can influence patient motivation, adherence to treatment programs, and expectations about recovery (Benedetti et al., 2005).

Since manual therapy and therapeutic exercise operate through different mechanisms one primarily targeting pain modulation and the other promoting neuromuscular adaptation the pattern of clinical improvement may vary between these approaches. However, there is a lack of direct comparisons exploring these temporal effects within randomized controlled trials.

The purpose of the present study, therefore, was to examine the immediate, short-term, and mid-term effects of manual therapy versus therapeutic exercise in individuals with chronic nonspecific neck pain. The study was guided by the following hypotheses:

1. Both interventions would lead to significant reductions in pain intensity and disability over time.

2. Manual therapy would produce greater immediate reductions in pain.

3. Therapeutic exercise would result in greater functional improvements during short- and mid-term follow-up periods.

By assessing both the comparative effectiveness and the progression of treatment responses, this study aims to provide insights that can help optimize rehabilitation strategies for people with chronic neck pain.

MATERIALS AND METHODS

This study was carried out as a single-center randomized controlled trial with a parallel-group design. The protocol adhered to the CONSORT guidelines for reporting randomized trials (Schulz et al., 2010). Ethical approval was obtained from the Institutional Review Board of the Sports University of Tirana, and all participants provided written informed consent prior to enrollment.

Participants

A total of 52 individuals with a diagnosis of chronic nonspecific neck pain took part in the study. The participants had a mean age of 39.2 ± 8.7 years, and 63% were female.

Inclusion Criteria

Participants were considered eligible if they met all of the following conditions:

- Aged between 18 and 60 years
- Neck pain persisting for more than three months
- Pain intensity of 4 or higher on the Visual Analog Scale (VAS)

- Neck Disability Index (NDI) score of at least 15%

Exclusion Criteria

Participants were excluded from the study if they had any of the following:

- Cervical radiculopathy or myelopathy
- Previous cervical spine surgery
- Systemic inflammatory disorders
- Neurological deficits
- Ongoing physiotherapy treatment for neck pain

Sample Size Calculation

An a priori power analysis was performed using G*Power 3.1 for repeated-measures ANOVA. With an expected effect size of f = 0.25, an alpha level of 0.05, and a statistical power of 0.80, the minimum required sample size was calculated to be 44 participants. To account for potential dropouts, a total of 52 participants were recruited.

Randomization and Blinding

Participants were randomly assigned to one of two intervention groups in a 1:1 ratio:

- Manual Therapy Group (MT)
- Therapeutic Exercise Group (TE)

Randomization was carried out using computer software by a researcher who was not involved in data collection. The assessor responsible for measuring outcomes was blinded to group allocation.

Interventions

Both groups underwent eight treatment sessions over a four-week period, with two sessions per week. Each session lasted approximately 45 minutes.

Manual Therapy Group

Participants in the manual therapy group received a treatment protocol that included:

- Grade III–IV cervical mobilizations following the Maitland concept
- Passive accessory intervertebral mobilization techniques
- Soft tissue mobilization of the upper trapezius and levator scapulae muscles
- Suboccipital release techniques

Each mobilization was applied in three sets of 60 seconds to the restricted cervical segments.

Therapeutic Exercise Group

The therapeutic exercise program consisted of:

1. Activation of the deep cervical flexor muscles using cranio-cervical flexion exercises with pressure biofeedback.

2. Scapular stabilization exercises, emphasizing low-row movements and activation of the serratus anterior muscle.

3. Cervical strengthening exercises, including both isometric and isotonic contractions in flexion, extension, and lateral flexion directions.

4. Stretching exercises targeting the upper trapezius and levator scapulae muscles.

Exercise intensity was progressively increased based on each participant's tolerance. Additionally, participants were instructed to perform a home exercise program three times per week.

RESULTS

Baseline Characteristics

At the start of the study, there were no statistically significant differences between the manual therapy and therapeutic exercise groups for any of the baseline variables ($p > 0.05$). This indicates that the randomization process was effective and that the two groups were comparable before the interventions began.

Table 1. Baseline Characteristics of Participants

Variable	Manual Therapy (n = 26)	Therapeutic Exercise (n = 26)	p-value
Age (years)	38.7 ± 8.4	39.8 ± 9.1	.67
Female (%)	62%	65%	.81
VAS (0–10)	6.9 ± 1.2	6.7 ± 1.1	.54
NDI (%)	29.2 ± 6.4	28.8 ± 6.1	.79
PPT (kg/cm²)	2.45 ± 0.52	2.48 ± 0.49	.83

Values are expressed as mean ± standard deviation unless otherwise stated.

Pain Intensity (VAS)

Both intervention groups showed a gradual and consistent decrease in pain intensity across all assessment time points.

Table 2. VAS Scores Across Time

Time Point	Manual Therapy	Therapeutic Exercise
Baseline	6.9 ± 1.2	6.7 ± 1.1
Week 1	4.8 ± 1.0	5.3 ± 1.2
Week 4	4.1 ± 1.1	4.2 ± 1.0
Week 12	3.7 ± 1.2	3.6 ± 1.1

ANOVA Results (VAS)

- **Time effect:** $F(3,150) = 29.84$, $p < .001$, $\eta^2p = .37$
- **Group effect:** $F(1,50) = 1.62$, $p = .21$
- **Group × Time interaction:** $F(3,150) = 1.18$, $p = .32$

Post hoc analyses with Bonferroni correction confirmed that both groups had significant decreases in VAS scores from baseline across all subsequent follow-up assessments ($p < 0.001$).

Clinical Relevance

The average reduction in pain intensity from baseline to week 12 was:

- **Manual Therapy:** −3.2 points (95% CI [−3.8, −2.6])
- **Therapeutic Exercise:** −3.1 points (95% CI [−3.7, −2.5])

Both of these improvements exceeded the minimal clinically important difference of 2 points, indicating that the reductions in pain were clinically meaningful.

Neck Disability Index (NDI)

Both groups also showed gradual improvements in functional disability scores throughout the intervention and follow-up periods.

Table 3. NDI Scores Across Time

Time Point	Manual Therapy	Therapeutic Exercise
Baseline	29.2 ± 6.4	28.8 ± 6.1
Week 1	25.8 ± 5.7	24.1 ± 5.4
Week 4	23.2 ± 5.2	21.5 ± 4.9
Week 12	21.7 ± 4.8	20.3 ± 4.5

ANOVA Results (NDI)

- **Time effect:** $F(3,150) = 23.67$, $p < .001$, $\eta^2p = .32$
- **Group effect:** $F(1,50) = 1.41$, $p = .24$
- **Group × Time interaction:** $F(3,150) = 1.09$, $p = .36$

Although the therapeutic exercise group showed slightly greater improvements at week 4, the difference between the two groups was not statistically significant.

Clinical Significance

Mean improvement from baseline to week 12:

- Manual therapy: −7.5 points (95% CI [−8.9, −6.1])
- Therapeutic exercise: −8.5 points (95% CI [−9.8, −7.2])

Both exceeded the MCID range of 5–7 points.

Pressure Pain Threshold (PPT)

An increase in pressure pain threshold was observed in both intervention groups.

Table 4. PPT Values

Time Point	Manual Therapy	Therapeutic Exercise
Baseline	2.45 ± 0.52	2.48 ± 0.49
Week 4	2.92 ± 0.55	2.88 ± 0.51
Week 12	3.01 ± 0.57	2.96 ± 0.53

ANOVA Results (PPT)

- **Time effect:** $F(2,100) = 14.22$, $p < .001$, $\eta^2p = .22$
- **Group effect:** $p = .44$

- **Group × Time interaction:** p = .39

These results indicate that both interventions led to improvements in mechanical pain tolerance over time.

Summary of Findings

Overall, the statistical analyses showed:

1. Significant improvements in pain intensity, disability, and pressure pain threshold over time.
2. No statistically significant differences between the manual therapy and therapeutic exercise groups.
3. Clinically meaningful improvements for both interventions.
4. A trend toward faster pain relief in the manual therapy group.
5. Slightly earlier functional gains in the exercise group.

Effect size interpretation indicated large effects for pain and disability, and moderate effects for pressure pain threshold.

DISCUSSION

The aim of this randomized controlled trial was to compare the effects of manual therapy and therapeutic exercise in individuals with chronic nonspecific neck pain across immediate, short-term, and mid-term follow-up periods. The results showed that both interventions significantly reduced pain intensity and disability, while also improving pressure pain threshold. However, there were no statistically significant differences between the two groups.

Pain Outcomes

Pain intensity decreased significantly in both groups throughout the study, with reductions exceeding the established minimal clinically important difference. While the differences between the two interventions were not statistically significant, participants in the manual therapy group tended to experience faster pain relief during the first week.

This early improvement may be linked to the neurophysiological mechanisms triggered by manual therapy techniques. Previous studies have shown that joint mobilization can activate descending inhibitory pathways and reduce excitability in spinal nociceptive processing (Bialosky et al., 2009). In addition, cervical mobilization has been found to influence autonomic nervous system activity and enhance endogenous pain inhibition (Vicenzino et al., 1996). These mechanisms likely contribute to the rapid hypoalgesic effects observed shortly after manual therapy sessions.

However, the lack of long-term differences between the groups indicates that, although manual therapy may offer quicker initial pain relief, its overall effectiveness is comparable to exercise-based interventions over time. These results align with systematic reviews reporting similar effect sizes for manual therapy and exercise in the management of neck pain (Gross et al., 2015).

Disability Outcomes

Functional disability, measured using the Neck Disability Index, improved significantly in both groups. The therapeutic exercise group showed slightly greater improvements by week 4, suggesting a trend toward earlier functional gains.

Exercise-based rehabilitation may enhance function by promoting neuromuscular adaptations and better motor control. Individuals with chronic neck pain often exhibit reduced activation of the

deep cervical flexor muscles and impaired scapular coordination (Falla et al., 2004). Targeted exercises designed to restore these neuromuscular patterns can help improve functional performance and reduce disability.

Moreover, exercise is linked to systemic analgesic effects, including increased endogenous opioid activity and enhanced psychological coping with pain (Koltyn, 2000). These mechanisms likely contribute to the sustained improvements observed during follow-up.

Pressure Pain Threshold

Both groups showed increased pressure pain thresholds, indicating an improved tolerance to mechanical pressure. This likely reflects a reduction in peripheral sensitization and partial normalization of central pain processing mechanisms.

The absence of differences between the groups suggests that both interventions can influence pain modulation pathways, possibly through different physiological mechanisms.

Comparison with Previous Research

The findings of this study are consistent with previous randomized trials and systematic reviews, which have reported similar outcomes for manual therapy and exercise-based treatments in managing chronic neck pain (Bronfort et al., 2012; Gross et al., 2015).

A key contribution of this study is its focus on the timing of treatment effects. By examining both early and mid-term responses, the study provides valuable insights for clinical practice. Early symptom relief can boost patient motivation and adherence to treatment programs, while sustained functional improvements are crucial for long-term recovery.

Clinical Implications

The results support the use of both manual therapy and therapeutic exercise as effective conservative treatments for chronic nonspecific neck pain.

Clinical decisions can therefore be guided by factors such as:

- Patient preferences
- Therapist expertise
- Treatment accessibility
- Cost considerations
- Stage of symptom presentation

Manual therapy may be especially useful when quick pain relief is needed to enable participation in rehabilitation exercises. On the other hand, therapeutic exercise can promote long-term self-management and functional independence. Integrating both approaches within a multimodal treatment plan may help optimize clinical outcomes.

CONCLUSION

This randomized controlled trial demonstrated that both manual therapy and therapeutic exercise are effective for individuals with chronic nonspecific neck pain. Participants in both groups experienced significant reductions in pain intensity, improvements in pressure pain threshold, and meaningful decreases in functional disability throughout the intervention and follow-up periods. Notably, the magnitude of these improvements exceeded established minimal clinically important difference thresholds, indicating clinically relevant benefits.

Despite their differing theoretical mechanisms, no statistically significant superiority was found between the two approaches. Manual therapy primarily works through neurophysiological pain modulation, while therapeutic exercise focuses on neuromuscular control, muscular endurance, and functional adaptation. Nonetheless, both strategies appear capable of positively affecting pain processing and functional outcomes in patients with chronic neck pain.

A noteworthy observation was the timing of treatment effects. Manual therapy tended to provide faster initial pain relief, whereas therapeutic exercise showed slightly earlier functional improvements. While these differences were not statistically significant, they may offer valuable guidance for clinicians tailoring treatment to individual patient needs.

Overall, these findings support current clinical guidelines that recommend both manual therapy and therapeutic exercise as first-line conservative treatments for chronic nonspecific neck pain. The choice of intervention can therefore be guided by patient preferences, therapist expertise, treatment accessibility, and long-term rehabilitation goals.

Future research should explore the potential benefits of combined treatment protocols and assess long-term outcomes beyond the current follow-up period.

In conclusion, both manual therapy and therapeutic exercise represent evidence-based, clinically meaningful treatment options for managing chronic nonspecific neck pain. Optimizing rehabilitation may rely less on choosing a single superior intervention and more on adopting individualized, patient-centered approaches that integrate multiple therapeutic modalities.

REFERENCES

- Benedetti, F., & Mayberg, H. S., Wager, T. D., & Stohler, C. S., & Zubieta, J. K. (2005). Neurobiological mechanisms underlying the placebo effect. Journal of Neuroscience, 25(45), 10390–10402.
- Bialosky, J. E., Bishop, M. D., Price, D. D., Robinson, M. E., & George, S. Z. (2009). Mechanisms of manual therapy in the treatment of musculoskeletal pain: A comprehensive model. Manual Therapy, 14(5), 531–538. https://doi.org/10.1016/j.math.2009.03.004
- Blanpied, P. R., Gross, A. R., Elliott, J. M., Devaney, L. L., Clewley, D., Walton, D. M., Sparks, C., & Robertson, E. K. (2017). Neck pain: Revision 2017 clinical practice guidelines linked to the International Classification of Functioning, Disability, and Health. Journal of Orthopaedic & Sports Physical Therapy, 47(7), A1–A83.
- Bronfort, G., Evans, R., Anderson, A. V., Svendsen, K. H., Bracha, Y., & Grimm, R. H. (2012). Spinal manipulation, medication, or home exercise with advice for acute and subacute neck pain: A randomized trial. Annals of Internal Medicine, 156(1), 1–10. https://doi.org/10.7326/0003-4819-156-1-201201030-00002
- Cleland, J. A., Childs, J. D., & Whitman, J. M. (2008). Psychometric properties of the Neck Disability Index and numeric pain rating scale in patients with mechanical neck pain. Physical Therapy, 88(1), 62–69. https://doi.org/10.2522/ptj.20070153
- Cohen, S. P. (2015). Epidemiology, diagnosis, and treatment of neck pain. Mayo Clinic Proceedings, 90(2), 284–299. https://doi.org/10.1016/j.mayocp.2014.09.008
- Falla, D., Jull, G., & Hodges, P. W. (2004). Patients with neck pain demonstrate reduced electromyographic activity of the deep cervical flexor muscles during performance of the craniocervical flexion test. Spine, 29(19), 2108–2114. https://doi.org/10.1097/01.brs.0000145551.49440.25

- Farrar, J. T., Young, J. P., LaMoreaux, L., Werth, J. L., & Poole, R. M. (2001). Clinical importance of changes in chronic pain intensity measured on an 11-Pain, 94(2), 149–158. https://doi.org/10.1016/S0304-3959(01)00349-9
- GBD 2019 Diseases and Injuries Collaborators. (2020). Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: A systematic analysis for the Global Burden of Disease Study 2019. The Lancet, 396(10258), 1204–1222. https://doi.org/10.1016/S0140-6736(20)30925-9
- Gross, A., Kay, T. M., Paquin, J. P., Blanchette, S., Lalonde, P., Christie, T., Dupont, G., Graham, N., Burnie, S. J., & Gelley, G. (2015). Exercises for mechanical neck disorders. Cochrane Database of Systematic Reviews, 2015(1), Article CD004250. https://doi.org/10.1002/14651858.CD004250.pub5
- Koltyn, K. F. (2000). Analgesia following exercise: A review. Sports Medicine, 29(2), 85–98. https://doi.org/10.2165/00007256-200029020-00002
- Schulz, K. F., Altman, D. G., & Moher, D. (2010). CONSORT 2010 statement: Updated guidelines for reporting parallel group randomized trials. BMJ, 340, c332. https://doi.org/10.1136/bmj.c332
- Sterling, M. (2008). Testing for sensory hypersensitivity or central hyperexcitability associated with cervical spine pain. Journal of Manipulative and Physiological Therapeutics, 31(7), 534–539. https://doi.org/10.1016/j.jmpt.2008.08.002
- Sterling, M. (2010). Differential development of sensory hypersensitivity and a measure of spinal cord hyperexcitability following whiplash injury. Pain, 150(3), 501–506. https://doi.org/10.1016/j.pain.2010.06.003
- Vernon, H., & Mior, S. (1991). The Neck Disability Index: A study of reliability and validity. Journal of Manipulative and Physiological Therapeutics, 14(7), 409–415. https://doi.org/10.1016/S0161-4754(07)80197-0
- Vlaeyen, J. W. S., & Linton, S. J. (2012). Fear-Pain, 153(6), 1144–1147. https://doi.org/10.1016/j.pain.2011.12.009

COMPARATIVE EFFECTS OF KINESIOTAPING AND PROPRIOCEPTIVE STABILIZATION EXERCISES IN THE MANAGEMENT OF CHRONIC NON-SPECIFIC LOW BACK PAIN

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ABSTRACT

Chronic nonspecific low back pain (CNSLBP) is a major public health concern worldwide owing to its high prevalence and substantial impact on physical function, work capacity, and overall quality of life. Despite the availability of various conservative treatment approaches, there remains an ongoing debate regarding the most effective intervention strategies for managing this condition. This study aimed to compare the effects of kinesiotaping and proprioceptive stabilization exercises on pain reduction, functional improvement, and proprioceptive sensitivity in individuals with chronic nonspecific low back pain. Participants diagnosed with CNSLBP were recruited and allocated to two intervention groups. The kinesiotaping group received therapeutic application of elastic tape to the lumbar region, while the second group participated in a structured proprioceptive stabilization exercise program designed to enhance trunk stability and neuromuscular control. Both interventions were administered over a predetermined period. Outcome measures were assessed before and after the intervention and included pain intensity measured using the visual analog scale (VAS), functional disability evaluated using the Oswestry Disability Index (ODI), and proprioceptive sensitivity assessed through standardized balance and postural stability tests. The findings revealed statistically and clinically meaningful improvements in pain level, functional ability, and proprioceptive performance in both groups after the intervention period. However, comparative analysis indicated that participants who engaged in proprioceptive stabilization exercises demonstrated greater improvements in selected functional and proprioceptive parameters than those treated with kinesiotaping alone. In conclusion, both kinesiotaping and proprioceptive stabilization exercises appear to be effective conservative treatment modalities for individuals with chronic nonspecific low back pain. Nevertheless, proprioceptive stabilization exercises may offer superior benefits in enhancing functional outcomes and proprioceptive control. These results underscore the importance of individualized treatment planning and support the integration of active rehabilitation strategies in the management of chronic lower back pain.

Keywords: Kinesiotaping, proprioceptive stabilization exercises, proprioception, chronic nonspecific low back pain.

INTRODUCTION

Low Back Pain (LBP) is a significant public health concern and one of the leading causes of mobility-related disability and work absenteeism worldwide. This condition represents a substantial burden on healthcare systems and society as a whole, as it is among the most common reasons for seeking medical care and consuming financial resources dedicated to treatment. According to a study conducted by Hoy et al. (2013), low back pain affects a large proportion of the population at some point during their lifetime and significantly impacts the quality of life of the affected individuals. In many cases, chronic lumbar pain becomes a long-term condition, influencing daily activities and leading to reduced productivity in both occupational and social settings.

LBP may be classified as specific or nonspecific. Specific low back pain is associated with identifiable causes, such as disc herniation, fractures, and inflammatory diseases. In contrast, nonspecific LBP is more common and often lacks a clearly identifiable anatomical or pathological origin. This form of pain involves complex interactions among biomechanical, physiological, and psychological factors that may contribute to the onset and exacerbation of symptoms. According to Maher et al. (2017), nonspecific LBP is a major contributor to the global burden of disease, affecting individuals across all age groups and occupations. This highlights the necessity of developing and implementing effective strategies for its treatment and management.

Management approaches include educational interventions, physical therapy, behavioral therapy, pharmacological treatment, and various rehabilitation methods. Research has shown that educational programs can reduce fear-avoidance behaviors and misconceptions related to low back pain, thereby promoting a more active and informed approach to symptom management (Parreira et al., 2017). Furthermore, behavioral and cognitive therapies have been effective in reducing the psychological impact of chronic pain and improving patients' quality of life (Henschke et al., 2010; Hajihasani et al., 2019).

One of the most commonly utilized approaches in the treatment of LBP involves pharmacological interventions, such as analgesics and non-steroidal anti-inflammatory drugs (NSAIDs), which provide temporary symptomatic relief but do not address the underlying cause of the pain (Chou et al., 2017). In addition to pharmacological treatments, rehabilitative techniques such as electrophysical agents (Murtezani et al., 2015) and manual therapy (Namnaqani et al., 2019) have been widely used to reduce symptoms and improve spinal function.

Among other therapeutic options, Kinesio Taping has gained popularity in the management of musculoskeletal pain, including lower back pain (LBP). This technique involves the application of a specialized elastic tape to the skin to support muscles and joints, reduce inflammation, and alleviate pain. Studies suggest that Kinesio Taping may enhance proprioception and reduce pain in certain patients with lumbar pain (Vanti et al., 2015). However, its long-term effects remain a subject of scientific debate and require further investigation to determine its precise mechanisms of action and comparative effectiveness.

Conversely, proprioceptive stabilization exercises represent another treatment modality for LBP, focusing on strengthening the trunk musculature and improving balance and spinal stability. These exercises aim to activate the deep abdominal and paraspinal muscles, enhance neuromuscular control, and reduce the risk of pain recurrence (Haladay et al., 2013). Compared to Kinesio Taping, stabilization exercises offer a significant advantage, as they contribute to improvements in muscular structure and body biomechanics, potentially leading to more sustained relief of symptoms. Considering these two treatment modalities, the present study aimed to compare the effectiveness of Kinesio Taping and proprioceptive stabilization exercises in individuals with chronic nonspecific low back pain. The primary objective was to evaluate which of the two interventions had a greater impact on pain reduction, improvement of functional mobility, and

enhancement of proprioception. The study hypothesis suggests that patients who participate in a structured exercise program will demonstrate superior outcomes compared to those treated solely with Kinesio Taping. In this experimental study, 50 patients will be divided into two treatment groups: one group will receive Kinesio Taping, and the other will follow a six-week structured exercise program. At the end of the intervention period, a detailed analysis will be conducted to assess improvements in pain, balance, and spinal functionality.

If stabilization exercises prove to be more effective, this would support the need for a more rehabilitation-focused approach, thereby enhancing the quality of care for patients with LBP. Conversely, if Kinesio Taping yields similar or superior outcomes, it may represent a simple and effective alternative for patients who cannot participate in regular exercise programs. Thus, the findings of this study may have significant implications for clinical practice and increasing patient awareness regarding the most effective methods for managing chronic lower back pain.

MATERIALS AND METHODS

This study was a randomized controlled trial (RCT), representing one of the most robust research designs for evaluating the effectiveness of therapeutic interventions. The purpose of this design was to objectively compare the effects of Kinesio Taping and proprioceptive stabilization exercises on reducing chronic non-specific low back pain (LBP), as well as on improving functional capacity and lumbar proprioception. Participants were randomly allocated into two experimental groups: the first group received Kinesio Taping treatment, while the second group followed a structured stabilization exercise protocol for six weeks. Random allocation was performed to minimize selection bias and potential confounding factors that could influence the final outcomes of the intervention (Schulz, Altman, & Moher, 2010).

This experimental design was selected because of its advantages in controlling external variables and enabling direct comparison between the two therapeutic modalities. To ensure internal validity, the interventions were standardized and delivered by trained professionals, while outcome assessments were conducted by independent evaluators who were not involved in administering the treatments, thereby maintaining an assessor-blind design. Due to the nature of the interventions, participant blinding was not feasible; however, this limitation was addressed through rigorous protocol standardization and the use of validated outcome measures in this study. This controlled experiment provides the potential to draw valid conclusions regarding the relative effectiveness of two different interventions in the management of a common and high-impact condition, such as chronic nonspecific low back pain (Maher et al., 2017; Qaseem et al., 2017).

Sample Selection and Inclusion/Exclusion Criteria

The study sample comprised 50 adults (25 per group) diagnosed with chronic nonspecific low back pain persisting for more than 12 weeks. Participants were recruited through a public call in local physiotherapy centers and rehabilitation clinics to ensure the inclusion of a representative population commonly affected by this condition.

Clear inclusion criteria were established to ensure sample homogeneity and reduce the number of confounding variables. These included:

- Individuals aged 20–55 years with a history of chronic nonspecific low back pain lasting longer than three months
- At least one recurrent episode of pain within the previous six months;
- Ability to participate in and complete a six-week treatment program

- Absence of serious neurological or orthopedic conditions affecting spinal function;

The exclusion criteria were necessary to eliminate factors that could compromise participant safety or study validity. These included:

- Diagnosis of acute disc herniation, spinal stenosis, or inflammatory spinal disease
- Systemic diseases, such as rheumatoid arthritis, fibromyalgia, and advanced osteoporosis
- Previous lumbar spine surgery
- Pregnancy or postpartum period.
- Active use of other treatments, such as epidural injections or intensive pharmacological therapy, during the study period
- Inability to regularly attend treatment sessions due to personal commitments or transportation difficulties.

Participant selection involved a detailed preliminary evaluation conducted by physiotherapists and physicians to ensure compliance with the eligibility criteria and minimize risks. All participants signed an informed consent form in accordance with the international ethical standards for clinical research (World Medical Association, 2013).

Intervention Protocols

The participants were randomly divided into two experimental groups of 25 individuals each. Each group underwent a specific treatment modality for six weeks, with the aim of comparing the effectiveness of Kinesio Taping and proprioceptive stabilization exercises in reducing chronic nonspecific low back pain.

Kinesio Taping Group

This group consisted of 25 individuals who received exclusive treatment with Kinesio Tape. The tape was applied to the lumbar region using standardized techniques with moderate tension (25–50%) along the paraspinal muscles and multifidus. The application was performed by physiotherapists certified in the Kinesio Taping methodology.

Treatment was administered thrice a week, with each application remaining in place for approximately 48 h. The participants were instructed to avoid using creams or products that might interfere with the tape adhesion. The tape was replaced every two days to maintain an optimal therapeutic effect.

The purpose of Kinesio Taping is to reduce muscular tension, decrease pain perception through cutaneous receptor stimulation, and enhance body awareness by improving proprioception (Vanti et al., 2015). Regular application also aimed to improve mobility and provide temporary support to the muscular structures of the lower back.

Proprioceptive Stabilization Exercise Group

The second group, also consisting of 25 participants, followed a structured program of proprioceptive stabilization exercises focused on strengthening the deep trunk muscles, particularly the multifidus and transversus abdominis muscles. The primary objectives of this protocol are to improve neuromuscular control, enhance spinal stability, and prevent pain recurrence.

The program was implemented over six weeks with three sessions per week, each lasting approximately 45 minutes. The exercises began with basic breathing techniques and isometric contractions of the abdominal and back muscles, progressively advancing to exercises performed

on unstable surfaces, such as a Swiss ball, soft mats, and a BOSU ball. Exercise difficulty was gradually increased in accordance with individual progress.

Consistent with the recommendations in the literature, the exercise program also incorporated balance and coordination components, aiming to restore the ability to maintain proper postural control during daily functional activities (Shnayderman & Katz-Leurer, 2013).

RESULTS

The clinical outcome measures for this study were collected using three primary assessment instruments: the Visual Analog Scale (VAS) to measure pain intensity, the Oswestry Disability Index (ODI) to assess functional disability, and proprioceptive/balance tests, such as the single-leg stance on an unstable surface. Data were statistically analyzed at baseline and at the end of the six-week intervention period for both groups.

In the Kinesio Taping group, the mean VAS score prior to the intervention was 6.4 ± 1.2, which decreased to 4.2 ± 1.1 following completion of the six-week treatment. This represents a mean reduction of 2.2 points, or approximately 34.3% in subjective pain intensity, which was statistically significant ($P < 0.05$).

In contrast, the proprioceptive stabilization exercise group demonstrated greater improvement. The mean baseline VAS score was 6.6 ± 1.3, which decreased to 2.8 ± 1.0 at the end of treatment, corresponding to a reduction of 3.8 points, or approximately 57.6%, with a high level of statistical significance ($p < 0.001$). The between-group difference in pain improvement was also statistically significant ($p = 0.02$), strongly favoring the exercise group.

Regarding functional disability, the Kinesio Taping group showed a decrease in ODI scores from 38.6 ± 7.4% at baseline to 29.2 ± 6.9% post-treatment, representing a functional improvement of approximately 9.4 pp or 24.3%. Although clinically relevant, a comparison with the exercise group highlighted a more pronounced contrast.

The stabilization exercise group experienced a greater improvement, with ODI values decreasing from 40.1 ± 6.8% to 21.3 ± 5.5%, corresponding to an 18.8-point reduction (46.9 %). Statistical analysis demonstrated a significant between-group difference in ODI changes ($p < 0.01$), reinforcing the hypothesis that stabilization exercises exert a stronger impact on functional recovery. Proprioceptive performance, assessed through a 30-second single-leg stance test on an unstable surface (with both eyes open and eyes closed), revealed distinct outcomes for each group. The Kinesio Taping group improved the mean stance time (eyes closed) from 11.3 s to 16.1 s. In comparison, the exercise group improved from 10.9 s to 21.4 s in the same test. Furthermore, the participants in the exercise group demonstrated significant improvements in dynamic balance and postural control, particularly during the later stages of treatment, when more challenging unstable surfaces were introduced. The mean difference between the two groups in this test was statistically significant ($p = 0.004$), clearly reflecting the direct effect of the proprioceptive components incorporated into the exercise program.

TABLE 1. SUMMARY OF RESULTS

Parameter	Kinesio-Taping Group	Stabilization Exercise Group	p-value
VAS (pain)	−2.2 points	−3.8 points	p = 0.02
ODI (disability)	−9.4%	−18.8%	p < 0.01
Balance/Proprioception (eyes closed)	+4.8 sec	+10.5 sec	p = 0.004

These clinical data clearly demonstrate that both treatment modalities provide significant improvements in patients with chronic nonspecific low back pain (NSCLBP). However, proprioceptive stabilization exercises were more effective in reducing pain intensity, restoring functional capacity, and improving balance than Kinesio Taping alone. These findings support the implementation of a more active and long-term therapeutic approach for the management of this condition.

Between-Group Comparison and Statistical Analysis

This section focuses on the comparative analysis of the outcomes between the two experimental groups: the Kinesio Taping (KT) group and the Proprioceptive Stabilization Exercise (PSE) group, with the aim of determining the relative effectiveness of each intervention on pain reduction, functional disability, and improvement in lumbar proprioception. To ensure statistical objectivity and validity, independent samples t-tests, repeated measures ANOVA, and the Wilcoxon signed-rank test were employed when the data were not normally distributed.

At baseline, both groups demonstrated comparable VAS scores (KT: 6.4 ± 1.2; PSE: 6.6 ± 1.3; p = 0.58), indicating good initial equivalence. After the six-week intervention, the KT group showed a mean reduction of 2.2 points, whereas the PSE group demonstrated a greater reduction of 3.8 points, representing a statistically and clinically significant difference in favor of the exercise intervention. Independent samples t-test analysis confirmed a statistically significant difference between the groups in pain reduction (p = 0.02; 95% CI), favoring the PSE group. This indicates that, although both interventions contributed to pain reduction, proprioceptive stabilization exercises produced stronger and more sustained effects.

Regarding functional disability, baseline ODI values were comparable (KT: 38.6 ± 7.4%; PSE: 40.1 ± 6.8%; p = 0.45). However, the improvement in ODI was more modest in the KT group (9.4% reduction), whereas the PSE group demonstrated a substantially greater and clinically meaningful improvement (18.8% reduction).

Repeated-measures ANOVA assessing the “group × time” interaction yielded p < 0.01, confirming significantly greater functional improvement in the exercise group. The calculated effect size (Cohen’s d = 0.87) was large and clinically significant, reflecting a substantial difference in functional outcomes between the two interventions.

Proprioception was evaluated using a single-leg stance test on an unstable surface with eyes closed. The KT group improved their mean balance time from 11.3 s to 16.1 s, whereas the PSE group improved from 10.9 s to 21.4 s.

The Mann–Whitney U test was applied due to the non-normal distribution of some balance-related variables. The between-group difference in balance improvement was statistically significant (p = 0.004), with the PSE group demonstrating a notably higher median improvement than the control group. This finding is also clinically meaningful, as improved balance performance translates to enhanced stability during everyday activities, such as walking on uneven surfaces or maintaining a single-leg stance during dressing. Overall, the comparative statistical analysis confirmed that

proprioceptive stabilization exercises offer superior benefits across all measured variables compared with Kinesio Taping, supporting the preference for active rehabilitation strategies in the treatment of chronic nonspecific low back pain.

TABLE 2. OUTCOME MEASUREMENTS

Outcome Measure	Kinesio Taping (KT)	Stabilization Exercises (USP)	Between-Group p-value	Statistical Test Used	Effect Size
VAS (Pain Reduction)	−2.2 ± 1.2	−3.8 ± 1.3	$p = 0.02$	Independent t-test	—
ODI (Functional Improvement)	−9.4%	−18.8%	$p < 0.01$	Repeated Measures ANOVA	Cohen's d = 0.87
Single-Leg Stance (Eyes Closed)	+4.8 sec	+10.5 sec	$p = 0.004$	Mann–Whitney U	—
Baseline VAS Comparison	6.4 ± 1.2	6.6 ± 1.3	$p = 0.58$	Independent t-test	—
Baseline ODI Comparison	38.6 ± 7.4%	40.1 ± 6.8%	$p = 0.45$	Independent t-test	—

The results indicated that both interventions were effective; however, the Proprioceptive Stabilization Exercise group demonstrated a clear advantage across all three measured variables. These findings are consistent with the existing literature (Haladay et al., 2013; Shnayderman & Katz-Leurer, 2013), which emphasizes that interventions targeting the neuromuscular system and enhancing postural control tend to produce more sustained benefits in the management of low back pain. This analysis further supports the primary hypothesis of this study, suggesting that active treatments (such as structured exercise programs) yield more comprehensive and long-lasting effects than passive interventions such as Kinesio Taping. While Kinesio Taping may provide short-term symptomatic relief, it appears to be less effective as a standalone long-term solution for chronic nonspecific low back pain (NSCLBP).

Based on these findings, it is recommended that clinical practice prioritize active rehabilitation strategies and individualized stabilization exercise programs for patients with chronic nonspecific low back pain to achieve more sustainable functional and symptomatic improvements.

DISCUSSION

One of the principal strengths of this study lies in its randomized controlled trial (RCT) design, which is widely regarded as the gold standard for evaluating the effectiveness of interventions in clinical research. The random allocation of participants into two equal groups contributed to the reduction of systematic bias and enhanced the internal validity of the findings.

Another important strength is the use of validated and standardized outcome measures for the assessment of clinical parameters, including the Visual Analog Scale (VAS) for pain intensity, Oswestry Disability Index (ODI) for functional disability, and proprioceptive testing through static balance assessment on unstable surfaces. These instruments are well established in the literature and increase the reliability and comparability of results.

Furthermore, the six-week intervention period for both groups represented a sufficient timeframe to observe measurable changes in clinical parameters, particularly for physiotherapeutic interventions aimed at neuromuscular and functional adaptations. In this context, the inclusion of a structured and progressive stabilization exercise protocol enhanced the practical quality of the intervention and added substantial clinical value. The clarity and objectivity of the statistical analyses also constitute notable strengths. The study identified within-group improvements and

examined between-group differences using appropriate statistical tests, with interpretations aligned with the relevant scientific literature. This approach ensures that the findings are not only statistically significant but also clinically meaningful and applicable in practice. Despite these strengths, several limitations should be considered. First, the sample size was relatively small, with only 25 participants per group. Although statistically significant effects were observed, a larger sample size would allow for more robust analyses and may reveal additional subgroup effects, such as the influence of age, sex, or pain duration on intervention efficacy. Second, the follow-up duration was limited to the immediate post-intervention period. The study did not include long-term follow-up assessments to evaluate the sustainability of outcomes, particularly in the Kinesio Taping group, where the effects are generally considered to be short-term. The absence of long-term follow-up data limits the ability to draw definitive conclusions regarding the enduring impact of both treatment approaches. Additionally, owing to the nature of the interventions, participant blinding was not feasible, which introduced a potential source of bias. Although the outcome assessors were blinded, the participants were aware of the treatment they were receiving. This awareness may have influenced pain perception or functional test performance, particularly if participants had different expectations regarding the effectiveness of the two interventions. Finally, the generalizability of the findings may be limited by specific inclusion and exclusion criteria. By excluding individuals with systemic diseases, prior spinal surgery, or pregnancy, the results cannot be automatically generalized to broader populations with low back pain, including those with common comorbidities frequently encountered in clinical practice.

CONCLUSION

This randomized controlled study compared the effects of kinesio-taping (KT) and proprioceptive stabilization exercises (USP) in individuals with non-specific chronic low back pain (NSCLBP), one of the most prevalent conditions with a significant impact on health and well-being worldwide. The findings of this study provide an in-depth overview of the effects of these two interventions on pain reduction, physical functionality, and proprioceptive ability during a 6-week intervention period. The results clearly indicate that both therapeutic interventions positively contributed to reducing lower back pain symptoms, but with significantly greater efficacy in the group that followed the proprioceptive stabilization exercise program. Specifically, pain assessment using the Visual Analog Scale (VAS) showed a more pronounced improvement in the exercise group (mean reduction of 3.8 points) than in the Kinesio taping group (reduction of 2.2 points).

Furthermore, improvement in functional disability, measured using the Oswestry Disability Index (ODI), reinforces the superiority of the exercise intervention. The USP group showed a substantial improvement, with an 18.8% reduction in the disability index, indicating a return to higher functionality in daily life and increased capacity to perform basic tasks such as walking, standing or sitting for prolonged periods, lifting objects, and achieving quality sleep. In comparison, improvement in the KT group was considerably more modest, with a 9.4% reduction, which in many cases did not represent clinically meaningful functional changes for patients.

One of the most important aspects of this study is the analysis of proprioception and balance, which are essential components for spinal stability and the prevention of pain recurrence. Balance tests on unstable surfaces, performed with eyes closed, showed a significant improvement in the USP group, with an average increase of over 10 seconds in standing time, compared to only 4.8 seconds improvement in the KT group. These data indicate that proprioceptive exercises not only contribute to reducing subjective pain symptoms but also strengthen the body’s capacity to maintain stability and respond to everyday biomechanical challenges.

In practical terms, this translates into reduced dependence on assistive devices, decreased need for analgesic medications, and most importantly, a faster return to social and professional activities.

Comparatively, the kinesio-taping intervention, although simpler and less demanding for the patient, demonstrated more limited and primarily symptomatic effects. In contrast, proprioceptive stabilization exercises provided a more comprehensive and holistic solution, addressing not only symptom reduction but also the underlying cause of pain through strengthening deep trunk muscles, improving neuromuscular control, and enhancing body awareness.

This study has generated significant findings that emphasize the relative superiority of active interventions, such as proprioceptive stabilization exercises, compared to passive interventions like kinesio-taping, in the management of non-specific chronic low back pain. The results support the notion that therapeutic approaches that actively engage the patient, involve functional participation, and enhance the body's ability to control and manage biomechanical loads are more successful in achieving long-term and sustainable outcomes.

REFERENCES

- Chou, R., Deyo, R., Friedly, J., Skelly, A., Hashimoto, R., Weimer, M., … Fu, R. (2017). Nonpharmacologic therapies for low back pain: A systematic review for an American College of Physicians clinical practice guideline. Annals of Internal Medicine, 166(7), 493–505. https://doi.org/10.7326/M16-2459
- Delitto, A., George, S. Z., Van Dillen, L. R., Whitman, J. M., Sowa, G., Shekelle, P., … Godges, J. J. (2012). Low back pain: Clinical practice guidelines linked to the International Classification of Functioning, Disability, and Health from the Orthopaedic Section of the American Physical Therapy Association. Journal of Orthopaedic & Sports Physical Therapy, 42(4), A1–A57. https://doi.org/10.2519/jospt.2012.42.4.A1
- Hajihasani, A., Rouhani, M., Salavati, M., Haghani, H., & Kahlaee, A. H. (2019). The influence of cognitive behavioral therapy on pain and disability in patients with chronic low back pain: A systematic review and meta-analysis of randomized controlled trials. The Clinical Journal of Pain, 35(6), 508–523. https://doi.org/10.1097/AJP.0000000000000711
- Haladay, D. E., Miller, S. J., Challis, J. H., Davidson, B. S., & Uhl, T. L. (2013). Quality of systematic reviews on specific spinal stabilization exercise for chronic low back pain. Journal of Orthopaedic & Sports Physical Therapy, 43(4), 242–250. https://doi.org/10.2519/jospt.2013.4440
- Hawker, G. A., Mian, S., Kendzerska, T., & French, M. (2011). Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). Arthritis Care & Research, 63(S11), S240–S252. https://doi.org/10.1002/acr.20543
- Henschke, N., Maher, C. G., Refshauge, K. M., Herbert, R. D., Cumming, R. G., & Bleasel, J. (2010). Prognosis in patients with recent onset low back pain in Australian primary care: Inception cohort study. BMJ, 340, b3829. https://doi.org/10.1136/bmj.b3829
- Hoy, D., March, L., Brooks, P., Blyth, F., Woolf, A., Bain, C., … Buchbinder, R. (2013). The global burden of low back pain: Estimates from the Global Burden of Disease 2010 study. Annals of the Rheumatic Diseases, 73(6), 968–974. https://doi.org/10.1136/annrheumdis-2013-203636
- Lephart, S. M., Pincivero, D. M., Giraido, J. L., & Fu, F. H. (1997). The role of proprioception in the management and rehabilitation of athletic injuries. The American Journal of Sports Medicine, 25(1), 130–137. https://doi.org/10.1177/036354659702500118
- Maher, C., Underwood, M., & Buchbinder, R. (2017). Non-specific low back pain. The Lancet, 389(10070), 736–747. https://doi.org/10.1016/S0140-6736(16)30970-9

- Montalvo, A. M., Cara, E. L., & Myer, G. D. (2014). Effect of kinesiology taping on pain in individuals with musculoskeletal injuries: Systematic review and meta-analysis. The Physician and Sportsmedicine, 42(2), 48–57. https://doi.org/10.3810/psm.2014.05.2067
- Murtezani, A., Ibraimi, Z., Osmani, T., Meka, V., & Rrecaj-Malaj, S. (2015). A comparison of McKenzie therapy with a strengthening exercise program for the treatment of low back pain: A randomized controlled trial. European Journal of Physical and Rehabilitation Medicine, 51(6), 726–732.
- Namnaqani, F. I., Mashabi, A. S., Yaseen, K. M., & Alshehri, M. A. (2019). The effectiveness of manual therapy for treating non-specific low back pain: A systematic review. Journal of Physical Therapy Science, 31(6), 520–527. https://doi.org/10.1589/jpts.31.520
- Palmieri, R. M., Ingersoll, C. D., Stone, M. B., & Krause, B. A. (2002). Center-of-pressure parameters used in the assessment of postural control. Journal of Sport Rehabilitation, 11(1), 51–66. https://doi.org/10.1123/jsr.11.1.51
- Parreira, P. D. C. S., Costa, L. D. C. M., Hespanhol, L. C., Lopes, A. D., & Costa, L. O. P. (2017). Current evidence does not support the use of kinesio taping in clinical practice: A systematic review. Journal of Physiotherapy, 60(1), 31–39. https://doi.org/10.1016/j.jphys.2016.10.012
- Qaseem, A., Wilt, T. J., McLean, R. M., & Forciea, M. A. (2017). Noninvasive treatments for acute, subacute, and chronic low back pain: A clinical practice guideline from the American College of Physicians. Annals of Internal Medicine, 166(7), 514–530. https://doi.org/10.7326/M16-2367
- Schulz, K. F., Altman, D. G., & Moher, D. (2010). CONSORT 2010 statement: Updated guidelines for reporting parallel group randomised trials. BMJ, 340, c332. https://doi.org/10.1136/bmj.c332
- Shnayderman, I., & Katz-Leurer, M. (2013). Rehabilitation for low back pain: A review of clinical effectiveness of various treatment modalities. Disability and Rehabilitation, 35(7), 543–552. https://doi.org/10.3109/09638288.2012.705532
- Vanti, C., Bertozzi, L., Gardenghi, I., Turoni, F., Guccione, A. A., & Pillastrini, P. (2015). Effectiveness of neurodynamic mobilization in the treatment of carpal tunnel syndrome: A randomized controlled trial. Journal of Manipulative and Physiological Therapeutics, 38(4), 263–272. https://doi.org/10.1016/j.jmpt.2015.03.002

INVESTIGATION OF RIVER TRAINING SOLUTIONS FOR THE KHANH TRACH REACH OF THE LAI GIANG RIVER, BINH DINH PROVINCE

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ABSTRACT

River flow is inherently complex and often alters channel morphology, leading to erosion and sediment deposition. The Khanh Trach reach of the Lai Giang River in Binh Dinh Province, Vietnam, approximately 1,600 m in length, is a curved reach that is regularly affected by flood flows. Over many years, continuous erosion, deposition, and bank scouring have increased channel curvature and instability, posing serious threats to local communities, infrastructure, and riverside assets.

Investigating and proposing appropriate river training solutions for the Khanh Trach reach is therefore essential to stabilize the channel, enhance flood discharge capacity, and mitigate bank erosion. In this study, the numerical models MIKE 11 HD and MIKE 21 FM were applied to simulate the hydrodynamic regime of the Lai Giang River under various structural layout scenarios. The results propose feasible engineering alternatives that meet river training objectives, reduce flood-induced damage, support flood prevention and river management efforts, and contribute to socio-economic development and improved living conditions for residents along the Lai Giang River in Hoai Nhon District, Binh Dinh Province, Vietnam.

Keywords: Channel morphology, River training, Lai Giang river, Binh Dinh Province, Numerical models.

INTRODUCTION

The Lai Giang River is one of the major rivers located in the northern part of Binh Dinh Province (Nguyen Tan Huong, 2004) and plays an important role in the livelihood and socio-economic development of the northern districts of the province. The formation and morphological evolution of the Lai Giang River channel are highly complex, particularly in the Khanh Trach reach. In recent years, rapid socio-economic development has significantly accelerated the process of urbanization (Nguyen Van Bao, 2018).

Infrastructure facilities have been extensively constructed along both banks of the Lai Giang River, altering the natural topography and hydraulic conditions of the riverside areas. In addition, climate change has become increasingly severe, with extreme weather events leading to heavy rainfall and prolonged flooding (Vu, M. T., et al., 2017). Meanwhile, regional planning in the area remains incomplete. These factors have intensified flooding, channel instability, and riverbank erosion, resulting in considerable economic losses and adverse impacts on local communities.

Planning for the regulation of the Lai Giang River in general, and investigating river training solutions for the Khanh Trach reach in particular, is an urgent requirement for achieving sustainable socio-economic development in the locality.

The Khanh Trach reach of the Lai Giang River, which flows through Hoai My Commune, Hoai Nhon District, Binh Dinh Province, is approximately 1.6 km in length and located about 3.0 km upstream of the An Du estuary. Over many years, this reach has been frequently affected by flood flows, resulting in continuous channel erosion and riverbank instability. Consequently, the river has become increasingly sinuous and sharply curved, posing significant threats to local residents, their property, and riverside infrastructure.



Figure 1. Map of the river system in Binh Dinh province**.**

Therefore, investigating and identifying effective river training measures for the Khanh Trach reach to ensure channel stability, enhance flood conveyance capacity, and mitigate bank erosion is essential (Artur Radecki-Pawlik et al., 2018; B. Przedwoski et al., 1994; Leo C. Van Rijn, 1993;

Nguyen The Hung, 2024; P. Ph. Jansen et al., 1979; Pierre Y. Julien, 2002; Ramakar Jha et al., 2022; Weiming Wu, 2007 ; Zhao-Yin Wang et al., 2015). These efforts will contribute to socio-economic development and improve the living conditions of communities residing along the Lai Giang River.

EXISTING CONDITIONS OF THE KHANH TRACH REACH

Hydraulic regime

Topographical and geological features

The Khanh Trach reach, approximately 1.6 km in length, is located along the main channel of the Lai Giang River between chainages K11+730m and K13+330m (Nguyen Van Bao, 2018). Its geographical coordinates are approximately 14027’58” N latitude; 109004’20” E longitude (Nguyen Tan Huong, 2004). The upstream portion of the reach is relatively straight and stable, with a channel width of 236 m. The middle reach widens to 477 m and bends toward the right bank with a radius of curvature of 352 m, forming two flow channels separated by Ong Muoi islet. The downstream section narrows to 115 m, representing the narrowest part of the Lai Giang River within this reach, and curves toward the right bank with a radius of curvature of 149 m.

The riverbed elevation ranges from −8.11 m to +1.01 m. The channel slopes laterally toward the right bank and longitudinally in the downstream direction. The right branch has bed elevations varying from −2.0 m to −8.0 m and is deeper and wider than the left branch (approximately −1.5 m). As a result, flow is primarily concentrated toward the right bank, which is the main cause of annual riverbank erosion in the Khanh Trach reach during flood events. In the downstream section, severe bed scour has been recorded, with elevations ranging from −4.7 m to −8.3 m. The terrain along both riverbanks is relatively flat. The floodplain elevation varies from 3.9 m to 4.3 m, while the riverbank elevation ranges from 5.2m to 5.6m (Nguyen Van Bao, 2018).

Along both banks of the Khanh Trach reach, the surface geology is of mixed fluvial–marine sedimentary origin (amQ). The deposits primarily consist of fine-grained sandy clay, dark yellow to dark brown in color, containing minor organic matter, mainly plant humus. In its natural state, the soil ranges from weakly cohesive to moderately dense. It is commonly encountered in a loose condition, with some zones exhibiting slight plasticity. The soil composition varies irregularly both laterally and with depth, and the layer thickness shows significant variation, ranging from approximately 3 to 4 meters (Nguyen Van Bao, 2018). Although the soil is nutrient-rich and suitable for agricultural cultivation, it is highly susceptible to erosion and scouring under the influence of river flow.



Figure 2. Khanh Trach curved reach, Lại Giang River, Binh Định province.

The riverbed geology primarily consists of alluvial and sedimentary deposits with substantial thickness increasing seaward. The materials are composed mainly of fine- to medium-grained sand interbedded with clayey silt containing decomposing plant and animal remains. The riverbank soils range from moderate to weak in strength, making them highly vulnerable to erosion induced by river flow. This process forms steep, near-vertical banks that are inherently unstable and prone to slope failure and bank collapse, particularly during the rainy season when the soil becomes fully saturated. Prolonged and repeated erosion over many years has led to the formation of a meandering river section, with the curvature progressively increasing over time.

Flow regime

The Lại Giang River extends 18.51 km from the confluence of the An Lao and Kim Son rivers to the An Du estuary (river outlet). The length of the river from the confluence to the Khanh Trach reach is approximately 11.73 km. The Lại Giang River basin, measured up to the Khanh Trach reach, has a total catchment area of 1,337.8 km². The flow regime of the Lại Giang River at the Khanh Trach reach is characterized by two distinct seasons: the low-flow (dry) season and the flood season (Nguyen Van Bao, 2018).

At the beginning of the dry season (January), river discharge remains relatively abundant because the basin retains substantial water storage from the previous rainy season, while water demand is still low. As a result, flow through the Khanh Trach reach is maintained. By April, however, discharge in the upstream tributaries decreases significantly, while water demand increases due to irrigation withdrawals and water ABSTRACTion works. Consequently, river discharge declines sharply, and flow reaching the Khanh Trach reach during this period becomes extremely low, with some sections approaching near-dry conditions.

During the early flood period (May–June), although the basin receives supplementary rainfall, river discharge declines rapidly in the subsequent months. As a result, low-flow conditions persist and drought conditions continue until the onset of the main rainy and flood season. During the dry season, agricultural water demand is high. As a result, upstream hydraulic structures and in-river diversion works regulate and ABSTRACT water for irrigation areas. Consequently, discharge reaching the Khanh Trach reach during the low-flow period is very limited, consisting mainly of inflow from the Kim Son River basin. Most of the An Lao River flow is diverted to its irrigation command area by the Lại Giang weir. Therefore, the impact of low-flow discharge on the Khanh Trach reach is negligible and does not significantly influence morphological changes within this river reach.

Table 1. Characteristics of the low-flow season of the Lai Giang River

Frequency (%)	F_{lv}	50	75	80	85	90	95	Parameters
Q(m^3/s)	1337,8	19,28	14,25	13,24	12,17	10,99	9,53	Q_{tbk}= 21,1m^3/s; C_v= 0,44; C_s=1,20

The flood season in the Lại Giang River basin typically extends from October to December. However, in certain years, early or late flood events may occur from September and may persist into January. Flood discharge passing through the Khanh Trach reach is primarily represented by measurements at the Bong Son hydrological station. This constitutes the dominant flow regime, characterized by high peak discharges and prolonged flood duration. When flood events occur, the

flow transports a substantial volume of sediment, including silt and sand eroded from upstream mountain slopes and riverbeds, conveying these materials downstream.

At the Truong Gao sandbar, located along the convex (point bar) bank of the Khanh Trach reach, a considerable volume of sediment is deposited annually. This accumulation progressively narrows the right-hand distributary channel, causing the main flow to concentrate in the left-hand channel. As a result, flow velocity in the left channel increases, intensifying bank erosion and riverbank instability along the Khanh Trach reach in recent years. This process has led to continuous morphological adjustment, with the river channel becoming progressively more curved over time.

Table 2. Water Levels and Peak Flood Discharges at Bong Son Hydrological Station.

Frequency (%)	2	5	10	20	25	Htb	Cv	Cs
H (m)	10,36	9,60	8,98	8,31	8,07	7,40	0,16	0.90
Q (m3/s)	4.931	4.056	3.338	2.776	2.587	2.087	0,16	0.90

In general, flood events in this basin are of relatively short duration. However, flood flows passing through the Khanh Trach reach cause significant damage each year due to riverbank erosion and inundation. These impacts are exacerbated by channel meandering and the progressive narrowing of the downstream outlet of this river reach (Nguyen Tan Huong, 2004).

Current status of riverbed changes

The Khanh Trach reach curves toward the right bank, making the channel morphology less stable under the influence of flow (Leo C. Van Rijn, 1993; Maynord, S.T., 1996; Nguyen The Hung et al., 2016; Zhao-Yin Wang et al., 2015). In previous years, channel changes occurred slowly because major floods were infrequent. In addition, the terrain on both sides of the main Lai Giang River was relatively low, allowing floodwaters to spread over the surrounding area. This reduced the flow concentration and velocity within the main channel.

In recent years, under the influence of climate change, rainfall in the area has become increasingly irregular in both magnitude and intensity. At the same time, rapid socio-economic development has led to a growing density of technical infrastructure works. The terrain along both riverbanks has been modified and elevated by the construction of dikes, revetments, and other infrastructure facilities. Consequently, during the rainy and flood season, river water levels rise significantly and large flood discharges pass through the reach, intensifying channel bed scour and bank erosion (Chen X, Han Q, Fang C., 2007; Guangming Tan et al., 201; Nguyen Van Bao, 2018; Pickup G, et al., 1976; Sun D, et al., 2013; Zhang W., et al., 2018). In some locations, bank retreat has reached up to 10 meters.

Channel incision and bank erosion have occurred predominantly along the right bank, while the left bank has experienced sediment deposition, with sand–silt layers accumulating to elevations ranging from –1.0 meters to +2.5 meters. In comparison, the general riverbed elevation varies between –2.5 meters and –4.5 meters. At the downstream end of the reach, due to the narrowing of the channel cross-section, severe local scour has developed, reaching an elevation of –8.2 meters. Flood discharge is the primary driving factor responsible for the morphological changes observed in the Khanh Trach reach.

In summary, the causes of riverbank erosion can be identified as follows:

- The river reach is curved and meandering, and is therefore strongly influenced by flow direction and secondary currents;
- The engineering geological conditions near the river mouth are relatively weak, with a high proportion of fine-grained sediments that are easily eroded and transported;

- Frequent occurrences of heavy rainfall and high-intensity floods;
- Deforestation in the upstream catchment has resulted in low forest cover, leading to rapid flood rise. This accelerates hillside erosion, increases sediment yield, and raises sediment concentration in the river;
- The absence of upstream reservoirs capable of regulating and attenuating flood discharge;
- Construction of technical infrastructure along the riverbanks, such as raising dikes to confine floodwaters, which alters the natural flow regime.

The mechanism of riverbed deformation in the Khanh Trach reach follows the natural fluvial processes that govern channel evolution in curved river reaches (B. Przedwoski et al., 1994; Leo C. Van Rijn, 1993; Nguyen The Hung, 2024). Erosion in the Khanh Trach reach is particularly evident during both the rising and receding stages of floods. Analysis of the erosive processes indicates that river discharge is the primary factor causing bank erosion, particularly the relatively high discharges occurring during the rainy and flood seasons. The intensity of bank erosion depends mainly on the strength of secondary (helical) flow developed within the curved reach. Flood-season discharges in the Lai Giang River exceed the critical erosion threshold of the soil and rock materials forming the sloping riverbanks in this area. Consequently, bank instability occurs, leading to sliding and bank failure.

During the rainy and flood seasons, the soil and rock materials become saturated by rainfall, which significantly increases the likelihood of slope failure. The riverbed and bank materials in this area are predominantly composed of clay and fine sand. As the moisture content increases, the unit weight of the soil mass on the riverbank slope also increases due to saturation. The increase in self-weight of the soil mass, together with the weakening of interparticle bonding and changes in soil consistency, leads to a reduction in shear strength parameters. Consequently, both the cohesion and the internal friction angle of the soil decrease, thereby reducing slope stability. An increase in moisture content also produces a lubricating effect on soil particle surfaces. This further highlights the influence of groundwater on the development of slide masses. The wetting and saturation of soil and rock materials increase the unit weight of the soil mass on the slope. This added self-weight, combined with the reduction in shear strength, is one of the primary factors contributing to slope instability and the occurrence of landslides (Pierre Y. Julien, 2002).

In general, morphological changes in the Khanh Trach reach are primarily driven by flood flows, which are the dominant cause of riverbank erosion. In addition, the riverbank materials consist mainly of fine sandy clay with low shear strength. The meandering channel planform, combined with deep local scour and steep, near-vertical banks, promotes the development of undercutting (bank toe erosion) along the river margin, leading to instability. Riverbank erosion typically occurs during the rainy season. It can therefore be concluded that erosion in the Khanh Trach reach results from the combined effects of topographic, geomorphological, geological, and hydrological conditions, together with human activities that have altered the natural flow regime of the river (Pierre Y. Julien, 2002).

APPLICATION OF THE MIKE21-FM MODEL TO CALCULATE FLOOD FLOW THROUGH THE KHANH TRACH REACH

Introducing the MIKE21 FM model

The three- dimensional (3D) hydrodynamic equations are integrated into the MIKE 21 module. This module calculates two-dimensional (2D) horizontal flow using the finite volume method (Cunge J.A., et al., 1980; DHI, 2017; Weiming Wu, 2007). Spatially, the computational domain is discretized by unstrucked triangular elements. The governing equations are:

- *Continuity equation:*

$$\frac{\partial h}{\partial t} + \frac{\partial hU}{\partial x} + \frac{\partial hV}{\partial y} = hS \quad (1)$$

- *Momentum equations:*

$$\frac{\partial hU}{\partial t} + \frac{\partial hU^2}{\partial x} + \frac{\partial hUV}{\partial y} = fVh - gh\frac{\partial \eta}{\partial x} - \frac{h}{\rho_0}\frac{\partial p_a}{\partial x} - \frac{gh^2}{2\rho_0}\frac{\partial \rho}{\partial x} + \frac{\tau_{sx}}{\rho_0} - \frac{\tau_{bx}}{\rho_0} + \frac{\partial}{\partial x}(hT_{xx}) + \frac{\partial}{\partial y}\left(hT_{xy}\right) + hU_sS \quad (2)$$

$$\frac{\partial hV}{\partial t} + \frac{\partial hV^2}{\partial x} + \frac{\partial hUV}{\partial y} = fUh - gh\frac{\partial \eta}{\partial y} - \frac{h}{\rho_0}\frac{\partial p_a}{\partial y} - \frac{gh^2}{2\rho_0}\frac{\partial \rho}{\partial y} + \frac{\tau_{sy}}{\rho_0} - \frac{\tau_{by}}{\rho_0} + \frac{\partial}{\partial x}\left(hT_{xy}\right) + \frac{\partial}{\partial y}\left(hT_{yy}\right) + hV_sS \quad (3)$$

where:
U, V are the depth average velocity components in the x, and y directions respectively; T_{xx} , T_{yy} , T_{xy} are viscosity stress; f is the Coriolis coefficient; S are the discharge of source/sink points; ρ *is* the density of water; *Us, Vs* are the velocities of source/sink points; η is elevation; h=η+d is the depth of water; g is the acceleration due to gravity; t is time; x, y, are the Cartesian coordinates; p_a is the asmospheric pressure; ρ_0 is the standard atmospheric density; τ_s is surface stress; τ_b is the bed stress.

Boundary conditions:

+ Solid boundary: The normal flux is prescribed as zero (0). In the momentum equations, this condition results in full-slip along the solid boundary.

+ Liquid boundary: Open boundary conditions for the hydrodynamic equations can be specified in terms of discharge (flow rate), velocity, or water level (water surface elevation). For velocity and water level boundaries, the values on the boundary can be constant, vary over time but are fixed along the boundary, or vary both over time and along the boundary.

Applying the MIKE21 FM model

- *Topography data*

The topographic data used for the hydraulic calculations of the Khanh Trach reach were obtained from detailed field surveys, including both riverbed and riverbank topography along the Lại Giang River. The surveyed area covers the entire study reach with a total length of 3.0 km. The topographic surveys were conducted in 2016 and 2017; therefore, the dataset is considered to be of good quality and sufficiently reliable for digital terrain modeling and subsequent simulations using the two-dimensional (2D) hydrodynamic model.

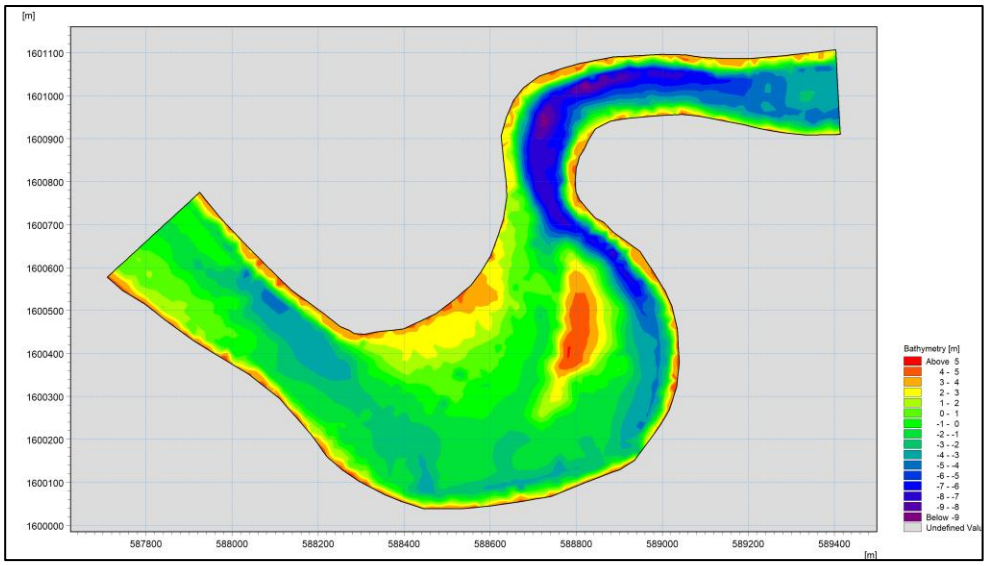


Figure 3. Topography of the Lai Giang River - Khanh Trach reach.

- *Construction of the Two- Dimensional (2D) Computational Mesh:*

The two-dimensional computational mesh was generated over the entire modeling domain using an unstructured triangular grid. The maximum area of each mesh element does not exceed 300 m², and the minimum internal angle of the triangular elements is 26°. The riverbed topography was interpolated onto the computational mesh to ensure accurate representation of the bathymetry in the numerical model.

- *Hydrological and hydraulic data:*

The discharge and water level data used as boundary conditions for the simulations were extracted from the results of the one-dimensional hydraulic model MIKE 11 HD, which had been calibrated for the flood event occurring from November 15 to November 17, 2013. The simulated reach of the Lại Giang River extends from Bong Son Bridge to An Du Estuary. The initial conditions for the two-dimensional model were specified as follows: the initial water level was set to 1.7 m, and the initial velocity was assumed to be zero throughout the computational domain.

Model Calibration:

A preliminary roughness coefficient was selected based on the characteristics of the riverbed topography and adjusted during the calibration process.

The main model parameters were configured as follows:

+ Simulation time step: □t = 30s;

+ Time step for Scaled Dynamic simulation: □t = 5s;

+ Eddy viscosity coefficient: Smagorinsky formulation: □ = 0.28;

+ Boundary conditions and initial conditions.

The simulations were performed by optimizing the Manning roughness coefficient (M) uniformly over the entire computational domain. The optimal value was determined to be approximately M ≈ 35, providing results consistent with those obtained from the calibrated one-dimensional (1D) hydraulic model.

Model verification was carried out by extracting results at the mid-reach location K12+667 m. The comparison between the 1D and 2D model outputs demonstrated a very strong agreement. The statistical performance indicators are summarized as follows:

+ Correlation coefficient: 1.000;

+ Peak error: 0.004;

+ Volume error: 0.004;

+ Peak time error: 0.01.

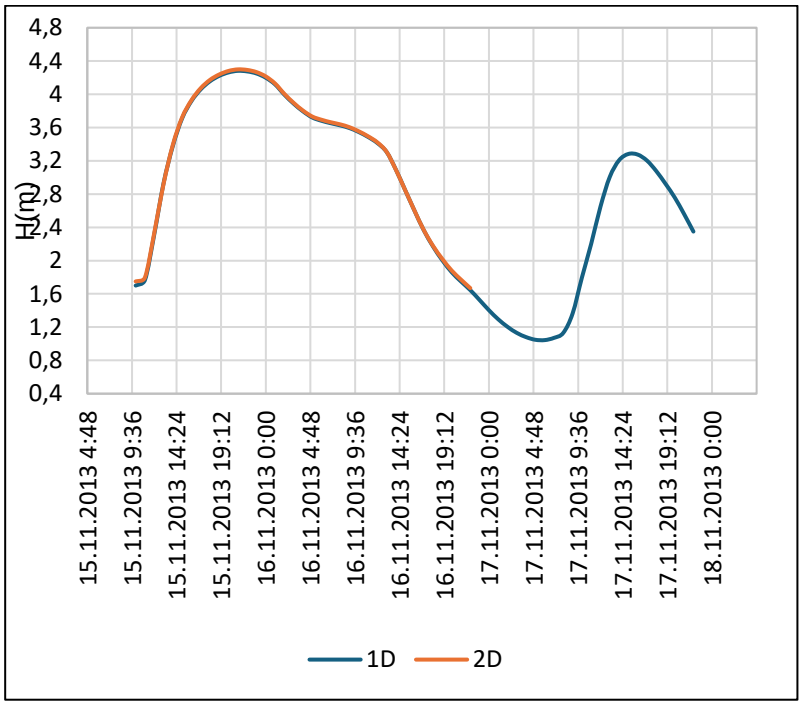


Figure 4. Results of Water Level Calibration at Location K12+667m.

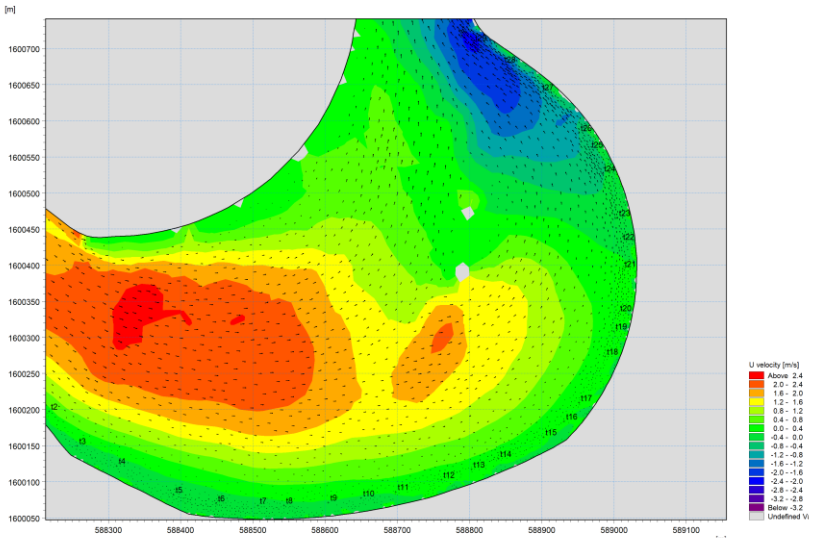
With comprehensive datasets on topography, hydrology, and synchronized observed flood data from the flood event of November 15÷17, 2013, the calibration of both the one-dimensional (1D) and two-dimensional (2D) hydraulic models produced very good agreement with observations. The Manning roughness coefficients adopted in the models were found to be consistent with the geomorphological and hydraulic characteristics of the river reach. The calibrated parameter set therefore satisfies the requirements for reliable hydraulic simulation. Consequently, the validated model configuration is suitable for simulating the existing (baseline) condition as well as various structural layout scenarios for engineering planning and assessment.

Hydrodynamic calculations based on the existing river channel

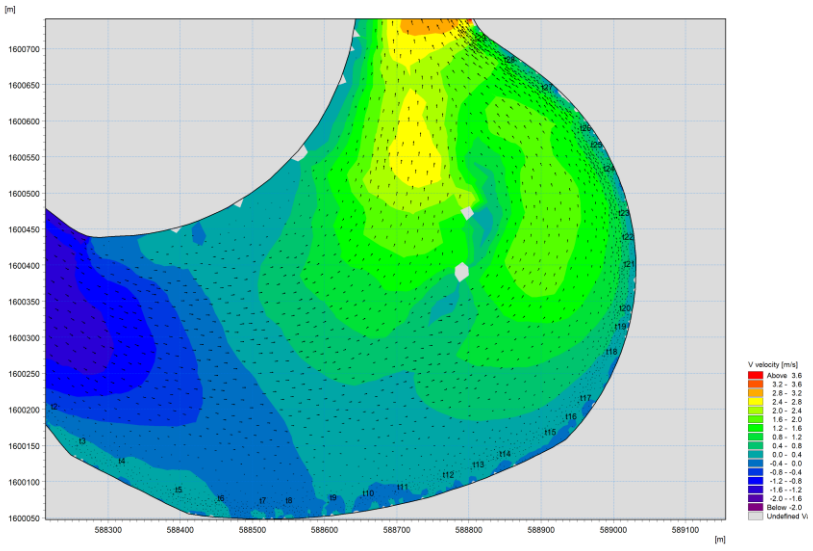
The hydrodynamic simulations were conducted under the assumption of the existing river channel conditions. The riverbed topography was kept unchanged, while the riverbanks were raised to an elevation of +5.6 m along the current bank alignment. The computational mesh for the entire domain consisted of an unstructured triangular grid. Mesh elements along the riverbanks were locally refined to better represent near-bank hydraulic characteristics.

Discharge and water level boundary conditions were extracted from the one-dimensional MIKE 11 HD model corresponding to the design flood scenario with a return period of p = 10%. These values were applied at locations coinciding with the open boundaries of the two-dimensional model. To evaluate hydraulic characteristics along the existing riverbank, result extraction points

were defined along the toe of the bank line at a distance of approximately 20 m from the bank. A total of 30 monitoring points were established, labeled sequentially from T1 to T30.



(a)



(b)

Figure 5. Current river velocity field, p = 10% (at simulation time t=930 minutes) (a) Velocity field U; (b) Velocity field V

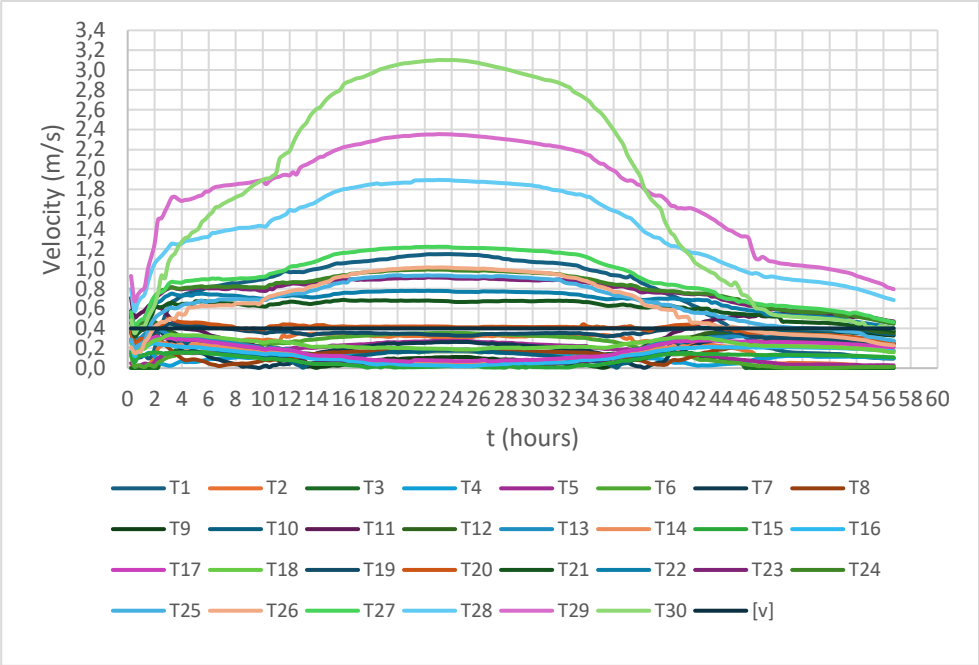


Figure 6. Flow velocity at locations T1÷T30; p = 10%; (at simulation time t=930 minutes).

The simulation results indicate that for a discharge of 1,568 m³/s, the near-bank flow velocity in the curved section of the Khanh Trach reach exceeds V > 0.4 m/s. However, the riverbed and bank materials in this area mainly consist of silt, clay, and fine-grained sand, for which the allowable non-erosive velocity ranges from [V] = 0.26÷0.40 m/s. Therefore, the computed flow velocity exceeds the critical threshold for erosion resistance, and the riverbanks do not satisfy the stability condition against scour.

This implies that the riverbanks in the Khanh Trach reach can remain stable only when the discharge is lower than 1,568 m³/s. In practice, floods on the Lai Giang River with discharges smaller than this value occur infrequently. During the main flood season, flow rates exceeding 1,568 m³/s are typically sustained for prolonged periods, leading to progressive bank erosion after each rainy season. Consequently, structural reinforcement and river training measures are required to protect the Khanh Trach riverbanks and ensure long- term stability.

It should also be noted that the velocities computed using the MIKE 21 FM model are generally lower than the actual flow velocities observed in the field. In practice, the real flow velocity is commonly about 1.1÷1.3 times the simulated value. Therefore, the actual erosive potential of the flow may be even greater than that indicated by the numerical results.

SOLUTIONS FOR REGULATING THE KHANH TRACH REACH

Objectives of River Training for the Khanh Trach Reach

The primary objective of river training for the Khanh Trach reach is to prevent erosion of the concave riverbank, improve flood conveyance capacity, and ensure the safety and stable living conditions of communities residing along the river (B. Przedwoski et al., 1994; Leo C. Van Rijn, 1993; Luong Phuong Hau, 2004; Nguyen The Hung, 2024; Pierre Y. Julien, 2002).

Criteria for river training

River training works for the Khanh Trach reach must satisfy the objectives of preventing riverbank erosion, mitigating channel erosion and sediment deposition, improving flood conveyance capacity, and minimizing the impacts of flood flows, including early-season floods, late-season

floods, and main-season floods with a p=10% exceedance probability. The works must ensure effective bank protection, stabilize the river alignment, improve flow conditions to maintain unobstructed conveyance, enhance landscape aesthetics, and harmonize with surrounding communities. The trained river reach must be consistent with the overall plan of the Lai Giang main river and be compatible with regional infrastructure and adjacent areas. Engineering solutions must ensure structural stability, environmental safety, improved visual quality, and contribute to sustainable socio-economic development (B. Przedwoski et al., 1994; Luong Phuong Hau, 2004; Nguyen The Hung, 2024; Pierre Y. Julien, 2002).

Engineering Design scenarios for River Training Works

In this paper, the authors analyzed and evaluated several feasible river training alternatives.

Combined Revetment and Low-Level Groyne Scheme

When constructing revetments along narrow and curved river reaches, toe scour frequently occurs. Therefore, to ensure long-term structural stability, appropriate toe protection measures are required. Low-level groynes are among the commonly applied solutions for mitigating bed scour (B. Przedwoski et al., 1994; Nguyen The Hung, 2024; Copeland, R.R., 1983; Maynord, S.T., 1996).

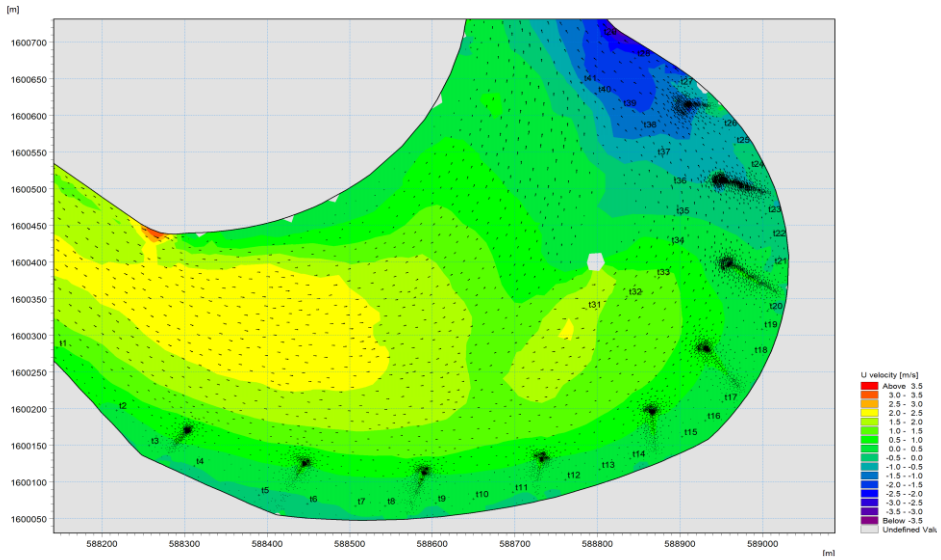
The combination of low-level groynes and bank revetments aims to protect the revetment toe, stabilize the riverbank slope, and redirect near-bed flow away from the bank to prevent local scour in the toe region. Additionally, low-level groynes promote sediment deposition and gradual bank accretion, thereby enhancing the overall stability of the revetment toe.

In this scheme, a system of nine groynes was arranged along the curved riverbank in combination with the revetment. The groyne lengths range from 26 m to 69 m. The groyne heads extend toward the trained channel alignment, while the roots are connected to the riverbank. The crest elevation is +▼0.3m, the crest width is 2.0 m, and the side slope is m = 1.5 (horizontal to vertical). The groynes are oriented at an angle of 70° relative to the training alignment. The structures are constructed of rubble stone, with submerged gabion mattresses installed for toe protection.

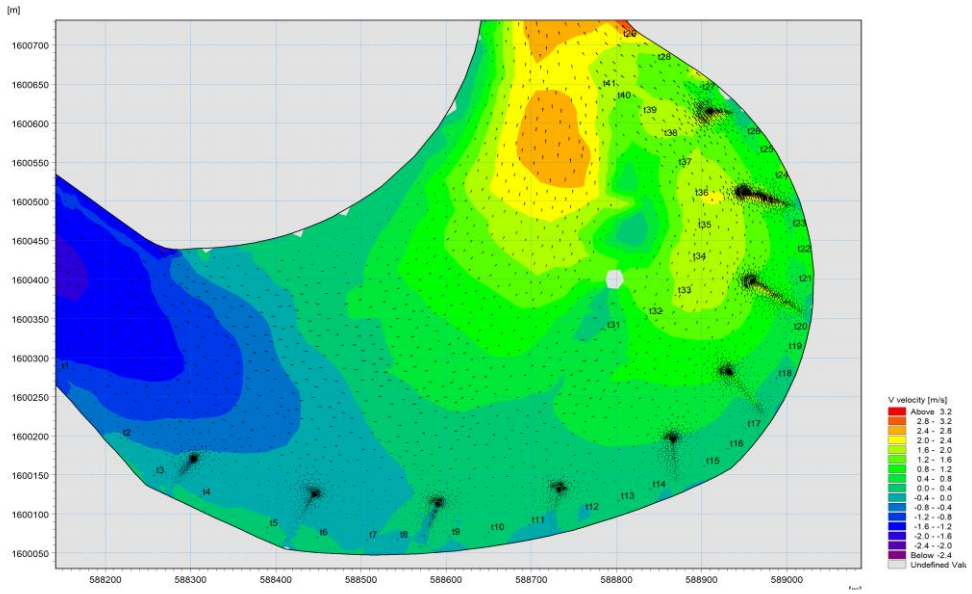
The training alignment ensures continuity between the upstream and downstream ends of the revetment, conforms to the natural topography, and provides smooth hydraulic transition through the curved reach. Accordingly, the alignment is divided into three consecutive sections connected by three curvature radii.

Simulation results indicate that flow velocity increases locally at the groyne heads and crests. Between adjacent groynes, no significant flow disturbance was observed, and near-bank velocities decreased, demonstrating a rational arrangement in terms of alignment, orientation angle, and groyne dimensions. Along the right bank, flow velocity decreased by 20%÷40% compared with the existing condition. At the extraction points near the toe of Ong Muoi sandbar, velocity increases at the upstream section (T31÷T33) and downstream section (T39÷T41) are negligible. In the middle section (T34÷T39), velocity increases range from 40% to 125%, with a maximum value of 2.0 m/s.

Overall, the combined revetment and low-level groyne scheme is suitable for protecting the Khanh Trach reach, as the river cross-section is relatively wide and flow redistribution has limited impact on the opposite bank. Although velocity increases occur at groyne heads, the magnitude of local scour remains limited. For the downstream groyne near the outlet, velocities increase due to channel narrowing; however, the overall hydraulic impact remains acceptable.



(a)



(b)

Figure 7. Velocity field of the combined revetment and low-level groyne scheme (at simulation time t = 930 minutes)

(a) Velocity field U; (b) Velocity field V

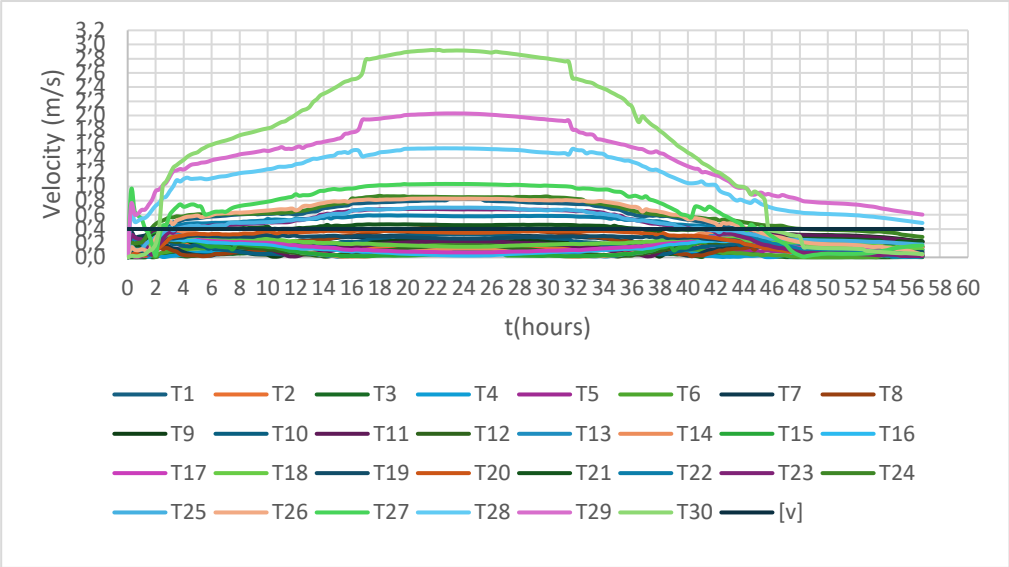


Figure1 8. Flow velocity at locations T1÷T30

In summary, the combined revetment and low-level groyne scheme is highly suitable for protecting the concave bank of the Khanh Trach reach. It effectively stabilizes the riverbank, prevents bank erosion, and mitigates flood-induced damage. The scheme provides high structural stability and strong technical feasibility. However, it does not resolve sediment deposition along the convex bank, nor does it significantly improve the overall flood conveyance capacity. The effectiveness of the training works is demonstrated by the substantial reduction of flow velocity along the concave bank. Nevertheless, at several locations near the downstream end of the reach, the near-bank velocity at the toe remains higher than the permissible limit. Therefore, an extension of the bed protection layer is required to prevent local toe scour. The construction cost of this scheme is relatively high.

High groyne scheme

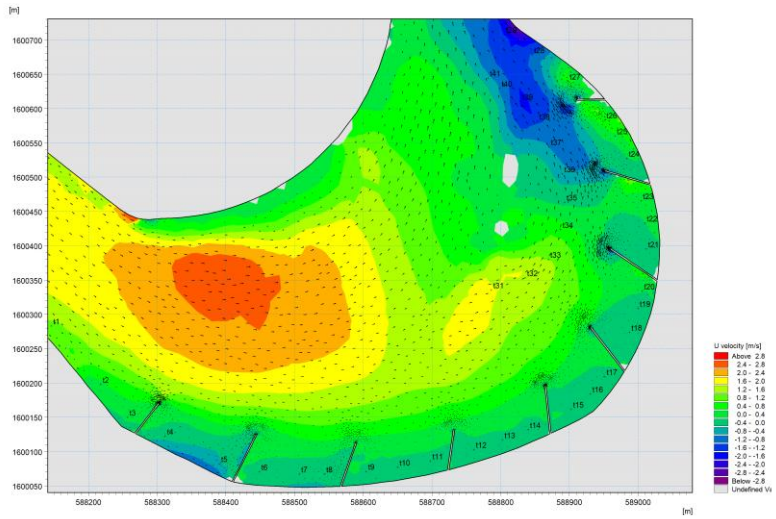
The primary objective of the high groyne system is to divert the main flow away from the concave bank and protect the natural riverbank (Francis, J.R., et al., 1968; Mohamed F. M. et al., 2011; Nguyen Quang Binh, et al., 2017; Nguyen The Hung et al., 2016). The training alignment and groyne layout of this scheme are similar to those of the low-level groyne scheme presented in Section 4.3.1. The system consists of nine groynes. The groynes range in length from 38 m to 81 m, with a crest width of 2.0 m, a crest elevation of +▼5.0m, and a side slope coefficient of m = 1.5. The groynes are oriented at an angle of 70° to the bank line.

The simulation results indicate that the main current is effectively deflected away from the concave bank. The arrangement of the groyne system is generally appropriate in terms of number, spacing, orientation, and structural dimensions. The flow between the groynes remains relatively stable, and no significant disturbance occurs at the groyne roots. The flow at the upstream and downstream junctions of each groyne is smooth. The near-bank velocity along the protected bank is significantly reduced. However, the flow velocity increases at the groyne heads, particularly at groynes No. 7, 8, and 9, where velocities increase more substantially due to channel narrowing. To mitigate this effect, reinforcement of the bed protection apron at the groyne heads is recommended.

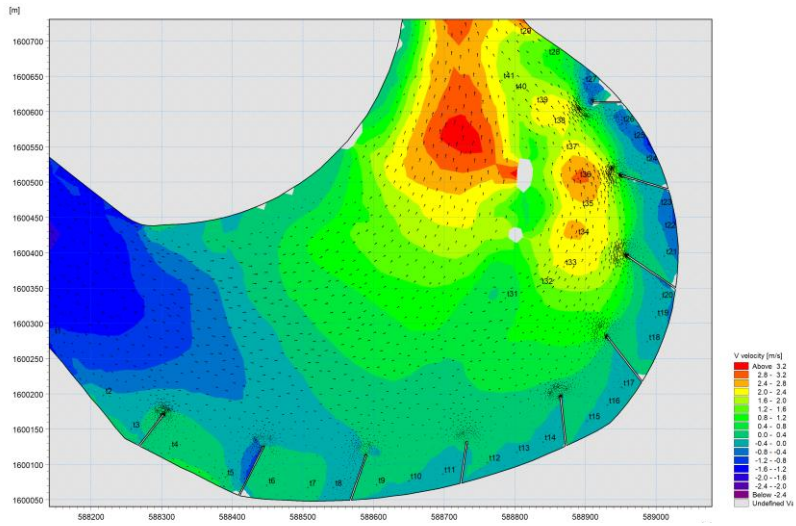
The calculated near-bank velocity decreases by 30%÷80% compared to the existing condition. On the left bank at the toe of Ong Muoi sandbar. In the upstream section (T31÷T33) and downstream

section (T39÷T41), velocity increases slightly by 20%÷40%. In the middle section (T34÷T38), velocity increases significantly by 80%÷200%, with a maximum value of 3.0 m/s.

Compared with the low-level groyne scheme, the high groyne scheme is more effective in diverting the flow away from the concave bank. However, the corresponding increase in flow velocity along the opposite bank in the downstream reach is also more pronounced.



(a)



(b)

Figure 9. Velocity field of the high groyne scheme (at simulation time t = 930 minutes)

(a) Velocity field U; (b) Velocity field V

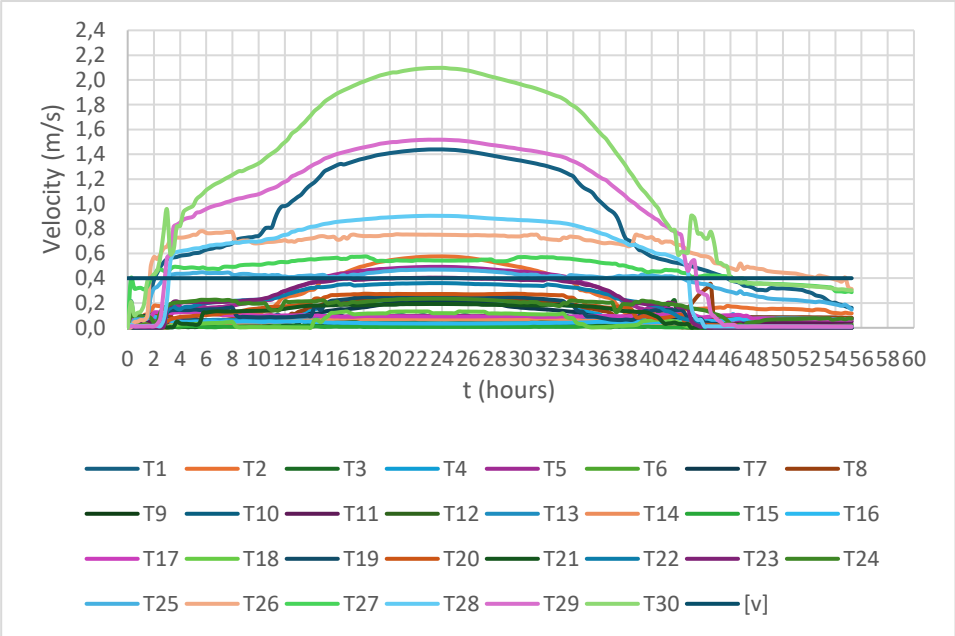


Figure 10. Flow velocity at locations T1÷T30

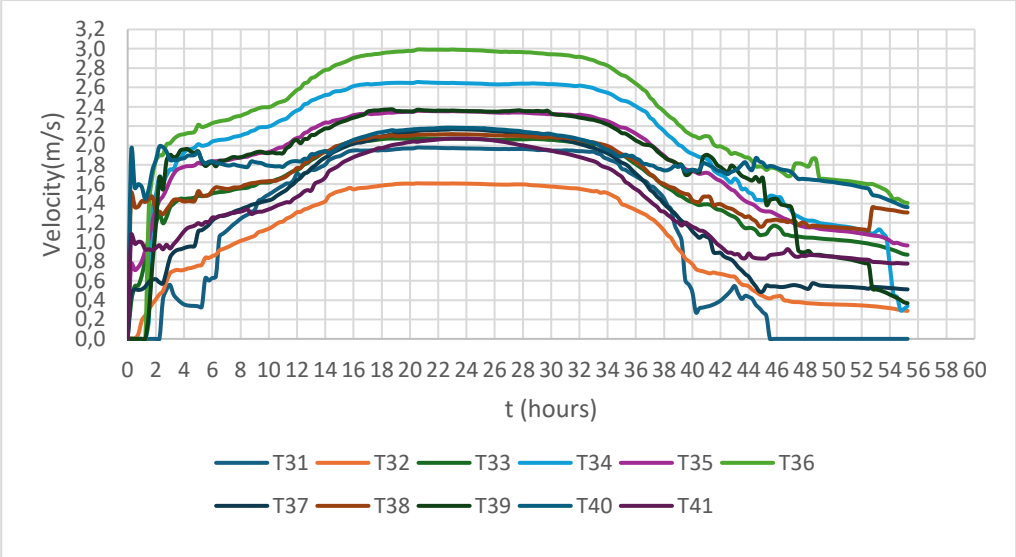


Figure 11. Flow velocity at locations T31÷T41

In summary, the high-level groyne scheme applied to the Khanh Trach reach effectively regulates the flow and significantly reduces the impact of flood discharge on the concave bank, thereby stabilizing the riverbank slope. However, it does not resolve sediment deposition in the left branch, nor does it substantially improve the overall flood conveyance capacity. Due to the narrowed cross-section at the downstream end of the training works, the near-bank velocity remains higher than the permissible limit; therefore, additional structural reinforcement is required to prevent local scour.

Because of severe scour at the concave bank, the groynes require relatively large structural heights, which reduces their overall stability. To ensure long-term structural safety, reinforcement of the groyne toe is necessary, particularly at the groyne heads and roots. In addition, morphological changes in the upstream and downstream sections of the reach (T1÷T30) should be closely monitored. The construction cost of this scheme is relatively low.

River creek plan

Flow in the Khanh Trach reach is characterized by bifurcation around Ong Muoi sandbar, forming two channels. The main flow predominantly concentrates in the right channel due to its lower bed elevation compared to the left channel. Under low-discharge conditions, flow is almost entirely confined to the right channel, while the left channel only conveys flow during high-water stages associated with large discharges. As a result, persistent concentration of the main flow in the right channel has caused significant riverbed scour and progressive bank erosion, leading to increasing curvature of the concave bank (B. Przedwoski et al., 1994; Luong Phuong Hau, 2004; Nguyen The Hung, 2024).

The channel diversion scheme aims to redistribute discharge between the two channels in order to prevent sedimentation in the left channel, reduce erosion in the right channel, enhance flood conveyance capacity, and stabilize overall channel morphology. To achieve these objectives, an appropriate hydraulic structure is required to regulate and divide the flow while ensuring long-term stability.

Common engineering measures for flow diversion include groynes, division dikes, training dikes, and bed-control structures. The proposed diversion plan for the Khanh Trach river reach involves using diversion embankments combined with lowering the elevation of the left channel bottom. The chosen construction method must ensure that the river water level does not increase compared to the current situation and that the riverbanks are not altered.

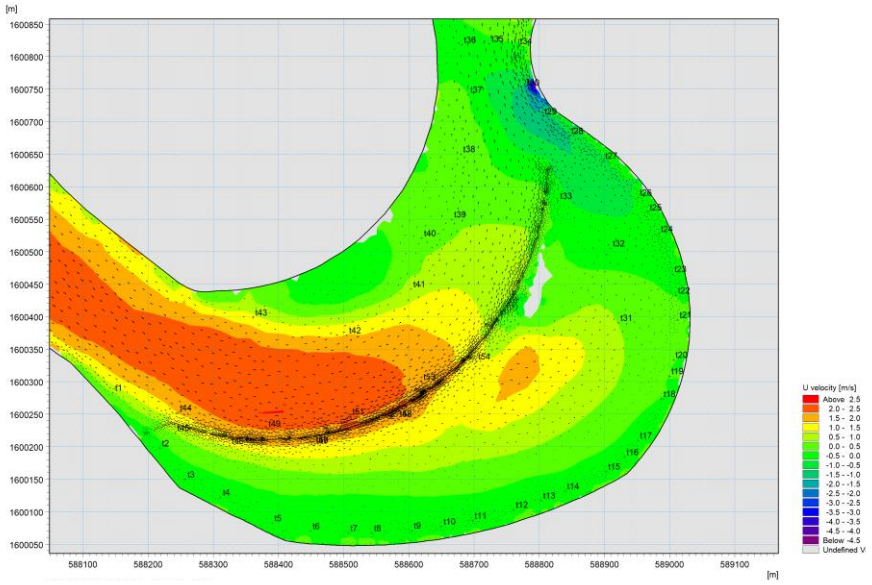
For the Khanh Trach reach, the proposed scheme consists of constructing a low division dike in the middle of the river, 850 m long and 2.0 m wide, with a curvature radius of R = 429 m, crest elevation of +1.0 m, and side slope coefficient m = 1.5; excavating and lowering the bed elevation of the left channel to –3.5 m over a width of 121 m. The selected scheme must ensure that the flood water level does not increase compared to the existing condition and that the natural riverbanks are not adversely altered.

Simulation results indicate that under low-flow conditions in the Lai Giang River, discharge is primarily concentrated in the left channel, while the right channel mainly experiences water-level fluctuations. Under high-flow conditions, when the water level exceeds the crest elevation of the division dike, discharge is redistributed between the two channels. The left channel becomes hydraulically dominant due to the influence of the training works (B. Przedwoski et al., 1994; Nguyen The Hung, 2024).

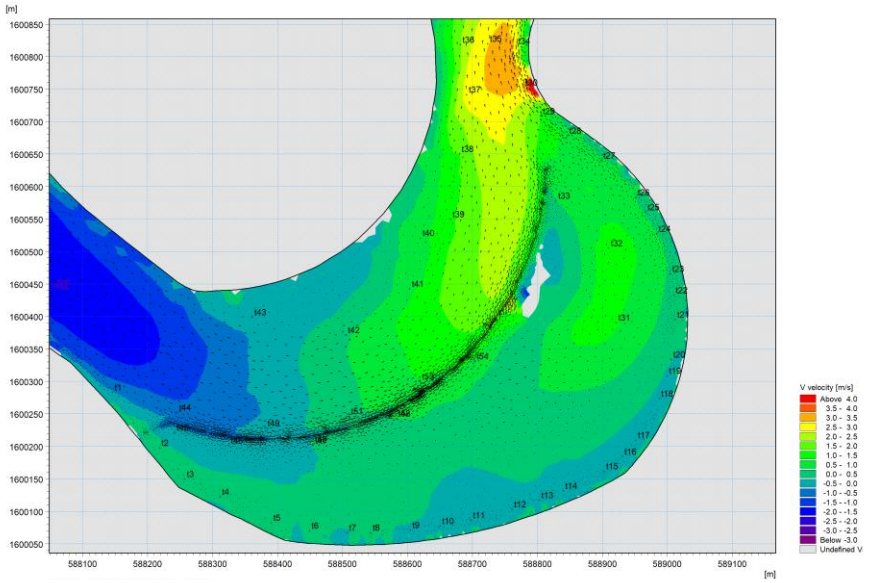
This redistribution significantly improves river regulation effectiveness. The sustained flow in the left channel enhances flood conveyance capacity, transports sediment downstream, and reduces deposition. The right channel receives partial discharge after flow passes over the division dike, functioning hydraulically similar to a broad-crested weir. Because discharge is divided, flow dominance in the right channel is reduced, thereby significantly decreasing bank erosion.

Although dividing the flow reduces impacts on both existing banks, flow velocity over the dike crest increases, which may threaten downstream stability. Therefore, riverbed protection upstream and downstream of the dike alignment is necessary.

The analysis indicates that the proposed scheme performs effectively. Near-bank velocity along the right branch decreases by 20%–50% compared to the existing condition, and the peak flood water level is reduced by approximately 0.2 m. The increased discharge in the left branch enhances sediment transport capacity and reduces channel infilling.



(a)



(b)

Figure 12. Velocity field of the river creek scheme (at simulation time t = 930 minutes)

(a) Velocity field U; (b) Velocity field V

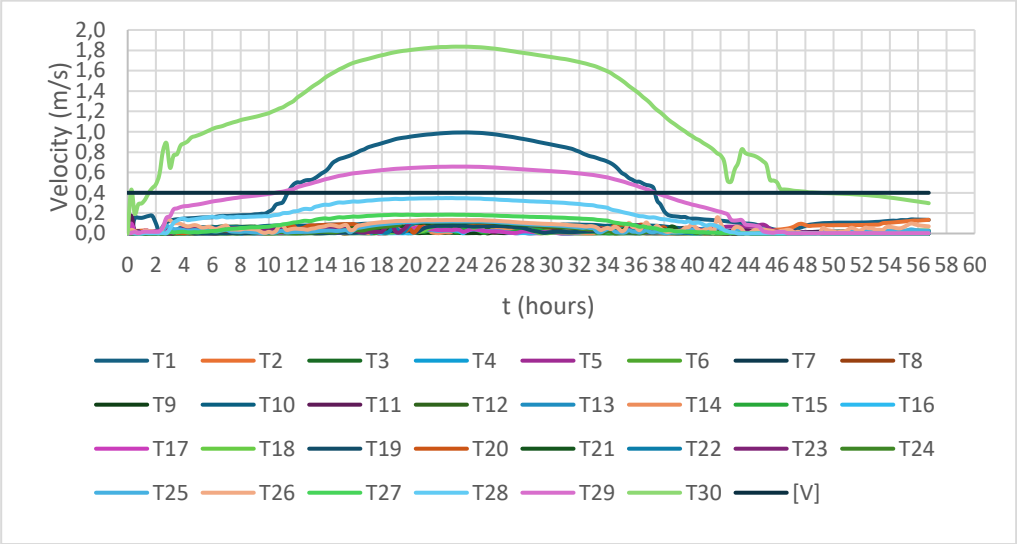


Figure 13. Flow velocity at locations T1÷T30

In summary, the proposed channel diversion scheme for the Khanh Trach reach provides significant river regulation benefits and addresses many of the stated management objectives. Its advantages include increased flood conveyance capacity, improved riverbank stability, prevention of sediment deposition, and low construction cost. The main drawback of this scheme is that the diversion embankment functions similarly to a weir; consequently, the high-velocity flow over the crest may cause erosion downstream, and the upstream water level may rise. Reinforcement of both the upstream and downstream aprons is therefore necessary to ensure long-term structural stability.

Closure of secondary branch

The objective of the secondary branch closure scheme is to concentrate the flow into the left channel. As a result, the right channel no longer conveys flow, and its banks are not directly affected by flood currents (B. Przedwoski et al., 1994; Nguyen The Hung, 2024; P. Ph. Jansen et al., 1979). Instead, they are influenced only by water-level fluctuations, thereby maintaining stability. Furthermore, this scheme enhances flood conveyance capacity, reduces flooding, and limits sediment deposition.

Similar to the aforementioned channel diversion scheme, the selected closure structure must satisfy the proposed objectives while ensuring that flood water levels do not increase and that the existing riverbanks are not adversely altered.

Based on the above conditions and the riverbed topography, the proposed closure scheme involves constructing a high embankment along the mid-channel, 858 m in length and 2.0 m in width, with a curvature radius of R = 429 m, a crest elevation of +▼5.0m, and a side slope coefficient of m = 1.5. The bed elevation of the left channel will be excavated to -▼4.5m, with a with of 121 m.

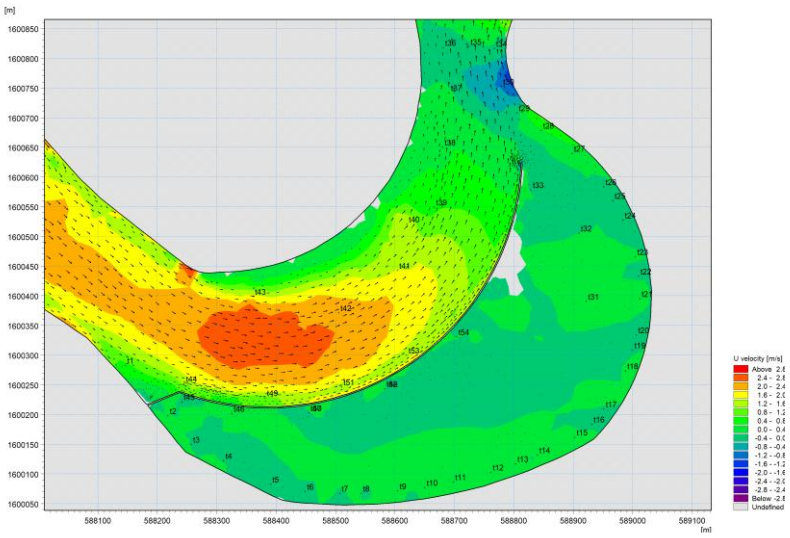
The calculation results show that the flow is concentrated in the left channel, following the curvature alignment of the embankment connecting the upstream and downstream sections. The flow velocity in the left channel increases significantly compared to the existing condition. The main current is evenly distributed along the channel without abrupt changes and tends to shift

toward the embankment alignment; therefore, the near-bank velocity along the existing left bank remains relatively low, with limited impact on bank stability.

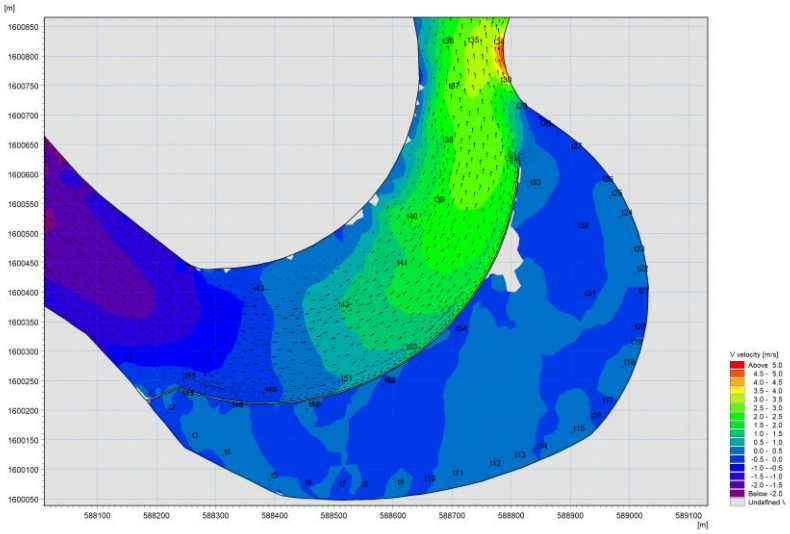
The smooth hydraulic transition between the existing river and the regulated channel accelerates flood conveyance, lowers flood water levels, reduces both the extent and duration of upstream inundation, and improves the safety of levee structures.

Flow in the left channel is maintained under all discharge conditions in the Lai Giang River. In particular, flood flows carrying large sediment loads are prevented from depositing within the channel, as most of the sediment is transported downstream to the river mouth. The right channel is no longer directly subjected to flow currents; instead, it experiences only water-level fluctuations, resulting in relatively low near-bank velocities.

The analysis indicates that the secondary branch closure scheme is technically feasible. Near-bank velocity along the right channel decreases significantly by 30%–80% compared to the existing condition, and the peak flood water level is reduced by approximately 0.4 m. The increased discharge in the left channel enhances sediment transport capacity and reduces channel deposition.



(a)



(b)

Figure 14. Velocity field of closure of secondary branch (at simulation time t = 930 minutes)

(a) Velocity field U; (b) Velocity field V

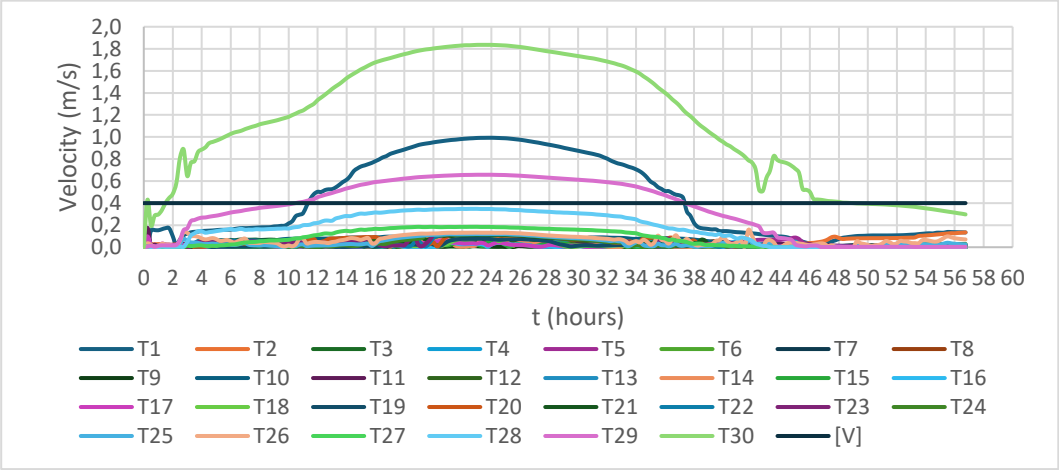


Figure 15. Flow velocity at locations T1÷T30

In summary, the secondary branch closure plan for the Khanh Trach reach offers the most effective river management solution, addressing many of the key river regulation concerns. Its advantages include increased flood conveyance capacity, lowered flood water levels, reduced flooding, enhanced riverbank stability, prevention of sediment deposition, and lower construction costs. However, when selecting this option, in addition to assessing the structural stability of the river training works, it is also necessary to conduct a comprehensive evaluation of the riverbed morphology of the Lai Giang River both upstream and downstream of the Khanh Trach reach.

DISCUSSION

The structural alternatives simulated in the computational model are well aligned with actual field conditions.

The hydrodynamic simulation results of the river training structures clearly demonstrate the trend and magnitude of flow velocity. These results provide a more comprehensive and detailed basis for evaluating and analyzing the effectiveness of the river training works compared with empirical formulas, while also enabling prediction of channel morphological evolution.

All proposed engineering alternatives effectively achieve the river training objectives, with the channel diversion and channel closure options demonstrating the most comprehensive performance.

All engineering alternatives are highly feasible, easy to implement, and involve relatively simple structural configurations.

The selection of a suitable engineering alternative should depend on the project objectives, local requirements, and socio-economic conditions at the time of implementation. Particular attention should be given to ensuring the long-term structural stability of the works, which is the most critical factor.

CONCLUSION

The study entitled "Study on River Training Solutions for the Khanh Trach Reach of the Lai Giang River, Binh Dinh Province" proposed four engineering alternatives that are suitable for the current conditions of the Khanh Trach reach and consistent with the river training objectives, including:

- Revetment combined with low groynes;
- High groynes;
- Channel diversion;
- Closure of secondary branch.

The engineering alternatives were developed based on a comprehensive analysis and evaluation of topographic, geological, hydrological, and hydraulic characteristics, as well as the current state of riverbed changes and the causes of bank erosion. The MIKE21-FM numerical model was applied to simulate the hydrodynamic behavior of the proposed engineering alternatives. The simulation results accurately reflect the physical characteristics of flow through the structures, providing a scientific basis for technical and economic decision-making in selecting the most appropriate construction option.

REFERENCES

Artur Radecki-Pawlik et al., (2018). Open Channel Hydraulics, River Hydraulic Structures and Fluvial Geomorphology. CRC Press.

B. Przedwoski et al., (1994). River Training Techniques Fundamentals, Techniques and Applications. Delf/Poznan.

Chen X, Han Q, Fang C., (2007). Variation of dominant discharge in lower Yellow River and its influence on river channel. J Hydraul Eng 38(1):15–22.

Copeland, R.R., (1983). Bank Protection Techniques Using Spur Dikes. Miscellaneous paper HL83-1, U. S. Army Engineer Waterways Experiment Station.

Cunge J.A., and al., (1980). Practical aspects of computational river hydraulics. Pitman Publishing INC.

DHI, (2017). *Mike 21 & Mike 3 flow model FM Hydrodynamic and Transport Module Scientific documentation*. WWW.mikepoweredbydhi.com/products/mike-21

Francis, J.R., Pattanick, A., and Wearne, S., (1968). "Observations of flow patterns around some simplified groyne structures in channels" Technical Note No. 8, Proc., Inst. of Civil Engineers, London, England, Dec., pp. 829-846.

Guangming Tan et al., (2019). Estimations and changes of the dominant discharge in Three Gorges Reservoir channel. Arabian Journal of Geosciences 12:82. https://doi.org/10.1007/s12517-019-4262-y

Leo C. Van Rijn, (1993). Principles of sediment transport in Rivers, Estuaries and coastal seas. Aqua Pub. , The Netherlands.

Luong Phuong Hau, (2004). River training works. Hydraulic Engineering Manual.

Maynord, S.T., (1996). "Toe-scour estimation in stabilized bendways", Journal of Hydraulic Engineering, 122(8), 460-464.

Mohamed F. M. Yossef and Huib J. de Vriend, (2011). "*Flow Details near River Groynes Experimental Investigation".* Journal Of Hydraulic Engineering, ASCE*,* Vol 137, pp. 1109-1121.

Nguyen Quang Binh, Nguyen The Hung, Nguyen Thong, (2017). Comparing the effectiveness of TELEMAC 3D and FLOW 3D in simulating flow over and around groynes. Proceeding of National Conference for Fluid Mechanics, pp 37-46.

Nguyen The Hung and Huynh Lam Nguyen, (2016). Reasonable distance between groynes placed on concave bank. Ministry of Construction Journal, pp. 181-185.

Nguyen Tan Huong, (2004). Climate and hydrological characteristics of Binh Dinh province.

Nguyen The Hung, (2024). River training. Construction Pub. House.

Nguyen Van Bao, (2018). Investigating for constructing protective embankments along the Lai Giang river at Khanh Trach reach, Binh Dinh province, M.Eng. Thesis.

P. Ph. Jansen et al., (1979). Principles of River Engineering. Pitman Pub.

Pickup G, Warner R. F., (1976). Effects of hydrologic regime on magnitude and frequency of dominant discharge. J Hydrol 29:51–75.

Pierre Y. Julien, (2002). River Mechanics. Cambridge University Press.

Ramakar Jha et al., Editors, (2022). River Hydraulics, Springer.

Sun D, Wang Q et al., (2013). Determination of dominant discharge of the lower Yellow River based on coefficient frequencies of flow sediment relationship. J Hydroelectr Eng 32(01):150–155.

Vu, M. T., Vo, N. D., Gourbesville, P., Raghavan, S. V., & Liong, S. Y., (2017). Hydro-meteorological drought assessment under climate change impact over the Vu Gia–Thu Bon river basin, Vietnam. Hydrological Sciences. Journal, 62(10), 1654–1668. https://doi.org/10.1080/02626667.2017.1346374

Weiming Wu, (2007). Computational River Dynamics. Taylor & Francis INC.

Zhang W., et al., (2018). Changes in dominant discharge and their influential factors in the middle and lower reaches of Yangtze River after the Three Gorges Dam impoundment. Adv Water Sci 29(03):331–338.

Zhao-Yin Wang et al., (2015). River Dynamics and Integrated River Management. Tsinghua University Press.

BEYOND THE CLASSROOM: THE USE OF EDUCATIONAL ROBOTICS IN SCIENCE EDUCATION FROM PARENTS' PERSPECTIVES

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Özet

Eğitsel robotların (ER) fen ve STEM eğitimine entegrasyonu, öğrencilerin 21. yüzyıl becerilerini geliştirmede kritik bir rol oynamasına rağmen, bu yenilikçi araçların ev-okul ekosistemindeki algılanış biçimi yeterince incelenmemiştir. Mevcut literatür çoğunlukla öğretmen ve öğrenci boyutlarına odaklanırken, teknoloji benimseme sürecinin kilit paydaşlarından olan velilerin perspektifleri sınırlı kalmıştır. Bu nitel durum çalışması, çocukları eğitsel robot deneyimine sahip velilerin, fen eğitiminde ER kullanımına yönelik inançlarını, tutumlarını ve farkındalık düzeylerini incelemeyi amaçlamaktadır. Amaçlı örnekleme yöntemiyle seçilen ve farklı sosyo-eğitimsel arka planlara sahip üç veli ile gerçekleştirilen yarı yapılandırılmış görüşmeler, tümevarımsal tematik analiz kullanılarak incelenmiştir. Araştırma bulguları velilerin ER'ye yönelik yüksek düzeyde duyuşsal onay (mutluluk, motivasyon) sergilediklerini, ancak ER'nin fen bilimlerindeki pedagojik işlevine dair bilişsel farkındalıklarının parçalı ve yüzeysel olduğunu ortaya koymuştur. Çalışma velilerin robotik uygulamalarını müfredata entegre bir fen öğrenme aracından ziyade, izole bir bilişim veya kulüp etkinliği olarak konumlandırdığını göstermektedir. Bu sonuçlar, STEM eğitiminde sürdürülebilir bir başarı için veli dijital okuryazarlığının artırılmasının ve ekolojik sistem yaklaşımı bağlamında stratejik okul-aile ortaklıklarının kurulmasının önemini vurgulamaktadır.

Anahtar Kelimeler: Eğitsel robotlar, Fen eğitimi, Veli algısı, STEM eğitimi, Nitel araştırma, Ev-okul iş birliği.

ABSTRACT

Although the integration of educational robotics (ER) into science and STEM education plays a critical role in fostering students' 21st-century skills, the perception of these innovative tools within the home-school ecosystem remains underexplored. While existing literature predominantly focuses on teacher and student dimensions, the perspectives of parents—key stakeholders in the technology adoption process—have received limited attention. This qualitative case study aims to investigate the beliefs, attitudes, and awareness levels of parents regarding the use of ER in science education, focusing on those whose children have prior ER experience. Data were collected through semi-structured interviews with three parents from diverse socio-

educational backgrounds, selected via purposive sampling, and analyzed using inductive thematic analysis. The findings reveal that while parents exhibit a high level of affective endorsement (e.g., increased student happiness and motivation), their cognitive awareness of the specific pedagogical function of ER in science is fragmented and superficial. The study indicates that parents tend to position robotics applications as isolated informatics or extracurricular club activities rather than as integrated science learning tools. These results emphasise the importance of enhancing parental digital literacy and establishing strategic school-family partnerships grounded in an ecological systems approach to ensure sustainable success in STEM education.

Keywords: Educational robotics, Science education, Parental perception, STEM education, Qualitative research, Home-school collaboration.

GİRİŞ

Eğitim sistemleri 21. yüzyılın hızla değişen sosyo-teknolojik dinamiklerine uyum sağlamak amacıyla, öğrencileri yalnızca pasif bilgi alıcıları olmaktan çıkarıp eleştirel düşünen, karmaşık problemleri çözebilen ve dijital teknolojileri yaratıcı bir şekilde kullanabilen bireyler olarak yetiştirmeyi hedeflemektedir (Trilling & Fadel, 2009). Bu bağlamda fen eğitimi, öğrencilerin bilimsel okuryazarlık düzeylerini artırmada ve 21. yüzyıl becerilerini kazanmalarında merkezi bir rol oynamaktadır. Özellikle STEM (Fen, Teknoloji, Mühendislik ve Matematik) temelli yaklaşımlar, bilimsel teorilerin gerçek yaşam senaryolarıyla ilişkilendirilmesine olanak tanıyarak öğrencilerin analitik düşünme süreçlerini derinleştirmektedir (Beers, 2011; Bybee, 2013). Bu yenilikçi pedagojik süreçte dijital araçlar, yalnızca öğretimi destekleyen yardımcı materyaller olmanın ötesine geçerek, soyut kavramların somutlaştırılmasını ve uygulamalı öğrenmenin gerçekleşmesini sağlayan temel bilişsel araçlar haline gelmiştir (Ertmer & Ottenbreit-Leftwich, 2010; Honey ve ark., 2014).

Bu teknolojik entegrasyon sürecinde, eğitsel robotlar (ER) fen ve STEM eğitiminin dönüştürücü bileşenlerinden biri olarak giderek daha fazla öne çıkmaktadır. Programlanabilir, etkileşimli ve dokunsal yapıları sayesinde ER; öğrencilere hipotez kurma, test etme, hata ayıklama ve iş birlikli problem çözme gibi üst düzey bilimsel süreç becerilerini uygulama imkânı sunmaktadır (Bers, 2010; Eguchi, 2014; Mubin ve ark., 2013). Literatürdeki çalışmalar, fen derslerine entegre edilen robotik etkinliklerin, öğrencilerin karmaşık fen kavramlarını anlamlandırma kapasitelerini, algılanan öz-yeterliklerini ve içsel motivasyonlarını anlamlı düzeyde artırdığını ortaya koymaktadır (Alimisis, 2013; Benitti, 2012; Sullivan & Heffernan, 2016).

Bununla birlikte eğitim teknolojilerinin sürdürülebilir ve etkili entegrasyonu yalnızca sınıf içi dinamiklerle, yani öğretmen ve öğrenci ekseniyle sınırlı bir olgu değildir. Bronfenbrenner'ın (1979) Ekolojik Sistemler Teorisi (Ecological Systems Theory) bağlamında ele alındığında, öğrencinin bilişsel ve duyuşsal gelişimi, içinde bulunduğu mikrosistemlerin (ev ve okul) karşılıklı etkileşimi ile doğrudan şekillenmektedir. Bu ekosistemde veliler, çocukların teknolojiye erişimini, evdeki teknolojik altyapıyı ve öğrenme araçlarına yönelik epistemolojik inançları belirleyen kilit geçit tutucular olarak işlev görmektedir. Nitekim teknoloji kabul ve veli katılımı modelleri, ailelerin eğitsel araçlara yönelik farkındalık ve destek düzeylerinin, çocukların söz konusu araçları benimseme ve akademik süreçlerine dahil etme başarılarını doğrudan yordadığını vurgulamaktadır (Çiftçi & Topal, 2020; Serholt ve ark., 2017).

Alanyazın incelendiğinde, eğitimde robotik kullanımına yönelik güncel araştırmaların ezici bir çoğunluğunun öğrenci kazanımlarına, akademik başarıya (Demirer & Erbaş, 2021; Li ve ark., 2020) veya öğretmen tutumlarına odaklandığı görülmektedir. Sınırlı sayıdaki çalışmada velilerin eğitsel robotlara yönelik genel görüşleri incelenmiş, ailelerin robotları yenilikçi ve motive edici bulmakla birlikte, ekran süresi, sosyal izolasyon, maliyet ve insan etkileşiminin azalması gibi

konularda kaygılar taşıdıkları rapor edilmiştir (Mubin ve ark., 2016; Tanaka & Kimura, 2019). Ancak bu çalışmalar genellikle robotların genel kullanımına veya okul öncesi dönemdeki sosyal işlevlerine odaklanmaktadır. Velilerin, robotların özel bir akademik disiplin olan fen eğitimindeki pedagojik işlevlerine, STEM kazanımlarına ve bilimsel okuryazarlığa katkılarına yönelik algılarını ve farkındalıklarını derinlemesine inceleyen nitel araştırmalar literatürde kritik bir boşluk oluşturmaktadır.

Bu boşluktan hareketle tasarlanan bu çalışma, eğitsel robotların ev-okul ekosistemindeki algılanış biçimini veli perspektifinden aydınlatmayı amaçlamaktadır. Velilerin fen eğitiminde robot kullanımına yönelik inanç ve tutumlarının anlaşılamaması, STEM eğitiminde planlanan müfredat hedeflerinin ev ortamında desteklenememesi ve okul-aile iş birliğinin zayıflaması riskini taşımaktadır. Bu doğrultuda araştırmanın temel amacı, çocukları eğitsel robot deneyimine sahip velilerin, bu teknolojilerin fen eğitimine entegrasyonuna yönelik görüşlerini incelemektir. Bu genel amaç doğrultusunda aşağıdaki araştırma sorusuna yanıt aranmıştır:

"Çocukları eğitsel robot deneyimine sahip velilerin, fen ve STEM eğitiminde eğitsel robot kullanımına yönelik algıları, inançları ve pedagojik farkındalık düzeyleri nelerdir?"

YÖNTEM

Araştırma Deseni

Bu çalışma, çocukları eğitsel robot (ER) kullanan velilerin fen ve STEM eğitimindeki ER kullanımına ilişkin deneyimlerini, algılarını ve inançlarını derinlemesine incelemek amacıyla nitel araştırma yaklaşımıyla tasarlanmıştır. Araştırmanın deseni olarak nitel araştırma yöntemleri içinde yer alan Çoklu Durum Çalışması (Multiple Case Study) benimsenmiştir (Yin, 2018). Durum çalışmaları, sınırları belirli bir sistemin, gerçek yaşam bağlamı içinde incelenmesine olanak tanır (Merriam, 2014). Katılımcıların birbirinden farklı sosyo-ekonomik ve eğitimsel arka planlara sahip olması, her bir velinin kendi bağlamı içinde farklı bir durum olarak ele alınmasını ve elde edilen bulguların karşılaştırılmasını sağlamıştır.

Çalışma Grubu

Araştırmanın çalışma grubu, amaçlı örnekleme yöntemlerinden ölçüt örnekleme ve maksimum çeşitlilik örneklemesi stratejileri bir arada kullanılarak belirlenmiş üç veliden oluşmaktadır. Ölçüt örnekleme bağlamında, araştırmaya dahil edilecek velilerin çocuklarının formal veya informal eğitim süreçlerinde en az bir dönem eğitsel robot (örneğin Lego, Arduino, mBot) deneyimine sahip olması temel kriter olarak belirlenmiştir. Maksimum çeşitlilik stratejisi ise velilerin teknolojiye ve eğitsel araçlara yönelik farklı bakış açılarını yakalayabilmek amacıyla meslek ve eğitim düzeylerindeki çeşitliliğin sağlanması için tercih edilmiştir. Katılımcıların demografik özelliklerine ilişkin detaylar Tablo 1'de sunulmuştur.

Tablo 1. *Velilere Ait Demografik Bilgiler*

Katılımcı Kod	Cinsiyet	Meslek	Eğitim Düzeyi	Yaş
V1	Erkek	Tıp Doktoru	Lisans	47
V2	Kadın	Ev Hanımı	Lise	42
V3	Erkek	Öğretmen	Lisans	38

Veri Toplama Araçları ve Süreci

Araştırmanın temel veri toplama aracı olarak, araştırmacılar tarafından literatür taraması doğrultusunda geliştirilen yarı yapılandırılmış görüşme formu kullanılmıştır. Görüşme formu katılımcıların eğitsel robotları tanımlama biçimlerini, bu araçların kullanım alanlarına yönelik farkındalıklarını ve öğrencilerin bilişsel, duyuşsal ve sosyal gelişimleri üzerindeki etkilerine ilişkin

gözlemlerini değerlendiren açık uçlu sorulardan ve alt sondalardan oluşmaktadır. Veri toplama aracının kapsam geçerliğini ve anlaşılırlığını sağlamak amacıyla fen eğitimi ve eğitim teknolojileri alanında uzman iki akademisyenin görüşüne başvurulmuş, gerekli düzenlemeler yapıldıktan sonra veri toplama sürecine geçilmiştir.

Verilerin Analizi

Görüşmelerden elde edilen nitel veriler, Braun ve Clarke (2006) tarafından çerçevesi çizilen Tematik Analiz yaklaşımı ve tümevarımsal kodlama yöntemiyle analiz edilmiştir. Analiz süreci, verilerin dökümünün yapılması ve araştırmacılar tarafından defalarca okunarak veriye aşinalık kazanılması, veri seti içindeki anlamlı ifadelere başlangıç kodlarının atanması, kodların ilişkili temalar altında gruplanması ve son olarak temaların araştırma soruları bağlamında tanımlanarak isimlendirilmesi aşamalarından oluşmuştur.

Geçerlik, Güvenirlik ve Etik Hususlar

Nitel araştırmalarda inandırıcılığı ve aktarılabilirliği sağlamak amacıyla Lincoln ve Guba (1985) tarafından önerilen stratejiler kullanılmıştır. Araştırmanın güvenirliğini artırmak için veri analizi sürecinde farklı uzman görüşleri alınmış, kodlayıcılar arası görüş birliği sağlanmıştır. Ayrıca, ulaşılan temalar ve yorumlar görüşmelerin ardından katılımcılarla paylaşılarak katılımcı doğrulaması yapılmıştır. Araştırmanın aktarılabilirliği ise araştırma sürecinin, katılımcı özelliklerinin ve bulguların zengin ve detaylı betimlemeler ile sunulması ve katılımcı alıntılarının doğrudan (tırnak içinde) verilmesiyle desteklenmiştir. Araştırma öncesinde tüm katılımcılardan "Bilgilendirilmiş Gönüllü Onam Formu" alınarak araştırma etiği güvence altına alınmıştır.

BULGULAR

Çocukları formal veya informal öğrenme ortamlarında eğitsel robot (ER) deneyimine sahip velilerle gerçekleştirilen yarı yapılandırılmış görüşmelerin tümevarımsal tematik analizi sonucunda, elde edilen veriler üç ana tema altında toplanmıştır: (1) Eğitsel Robotlara Yönelik İnançlar ve Tanımlamalar, (2) Disiplinlerarası Entegrasyon ve Fen Eğitimindeki İşleve Yönelik Farkındalık, (3) Bilişsel ve Duyuşsal Kazanımlara Yönelik Veli Gözlemleri. Velilerin görüşlerinden elde edilen kodlar ve tematik yapı Tablo 2'de özetlenmiştir.

Tablo 2. *Veli Görüşlerinden Elde Edilen Temalar ve Kodlar*

Temalar / Kategoriler	Kodlar	Katılımcılar
Tema 1: ER Tanımlamaları ve İnançlar	Etkileşimli Araç	V1
	İlgi Çekici Materyal	V1
	Mühendislik Becerilerini Geliştiren	V2
	Programlanabilir Sistem	V3
Tema 2: Kullanım Alanı ve Farkındalık	Bilişim Teknolojileri	V2, V3
	Yabancı Dil ve Müzik Öğretimi	V1
	Her Branş / Disiplinlerarası (Fen vb.)	V3
Tema 3: Öğrenci Üzerindeki Etkiler	Mutluluk ve Motivasyon (Duyuşsal)	V1, V3
	Okulu Sevme / Aidiyet (Duyuşsal)	V3
	Bilişsel Gelişim ve Muhakeme	V2
	Akademik Başarıda Artış	V3

Tema 1: Eğitsel Robotlara Yönelik İnançlar ve Tanımlamalar

Velilerin eğitsel robotları algılayış biçimleri, sahip oldukları mesleki arka plan ve dijital okuryazarlık düzeylerine göre belirgin farklılıklar göstermektedir. Teknik altyapıya sahip olmayan veliler (V1 ve V2), eğitsel robotları kavramsal olarak tanımlamaktan ziyade, kullanım amaçları ve işlevleri üzerinden pragmatik bir çerçevede değerlendirmişlerdir. Örneğin, sağlık sektöründe çalışan V1, eğitsel robotları birer "etkileşimli araç" olarak görürken, deneyimini ticari eğitim

setleri üzerinden yapılandırmıştır: *"Yıllar önce kızım için İngilizce eğitim seti almıştım"*. Benzer şekilde V2, robotik uygulamaları çocuğunun gelecekteki kariyer planlamasına dönük bir ön hazırlık olarak değerlendirmiştir: *"Okul aracılığıyla tanıştık; oğlumun ileride mühendislik alanında tercih yapması durumunda faydalı olabilir"*. Buna karşın mesleki formasyonu gereği konuya pedagojik ve teknik bir mercekten yaklaşan bilişim teknolojileri öğretmeni V3, robotları donanımsal ve yazılımsal esneklikleri bağlamında çok daha yapısal bir şekilde tanımlamıştır : *"Arduino ile tanışmamız yaklaşık 10 yıl önce oldu. Kolay programlanabilir ve düşük maliyetli olduğundan hızla yayıldı"*. Bu durum, velilerin eğitsel robotlara yönelik bilişsel algılarının homojen olmadığını ve teknolojik aşinalık düzeyinin bu inançları doğrudan şekillendirdiğini göstermektedir.

Tema 2: Disiplinlerarası Entegrasyon ve Fen Eğitimindeki İşleve Yönelik Farkındalık

Araştırmanın en çarpıcı bulgularından biri, velilerin eğitsel robotların **fen bilimleri eğitimindeki** potansiyeline yönelik farkındalıklarında ortaya çıkan boşluktur. V1 ve V2 kodlu katılımcılar, robotik uygulamaları müfredata entegre bir fen öğrenme aracından ziyade dil öğretimi, sanat (müzik) veya izole bir bilişim donanımı olarak konumlandırmıştır. V1, robot kullanımını *"İlk çocuğumda yabancı dil için kullandım; bu çocuğum ise müzikte"* şeklinde ifade ederken; V2 ise robotların fen eğitimiyle ilişkisini tamamen reddeden bir yaklaşım sergilemiştir: *"Bilişimde kullanıyorlar, fen derslerinde pek tercih edilmiyor"*. Bu ifadeler, velilerin ev-okul ekosisteminde STEM entegrasyonuna dair ciddi bir bilgi eksikliği yaşadıklarına işaret etmektedir. Öte yandan, alan uzmanı olan V3, eğitsel robotların fen eğitimi başta olmak üzere disiplinlerarası bir köprü işlevi görebileceğine dair güçlü bir pedagojik farkındalık yansıtmıştır: *"Fen ve teknoloji derslerinde mBot'lar çok kullanışlı; Scratch'in Türkçe olması, hiç yazılım bilmeyenlerin bile rahat kullanmasını sağlıyor. Hatta tarih dersi bile uygun olabilir"*. Bu bulgu, okullardaki robotik uygulamaların velilere doğru aktarılamaması durumunda, bu araçların fen eğitimi gibi temel disiplinlerdeki dönüştürücü rolünün gözden kaçırılabileceğini kanıtlamaktadır.

Tema 3: Bilişsel ve Duyuşsal Kazanımlara Yönelik Veli Gözlemleri

Veliler çocuklarının eğitsel robot deneyimlerine ilişkin gözlemlerini aktarırken, bu araçların özellikle duyuşsal alan üzerindeki pozitif etkileri konusunda güçlü bir fikir birliği sergilemişlerdir. Eğitsel robotlar veliler tarafından çocukları mutlu eden, motive eden ve oyunlaştırma yoluyla öğrenmeyi destekleyen eğlenceli unsurlar olarak görülmektedir. V1, bu süreci *"Tabii, oyun gibi zevk alarak yapıyordu"* diyerek betimlerken; V3, duyuşsal katılımın akademik çıktıları doğrudan beslediğine dikkat çekmiştir: *"Okulu severse öğrenmesi çok artar"*. Bilişsel kazanımlar boyutunda ise veliler, robotik etkinliklerin üst düzey düşünme becerilerini tetiklediğine inanmaktadır. Katılımcı V2, kısa vadede okul başarı notlarında majör bir farklılık hissetmediğini belirtse de, sürecin zihinsel kapasite üzerindeki uzun vadeli etkisine olan inancını şu sözlerle ifade etmiştir: *"Beyin gelişimini destekleyebilir, muhakeme yeteneğini kuvvetlendirir"*. Sonuç olarak veliler, eğitsel robotların akademik başarıyı artırmasından ziyade, ilk etapta öğrencilerin duyuşsal katılımını ve bilişsel esnekliklerini güçlendiren pedagojik katalizörler olduğuna inanmaktadır.

TARTIŞMA, SONUÇ VE ÖNERİLER

Eğitimdeki dijital dönüşüm süreci, yapay zekâ ve eğitsel robotların öğrenme ortamlarına entegrasyonunu hızlandırmış ve bu araçları etkileşimli, deneyimsel öğrenme sunan temel yapıtaşları haline getirmiştir. Ancak araştırmamızın bulguları, bu teknolojilerin etkili ve sürdürülebilir kullanımının yalnızca sınıf içi aktörlerle (öğretmen ve öğrenci) sınırlı bir olgu olmadığını velilerin algı, inanç ve tutumlarının da çocuğun evdeki destek düzeyini ve teknolojiye katılımını doğrudan şekillendirdiğini teyit etmektedir (Çiftçi & Topal, 2020; Özcan & Korkmaz, 2022; Serholt ve ark., 2017).

Araştırma bulguları incelendiğinde, teknolojik/bilişim uzmanlığı bulunmayan velilerin (V1 ve V2) eğitsel robotların pedagojik işlevlerine dair oldukça sınırlı ve yüzeysel bir bilgiye sahip oldukları görülmektedir. Bu veliler, robotik etkinlikleri fen bilimleri müfredatının entegre bir parçası olarak görmek yerine, daha çok okul sonrası sosyal faaliyet veya kulüp etkinliği olarak algılamaktadır. Bu yanılgı, mevcut eğitim sistemimizde eğitsel robot kullanımının genellikle müfredat dışı izole kulüp saatlerinde veya özel kurslarda verilmesi pratiğiyle (Alimisis, 2013) yakından ilişkilidir. Buna karşın, konuya pedagojik ve teknik bir mercekten bakan alan uzmanı veli (V3), robotların fen bilimleri başta olmak üzere çok yönlü kullanım potansiyeline ve dersler arası entegrasyonuna dikkat çekerek literatürle uyumlu bir perspektif yansıtmıştır.

Öğrenci kazanımları bağlamında değerlendirildiğinde veliler, eğitsel robotların çocukların okula yönelik ilgilerini artırdığını ve onları mutlu ettiğini vurgulayarak, önceliği bilişsel gelişimden ziyade duyuşsal alana verdiklerini göstermişlerdir. Veliler, bu araçların çocuklarının düşünsel muhakeme ve sosyal becerilerini kademeli olarak geliştirdiğine inanırken, aynı zamanda gelecekteki mesleki tercihlerine (örneğin mühendislik alanına) stratejik bir altyapı oluşturduğunu düşünmektedirler. Bu bulgu, robotik etkinliklerin öğrencilerin motivasyonunu, STEM kariyer ilgilerini ve akademik algılarını pozitif yönde etkilediğini vurgulayan literatürle güçlü bir şekilde örtüşmektedir (Chen & Chang, 2018; Chung ve ark., 2014; Yıldız & Gülseçen, 2021).

Öte yandan, veliler eğitsel robotlara genel hatlarıyla olumlu yaklaşmakla ve desteklemekle birlikte, eğitimin temelindeki insan faktörünün korunması gerektiğini, yani robotların kesinlikle öğretmenin yerini almaması ve kullanımlarının kontrollü, dengeli ve eğitsel hedeflerle sınırlı olması gerektiğini net bir duruşla savunmaktadırlar. Bu savunma mekanizması, ulusal literatürde velilerin teknolojiye dair sıklıkla dile getirdikleri ekran süresi artışı, dijital bağımlılık, donanım maliyetleri, sosyal etkileşim kaybı ve öğretmen yeterlilikleri gibi kaygılarla (Demirer & Erbaş, 2021; Güner & Doğru, 2019; Korkmaz ve ark., 2019) doğrudan paralellik göstermektedir. Uluslararası alanda Japonya bağlamında Tanaka ve Kimura (2019) ile Avrupa ülkelerindeki durumu inceleyen Serholt ve arkadaşları (2017) da benzer bir şekilde ailelerin yenilikçi teknolojileri desteklediklerini, ancak çocukların insan dışı varlıklarla aşırı duygusal bağ kurmasından ve bunun yaratabileceği sosyal gelişim erozyonundan ciddi endişe duyduklarını ortaya koymuştur. Dolayısıyla tüm bu sonuçlar, teknolojik araçların eğitim sistemine başarılı bir şekilde adapte edilmesinde veli tutumlarının belirleyici bir rol üstlendiğini ve robotik uygulamaların planlama aşamasında ailelerin pedagojik farkındalığının artırılmasının stratejik bir zorunluluk olduğunu kanıtlamaktadır.

Araştırmadan elde edilen tüm bu sonuçlar ve alan yazındaki mevcut boşluklar ışığında, politika yapıcılar, okul yöneticileri ve eğitimcilere yönelik şu stratejik öneriler geliştirilmiştir:

- Velilerin STEM entegrasyonu konusundaki yanılgılarını gidermek amacıyla, okul yönetimleri tarafından eğitsel robotların fen derslerindeki akademik işlevlerini açıklayan bilgilendirici içerikler (seminerler, bültenler) hazırlanmalıdır.
- Ekolojik sistemler yaklaşımının bir gereği olarak öğrencinin teknoloji kullanımını evde destekleyecek, öğretmen-veli iş birliğini salt bilgilendirmeden çıkarıp aktif katılıma dönüştürecek yeni iletişim modelleri geliştirilmelidir.
- Eğitsel robotların ve yapay zekâ tabanlı sistemlerin eğitim kurumlarına entegrasyonunda, pedagojik şeffaflık, veri gizliliği, etik ilkelere uyum ve sürekli rehberlik faaliyetleri kurumsal bir standart olarak benimsenmelidir.

Sonuç olarak, öğrencilerin robotik destekli fen eğitiminden duyuşsal, bilişsel ve sosyal anlamda maksimum düzeyde fayda sağlayabilmeleri, teknolojik süreci okul dışı ortamlarda da destekleyecek bilinçli ve farkındalığı yüksek velilerin varlığına bağlıdır.

KAYNAKÇA

Alimisis, D. (2013). Educational robotics: Open questions and new challenges. *Themes in Science and Technology Education, 6*(1), 63–71.

Beers, S. Z. (2011). *21st century skills:Preparing students for their future*. National Education Association.

Benitti, F. B. V. (2012). Exploring the educational potential of robotics in schools: A systematic review. *Computers & Education, 58*(3), 978–988.

Bers, M. U. (2010). The TangibleK robotics program: Applied computational thinking for young children. *Early Childhood Research & Practice, 12*(2).

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101.

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Harvard University Press.

Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher, 70*(1), 30–35.

Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. NSTA Press.

Chen, Y. L., & Chang, C. C. (2018). The impact of robotics integration on students' learning outcomes. *International Journal of Science Education, 40*(5), 567–586.

Chung, C. C., Cartwright, C., & Cole, M. (2014). Assessing the effectiveness of robotics education. *Journal of Educational Technology Development and Exchange, 7*(1), 1–16.

Çiftçi, S., & Topal, M. (2020). Eğitimde robotik uygulamaların öğrenciler üzerindeki etkisi. *Eğitim ve Bilim, 45*(202), 123–145.

Demirer, V., & Erbaş, Ç. (2021). The effects of robotics activities on students' academic achievement. *Education and Information Technologies, 26*(4), 4523–4542.

Eguchi, A. (2014). Robotics as a learning tool for educational transformation. *Proceedings of Society for Information Technology & Teacher Education International Conference* (s. 27–34).

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, beliefs, and culture intersect. *Journal of Research on Technology in Education, 42*(3), 255–284.

Güner, P., & Doğru, M. (2019). Robotik kodlama uygulamalarının öğrencilerin problem çözme becerilerine etkisi. *Eğitim ve Öğretim Araştırmaları Dergisi, 8*(2), 45–56.

Honey, M., Pearson, G., & Schweingruber, H. (2014). *STEM integration in K–12 education: Status, prospects, and an agenda for research*. National Academies Press.

Korkmaz, Ö., Altun, H., & Kaban, A. (2019). The effects of robotics on computational thinking skills. *Journal of Educational Computing Research, 57*(5), 1234–1256.

Li, Y., Schoenfeld, A. H., diSessa, A. A., Graesser, A. C., Benson, L. C., English, L. D., & Duschl, R. A. (2020). On computational thinking and STEM education. *Journal for STEM Education Research, 3*(2), 147–166.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. SAGE.

Merriam, S. B. (2014). *Qualitative research: A guide to design and implementation* (3. bs.). Jossey-Bass.

Mubin, O., Stevens, C. J., Shahid, S., Al Mahmud, A., & Dong, J. J. (2013). A review of the applicability of robots in education. *Journal of Technology in Education and Learning, 1*(1), 1–7.

Mubin, O., Stevens, C. J., Shahid, S., & Dong, J. (2016). Social robots in education: A review. *International Journal of Social Robotics, 8*(4), 587–599.

Özcan, D., & Korkmaz, Ö. (2022). The impact of robotics activities on students' engagement. *Education and Information Technologies, 27*(3), 3891–3908.

Öztürk, M. (2014). Nitel araştırma yöntemleri. *Sosyal bilimlerde araştırma yöntemleri* içinde (s. 157–182). Anı Yayıncılık.

Serholt, S., Barendregt, W., Obaid, M., & Vasalou, A. (2017). The case of classroom robots: Teachers' expectations and experiences. *International Journal of Social Robotics, 9*(3), 369–386.

Sullivan, F. R., & Heffernan, J. (2016). Robotic construction kits as computational manipulatives for learning in the STEM disciplines. *Journal of Research on Technology in Education, 48*(2), 105–128.

Tanaka, F., & Kimura, T. (2019). Educational applications of social robots in early childhood settings. *International Journal of Social Robotics, 11*(3), 351–365.

Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times*. Jossey-Bass.

Yıldız, E., & Gülseçen, S. (2021). Robotik uygulamaların öğrencilerin motivasyonuna etkisi. *Eğitim Teknolojisi Kuram ve Uygulama, 11*(2), 215–230.

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6. bs.). SAGE.

COMMUNICATIVE HEALTH LITERACY IN DIGITAL ENVIRONMENTS: A THEORETICAL MODEL PROPOSAL

DİJİTAL ORTAMDA İLETİŞİMSEL SAĞLIK OKURYAZARLIĞI: TEORİK BİR MODEL ÖNERİSİ

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ÖZET

Dijital iletişimin hızla yaygınlaşması, sağlık bilgisinin üretilme, dolaşıma girme ve gündelik kullanım biçimlerini belirgin biçimde dönüştürmektedir. Sağlıkla ilgili bilgi ve hizmetlere erişim ile etkileşimin giderek çevrimiçi araç ve ortamlar üzerinden gerçekleşmesi, dijital bağlamda sağlık okuryazarlığını elzem bir yeterlilik alanı olarak öne çıkarmaktadır. Bu çalışma, dijital ortamda sağlık okuryazarlığını iletişimsel bir çerçevede ele almaktadır. Özellikle hasta bireyin sağlık profesyoneli/kurumu ile kurduğu etkileşim üzerinden belirginleşen iletişimsel sağlık okuryazarlığı boyutuna odaklanmaktadır. Bu doğrultuda çalışma, kavramsal bir nitelik taşımaktadır. Birey, dijital araç ve kanallar ile sağlık profesyoneli/kurumu arasındaki ilişkiyi etkileşim türleri ve dijital kanal çeşitliliği ekseninde açıklamayı amaçlayan teorik bir model önerisi sunmaktadır. Önerilen model, dijital sağlık iletişiminin senkron ve asenkron etkileşim biçimlerini, kurumsal dijital iletişim pratiklerini ve topluluk temelli çevrimiçi etkileşimleri aynı çerçevede görünür kılmaktadır. Aynı zamanda iletişimsel sağlık okuryazarlığını, talep oluşturma, soru sorma, bilgiyi yapılandırma ve geri bildirim döngülerini yönetme gibi iletişim becerileriyle ilişkilendirmektedir. Bu yönüyle modelin, dijital sağlık iletişimi ve sağlık okuryazarlığı alanlarında yürütülecek ardıl çalışmalara bir zemin sağlayacağı düşünülmektedir.

Anahtar Kelimeler: Dijital iletişim, dijital sağlık iletişimi, sağlık okuryazarlığı, halkla ilişkiler, iletişimsel sağlık okuryazarlığı.

ABSTRACT

The rapid expansion of digital communication has markedly transformed the ways in which health information is produced, circulated, and used in everyday life. The growing reliance on online tools and environments for accessing and engaging with health-related information and services foregrounds health literacy in the digital context as an essential domain of competence. This study approaches digital health literacy within a communicative framework, with particular emphasis on the dimension of communicative health literacy that becomes salient through patients' interactions

with healthcare professionals and institutions. Accordingly, the study is conceptual in nature and proposes a theoretical model that aims to explicate the relationship between the individual (patient), digital tools and channels, and the healthcare professional/institution along the axes of interaction types and the diversity of digital channels. The proposed model renders synchronous and asynchronous modes of digital health communication, institutional digital communication practices, and community-based online interactions visible within a single framework. At the same time, it associates communicative health literacy with communication skills such as articulating demands, asking questions, structuring information, and managing feedback loops. In this respect, the model is considered to provide a basis for subsequent studies in the fields of digital health communication and health literacy.

Keywords: Digital communication, digital health communication, health literacy, public relations, communicative health literacy.

GİRİŞ

Dijital iletişim kanallarının gündelik yaşama yoğun biçimde nüfuz etmesi, sağlık alanında bilgiye erişim ve sağlık hizmetleriyle etkileşim biçimlerini köklü biçimde dönüştürmektedir. Günümüzde bireyler, sağlıkla ilgili bilgi ve hizmetlere çoğunlukla çevrimiçi ortamlar üzerinden ulaşmaktadırlar. Özellikle web sayfaları, sosyal medya platformları, arama motorları, mobil uygulamalar ve çevrimiçi topluluklar aracılığıyla sağlık içerikleriyle etkileşime girmektedirler. Bu düzlemde sorularına yanıt aramakta, deneyimlerini paylaşmakta ve sağlıkla ilişkili karar süreçlerini söz konusu dijital ekosistem içerisinde yönetmektedirler. Sağlık hizmetlerinin dijitalleşmesiyle görece daha görünür hâle gelen yeni bağlam, sağlık okuryazarlığının iletişimsel süreçlerde kullanılması bakımından daha geniş bir kavramsallaştırmayı gerekli kılmaktadır.

Sağlık okuryazarlığı genel olarak bireylerin sağlıkla ilgili bilgiye erişme, bu bilgiyi anlama, değerlendirme ve günlük yaşamda sağlık kararlarına uygulama yeterliliği olarak tanımlanabilmektedir. Bununla birlikte sağlık okuryazarlığı, sağlık sistemi içinde yön bulma, risk-yarar hesabı yapabilme, bilinçli karar geliştirebilme ve koruyucu davranışları planlayıp uygulayabilme gibi bilişsel ve davranışsal bileşenleri de içermektedir. Temel düzeyde bilgiyi edinme ve anlama ile başlayan süreç, bilgiyi kullanma ve iletişim kurma boyutuyla genişlemektedir. Nihayetinde eleştirel değerlendirme ve dönüştürme düzeyinde daha karmaşık becerilere erişmektedir.

Dijital ortamda sağlıkla ilgili etkileşimlerin çeşitlenmesi, sağlık okuryazarlığının özellikle iletişimsel boyutunu ön plana çıkartmaktadır. İletişimsel sağlık okuryazarlığı, bireyin farklı kaynaklardan edindiği sağlık bilgisini seçme, yorumlama, öznel koşullarına uyarlama ve sağlık sistemi içinde karar süreçlerine daha etkin katılımını olanaklı kılan sosyal yeterlilikler bütünüdür. Bireyin sağlık profesyoneli/kurumu ile kurduğu ilişkide soru sorma, belirtileri uygun biçimde ifade etme, seçenekleri karşılaştırabilme ve geri bildirim döngülerini yönetme gibi beceriler üzerinden somutlaşmaktadır. Ayrıca bireyi pasif bir alıcı konumundan çıkararak daha etkin bir özne konumuna taşımaktadır. Dijital kanalların yaygınlaşmasıyla söz konusu etkileşim, kurumsal dijital süreçler ve kitle iletişimi içerikleri gibi farklı düzlemlerde yeniden örgütlenmektedir.

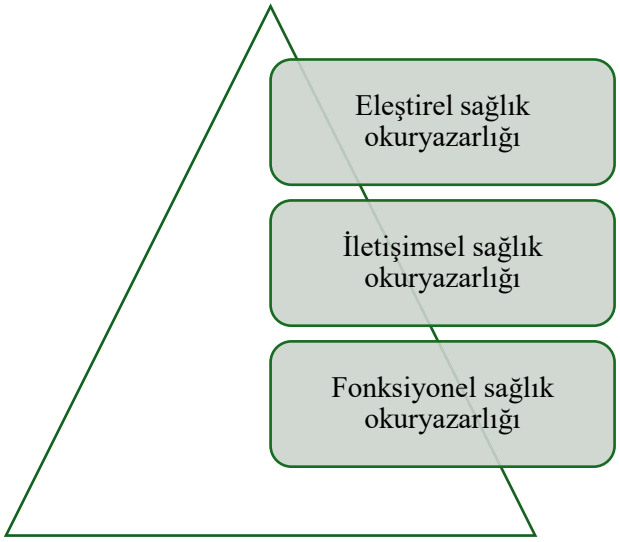
Bu çalışma, dijital ortamda iletişimsel sağlık okuryazarlığını kavramsal bir nitelikte ele almaktadır. Birey (hasta), dijital araç ve kanallar ile sağlık profesyoneli/kurumu arasındaki etkileşim süreçlerini açıklamayı amaçlayan teorik bir model önerisi geliştirmektedir. Model, dijital sağlık iletişiminin etkileşim biçimlerini, kurumsal dijital iletişim uygulamalarını ve çevrimiçi etkileşimleri görünür kılmayı amaçlamaktadır. Aynı zamanda etkileşim amaçları ile bu amaçların gerektirdiği çekirdek iletişim becerileri arasındaki bağıntıyı tartışmayı hedeflemektedir. Bu

doğrultuda çalışma, dijital sağlık iletişimi ve iletişimsel sağlık okuryazarlığı alanlarında gerçekleştirilecek diğer çalışmalara katkı sunmayı amaçlamaktadır.

SAĞLIK OKURYAZARLIĞI

Sağlık okuryazarlığı, bireylerin sağlıkla ilgili bilgiye erişme, bu bilgiyi anlama, değerlendirme ve günlük yaşamda sağlıkla ilgili kararlar alma yeterliliği olarak tanımlanabilmektedir (Liu vd., 2020). Bir yeterlilik alanı olan sağlık okuryazarlığı, sağlıkla ilgili yazılı materyalleri okuyup kavramanın ötesinde bir anlam ifade etmektedir (Sørensen, 2019). Bu bağlamda sağlık okuryazarlığı; sağlık sisteminde yön/yol bulma, getiri ve riskleri hesaplayabilme, sağlıkla ilgili bilinçli kararlar alabilme, koruyucu sağlık davranışlarını planlama ve uygulama, bireysel sağlığını yönetebilme gibi bilişsel ve davranışsal bileşenleri içermektedir.

Sağlık okuryazarlığı, hiyerarşik ve gelişimsel nitelik arz eden bir piramit olarak değerlendirilebilmektedir (Nutbeam, 2000; McCormack vd., 2010). Şekil 1'de sunulduğu üzere sağlık okuryazarlığı; sağlıkla ilgili bilgiyi edinme ve anlama düzeyinden, kullanma ve iletişim kurma düzeyine, nihayetinde eleştirel değerlendirme ve dönüştürme düzeyine ulaşan karmaşık bilişsel ve sosyal becerilerden oluşmaktadır. Düzeyler yaklaşımı, sağlık okuryazarlığının yalnızca okuma ve yazma kapasitesiyle sınırlı olmadığını, sağlık kararları, sağlık sistemiyle iletişim ve etkileşim oluşturma, toplumsal ve sistemsel belirleyicileri kavrama ve analiz etme gibi geniş bir yetkinlik alanını içerdiğine dikkat çekmektedir.



Şekil 1. Sağlık Okuryazarlığı: Düzeyler Yaklaşımı

Kaynak: Nutbeam, 2000.

Sağlık okuryazarlığının temelini oluşturan fonksiyonel sağlık okuryazarlığı (functional health literacy), temel düzeyde sağlık bilgisi okuma, anlama ve uygulamaya dönüştürme becerisi anlamına gelmektedir (Stormacq vd., 2020). Reçete talimatları, randevu bilgileri, bilgilendirme formları, onam metinleri ile koruyucu sağlık uyarıları gibi metinleri anlayabilme ve gündelik sağlık davranışlarına aktarabilme fonksiyonel sağlık okuryazarlığı ile ilişkilidir.

Sağlık okuryazarlığını ikinci düzeyini oluşturan iletişimsel sağlık okuryazarlığı (communicative health literacy) orta düzey sağlık bilgisini anlamak, sağlık profesyonelleri ile sağlık sistemiyle etkili iletişim kurarak bilgiyi yönetebilmek olarak tanımlanabilmektedir (Cesar vd., 2024). Bu

okuryazarlık kapsamında birey soru sorma, sağlık sorunları ile ilgili belirtileri uygun biçimde ifade etme, seçenekleri müzakere etme, risk-yarar hesabını yapabilme ve farklı kaynaklardan edindiği bilgileri kişisel durumuna uyarlayabilme gibi gelişmiş becerileri sergilemektedir.

Sağlık okuryazarlığının en üst düzeyi olan eleştirel sağlık okuryazarlığı (critical health literacy) ise bireyin sağlık bilgisine yönelik analitik ve eleştirel değerlendirmesi anlamına gelmektedir (Yıldız & Şahin, 2024). Fonksiyonel sağlık okuryazarlığına ve iletişimsel sağlık okuryazarlığına göre daha gelişmiş becerileri içeren eleştirel sağlık okuryazarlığı sağlık bilgisinin kaynağını sorgulama, kanıt gücünü analiz etme, çelişkili yaklaşımları ayırt etme, ticari/ideolojik yönlendirmeleri fark etme, sağlık mesajlarını sosyal, ekonomik ve kültürel bağlam içinde yorumlamayı sağlamaktadır.

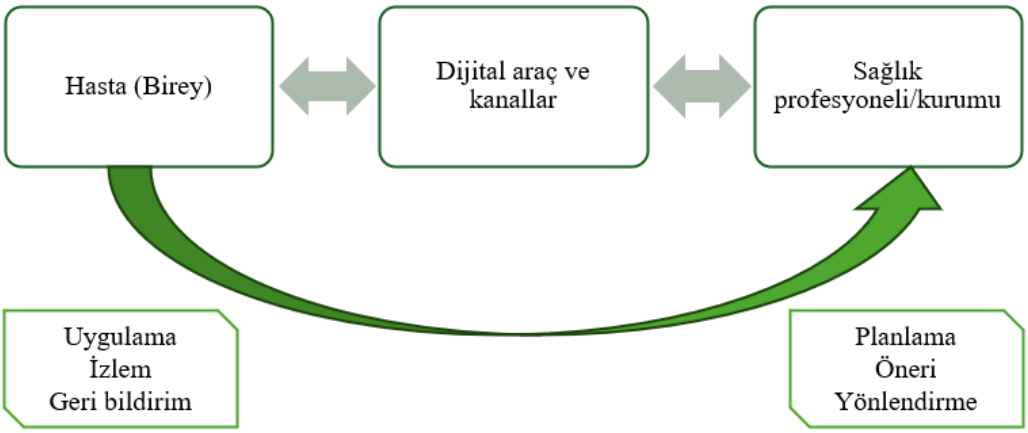
İLETİŞİMSEL SAĞLIK OKURYAZARLIĞI

'İletişimsel sağlık okuryazarlığı', bireylerin sağlıkla ilgili bilgiyle aktif ve amaç yönelimli bir ilişki kurmasını sağlayan bilişsel ve sosyal yeterlilikler bütünüdür (Smith vd., 2021). Fonksiyonel sağlık okuryazarlığının ötesine geçen bu okuryazarlık; yazılı ve sözlü sağlık mesajlarını anlamanın ötesinde bir anlam ifade etmekte ve farklı kaynaklardan edinilen bilgileri seçme, yorumlama, öznel yaşam koşullarına uyarlama ve sağlık sistemi içerisinde karar süreçlerine daha etkin katılmanı olanaklı kılmaktadır (Schulenkorf vd., 2022). Bu bağlamda iletişimsel sağlık okuryazarlığı, karmaşık ve çok sayıdaki sağlık bilgisine erişebilmeyi ve bu bilgilerin bireyler üzerindeki yönelimlerini değerlendirebilmeyi içermektedir (Rubin vd., 2011: 191-192).

Tones'e (2002: 288) göre iletişimsel sağlık okuryazarlığı, bireylerin günlük faaliyetlere katılımının artması için bireysel becerilerin kullanılmasını ve güçlendirilmesini kapsamaktadır. Bu çerçevede iletişimsel sağlık okuryazarlığı, iletişim becerilerinin güçlenmesi, çok sayıdaki bilgi arasından yararlı olanı seçebilme, hızla değişen sağlık sistemini kavrayabilme ve sistem içindeki bilgileri uygun biçimde uygulayabilme yeterliliğini de beraberinde getirmektedir (Fitzpatrick, 2023). Dolayısıyla bu okuryazarlık; fonksiyonel sağlık okuryazarlığında 'pasif alıcı' konumundaki bireyi, sağlık hizmeti etkileşimlerinde soru soran, açıklama talep eden, seçenekleri müzakere eden ve karar süreçlerine etkin katılan 'etkin bir özneye' dönüştürmektedir.

Nutbeam'ın (2000) sınıflandırmasında iletişimsel sağlık okuryazarlığı, fonksiyonel sağlık okuryazarlığına kıyasla daha gelişmiş bir nitelik arz etmektedir. Ona göre bu düzeyde sağlık okuryazarlığı; bilgiyi anlama ve kullanma, bilgiye farklı iletişim kanallarından ulaşma ve söz konusu bilgiyi yeni durumlara uygulama becerisi olarak karşılık bulmaktadır. Bu çerçevede birey, halihazırda var olan sağlık bilgilerini kullanarak sağlığını korumaya yönelik faaliyetlerde bulunmaktadır (Murdoch, 2021). Örneğin birey, sağlıklı besinlerin bilgisine sahip olmanın yanı sıra bu bilgiyi davranışa dönüştürerek sağlıklı besinleri diyetine dahil etmektedir.

İletişimsel sağlık okuryazarlığı, bireyin, diğer bir ifadeyle hastanın temel özne olduğu bir süreci ifade etmektedir (Finbråten vd., 2022). Dijital ortamda iletişimsel sağlık okuryazarlığının temel bileşenleri ve aralarındaki etkileşim, Şekil 2'de sunulmuştur. Modelde birey, dijital araç ve kanalları aracılığıyla sağlık profesyonel/kurumuyla iletişim kurmakta; bu etkileşim sonucunda planlama, öneri ve yönlendirme davranışları oluşmaktadır. Bireyin uygulama, izlem ve geri bildirim döngüsüyle süreç süreklilik ve sürdürülebilirlik kazanmaktadır.



Şekil 2. İletişimsel Sağlık Okuryazarlığı Modeli

Kaynak: Nutbeam, 2000, Norman & Skinner, 2006; van der Vaart & Drossaert, 2017'den yararlanılarak araştırmacılar tarafından uyarlanmıştır.

Dijital ortamda iletişimsel sağlık okuryazarlığı; farklı iletişim, kanal ve etkileşim biçimlerini içeren geniş bir uygulama alanına sahiptir (Ban vd., 2024). Dijital ortamda iletişimsel sağlık okuryazarlığının kapsamı, Tablo 1'de özetlenerek sunulmuştur. Tablo, Şekil 2'de sunulan iletişimsel sağlık okuryazarlığı modelinden hareketle birey/hasta, dijital araç ve kanallar ile sağlık profesyoneli/kurumu arasındaki ilişkiyi, iletişim türü ve dijital kanal türü ekseninde somut ve sınıflandırılmış bir biçimde ele almaktadır. Ayrıca tablo, söz konusu iki taraf arasındaki ilişkiyi iletişim türüne ve dijital kanal türüne göre etkili bir şekilde yürütebilmek için gereken çekirdek iletişim becerilerini göstermektedir.

Tablo 1. Dijital İletişim ve Kanal Türleri ile Gerekli İletişim Becerileri

İletişim Türü	Dijital Kanal Türü	Etkileşim Amacı	Gerekli İletişim Becerileri
Senkron klinik iletişim	Tele-sağlık, görüntülü görüşme, telefon, canlı sohbet	Şikâyet ve öneri aktarma, danışma, ortak karar verme	Soru sorma, belirtileri yapılandırma, geri bildirim alma-verme, anlama, teyit etme
Asenkron klinik iletişim	Hasta portalı mesajı, e-posta, e-reçete, e-sonuç sistemleri	Sonuç öğrenme, takip, belge paylaşımı	Mesajı yapılandırma, bilgi alma, talebi açıkça belirtme, takibi planlama
Kurumsal dijital iletişim	Online randevu sistemleri, e-nabız vb. sistemler, hastane uygulamaları	Hizmete erişim, kayıt, sevk ve rapor süreçleri	Yönergeleri izleme, formu doğru anlama, form doldurma, doğrulama ve kimlik yönetimi
Topluluk/akran iletişimi	Forumlar, hasta destek grupları, sosyal platformlar	Deneyim paylaşımı, sosyal destek, öneri	Deneyim-kanıt ayrımı, uygun soru sorma, bilgi doğrulatma, sınır koyma
Kitle iletişimi	YouTube, podcast, haber siteleri, sosyal medya içerikleri	Bilgi edinme, karar öncesi anlamlandırma	Karşılaştırma, uzmanla iletişime hazırlanma, ana mesajı anlamlandırma
Karar destek ve izlem teknolojileri	Semptom kontrol araçları, hatırlatıcılar, akıllı saat/bileklikler, giyilebilir cihaz uygulamaları	Öz-izleme, risk farkındalığı, davranış düzenleme	Veriyi yorumlama, eşik/uyarı mantığını anlama, sonuçları profesyonelle paylaşma

Kaynak: Nutbeam, 2000; Kayser vd., 2018; Hefner, 2019; Culmer, 2023'ten yararlanılarak araştırmacılar tarafından uyarlanmıştır.

SONUÇ VE ÖNERİLER

Sağlık okuryazarlığı; bilgiyi okumakla başlayan, bilgiyi iletişim ve etkileşim içinde kullanmakla güçlenen, bilgiyi eleştirel süzgeçten geçirerek karar almaya ve eyleme dönüştürmekle olgunlaşan bir yetkinlik alanı olarak kavramsallaştırılabilmektedir. İletişimsel sağlık okuryazarlığı; sağlık mesajlarını anlayabilme, sağlık faaliyetlerine katılma ve sağlık bilgisini koşullara uygun biçimde uygulayabilme gibi gelişmiş bilişsel, sosyal ve davranışsal becerileri içermektedir. Bireysel faydanın ve etkin katılımın belirginleştiği bu okuryazarlık türü, bireyin daha aktif olduğu bir sürece işaret etmektedir.

Bu çalışma, dijital iletişim ekosisteminin sağlık bilgi ve hizmetlerine erişim, etkileşim ve karar verme pratiklerini dönüştürdüğü günümüz bağlamında, sağlık okuryazarlığının "iletişimsel" boyutunu dijital ortam özgüllüğünde yeniden düşünmeyi gerekli kılan dinamiklerden hareket etmiştir. Bu çerçevede çalışma, dijital ortamda iletişimsel sağlık okuryazarlığını kavramsal bir nitelikte ele almıştır. Birey (hasta), dijital araç ve kanallar ile sağlık profesyoneli/kurumu arasındaki etkileşim süreçlerini açıklamayı hedefleyen teorik bir model önerisi geliştirmiştir.

Elde edilen kavramsal çerçeve, dijital ortamda sağlık okuryazarlığının yalnızca çevrimiçi sağlık bilgisini "bulma" ve "anlama" becerileriyle sınırlanamayacağını göstermektedir. Aynı zamanda sağlık iletişiminin farklı zamanlılık türleri (senkron/asenkron) ve farklı dijital kanal tipleri (tele-sağlık uygulamaları, portallar, sosyal platformlar, kitle içerikleri, karar destek/izlem teknolojileri) üzerinden işleyen bir etkileşim düzeni içinde değerlendirilmesi gerektiğini ortaya koymaktadır. Bu bağlamda iletişimsel sağlık okuryazarlığı, bireyin sağlık profesyonelleri ve sağlık sistemiyle kurduğu ilişkide soru sorma, kendini doğru ifade etme, bilgi talebini yapılandırma, geri bildirim döngülerini yönetme ve farklı kaynaklardan edinilen bilgileri kişisel durumuna uyarlama gibi beceriler aracılığıyla pasif alıcı konumundan etkin özne konumuna geçişini açıklayan bir yeterlilik alanı olarak belirginleşmektedir.

Çalışma kapsamında önerilen modelin temel katkısı, dijital sağlık iletişimini yalnızca teknoloji temelli bir erişim meselesi olarak değil, iletişim türleri ile kanal biçimlerinin ürettiği etkileşim amaçları ve bu amaçlara eşlik eden çekirdek iletişim becerileri üzerinden ele almasıdır. Model, birey ile sağlık profesyoneli/kurumu arasındaki etkileşimi; planlama, öneri ve yönlendirme davranışlarıyla şekillenen bir süreç olarak konumlandırmaktadır. Eş zamanlı olarak uygulama-izlem-geri bildirim döngüsü üzerinden süreklilik ve sürdürülebilirlik boyutuna da vurgu yapmaktadır. Böylelikle dijital ortamda iletişimsel sağlık okuryazarlığı, yalnızca bilgi edinmenin ötesindedir. Sağlıkla ilgili kararların oluştuğu ve yeniden değerlendirildiği dinamik bir etkileşim alanı olarak kavramsallaştırılmaktadır.

Elde edilen içgörülerden hareketle gelecek çalışmalara ve pratik uygulamalara yönelik çeşitli öneriler aşağıda sunulmuştur:

- Dijital ortamda iletişimsel sağlık okuryazarlığı, bireysel becerilerle sınırlı bir çerçeve yerine sağlık sistemi dinamikleri ve kanal ekolojisiyle birlikte konumlandırılmalıdır.
- Dijital temas noktaları, yalnızca işlem akışını yöneten araçlar olarak değil, bireyin talep oluşturmasını, anlamasını ve geri bildirim döngülerini yönetmesini destekleyen iletişim ortamları olarak tasarlanmalıdır.
- Bireylerin dijital kanallarda sağlıkla ilgili karar süreçlerine etkin katılımını güçlendirmek üzere bilgi doğrulama, uygun soru sorma ve profesyonel iletişime hazırlanma becerileri geliştirilebilir bir yetkinlik alanı olarak ele alınmalıdır.
- Önerilen modelin farklı dijital sağlık iletişimi bağlamlarında sınanması ve model bileşenleri arasındaki ilişkilerin kanal türlerine göre nasıl farklılaştığının ortaya konulması önem taşımaktadır.

- Uygulama-izlem-geri bildirim döngüsünün karar süreçleri ve sürdürülebilir sağlık davranışlarıyla ilişkisi ardıl çalışmalarda ayrıntılı biçimde tartışılmalıdır.

Sonuç olarak bu çalışma, dijitalleşen sağlık ekosisteminde iletişimsel sağlık okuryazarlığını, etkileşim biçimleri ve kanal çeşitliliğini bir model çerçevesinde ele alarak teorik bir öneri sunmaktadır. Önerilen çerçevenin, dijital sağlık iletişimi ve sağlık okuryazarlığı alanlarında yürütülecek ardıl çalışmalara kuramsal bir zemin sağlama potansiyeline sahip olduğu düşünülmektedir.

KAYNAKÇA

Ban, S., Kim, Y., & Seomun, H. (2024). Digital health literacy: A concept analysis. *Digital Health*, *10*, 1-15. https://doi.org/10.1177/20552076241287894

Cesar, F. C. R., Oliveira, L. M. D. A. C., Galvão, M. C., & Lacerda, A. L. A. (2024). How do healthcare professionals develop the communication process to promote patients' health literacy? *International Journal of Environmental Research and Public Health*, *21*(5), 536. https://doi.org/10.3390/ijerph21050536

Culmer, N., Smith, T. B., Stager, C., Wright, A., Fickel, A., Tan, J., Clark, C. T., Meyer, H., & Grimm, K. (2023). Asynchronous telemedicine: A systematic literature review. *Telemedicine Reports*, *4*(1), 366-386. https://doi.org/10.1089/tmr.2023.0052

Finbråten, H. S., Nowak, P., Griebler, R., Bíró, É., Vrdelja, M., Charafeddine, R., Griese, L., Bøggild, H., Schaeffer, D., Link, T., Kucera, Z., Mancini, J., & Pelikan, J. M. (2022). The hls19-com-p, a new instrument for measuring communicative health literacy in interaction with physicians: Development and validation in nine european countries. *International Journal of Environmental Research and Public Health*, *19*(18), 11592. https://doi.org/10.3390/ijerph191811592

Fitzpatrick P. J. (2023). Improving health literacy using the power of digital communications to achieve better health outcomes for patients and practitioners. *Frontiers in Digital Health*, *5*, 1264780. https://doi.org/10.3389/fdgth.2023.1264780

Gürel, E., & Taşkıran, İ. B. (2024). Sağlık okuryazarlığı: Kavramsal bir çalışma. E. Dervishi & M. Demir (Ed.), *10. International European Congress on Advanced Studies in Basic Sciences Full Text Book* içinde (ss. 908-916). IKSAD Publications.

Gürel, E., & Taşkıran, İ. B. (2024). E-sağlık okuryazarlığı: Kavramsal bir bakış. E. İ. Şahin & J. E. İbrahim (Ed.), *7. International Antalya Scientific Research and Innovative Studies Congress Full Text Book* içinde (ss. 1197-1206). IKSAD Publications.

Gürel, E., & Taşkıran, İ. B. (2025). Sağlık iletişimi üzerine bir değerlendirme. P. Karakurt & G. Giurgiu (Ed.), *11th International Artemis Scientific Research Congress Full Text Book* içinde (ss. 434-443). BZT Academy Publishing House.

Hefner, J. L., MacEwan, S. R., Biltz, A., & Sieck C.J. (2019). Patient portal messaging for care coordination: A qualitative study of perspectives of experienced users with chronic conditions. *BMC Family Practice*, *20*(1), 57. https://doi.org/10.1186/s12875-019-0948-1

Kayser, L., Karnoe, A., Furstrand, D., Batterham, R., Christensen, K. B., Elsworth, G., & Osborne, R. H. (2018). A multidimensional tool based on the ehealth literacy framework: Development and initial validity testing of the ehealth literacy questionnaire (ehlq). *Journal of Medical Internet Research*, *20*(2), e36. https://doi.org/10.2196/jmir.8371

Liu, C., Wang, D., Liu, C., Jiang, J., Wang, X., Chen, H., Ju, X., & Zhang, X. (2020). What is the meaning of health literacy? A systematic review and qualitative synthesis. *Family Medicine and Community Health*, *8*(2), e000351. https://doi.org/10.1136/fmch-2020-000351

McCormack, L., Bann, C., Squiers, L., Berkman, N. D., Squire, C., Schillinger, D., Ohene-Frempong, J., & Hibbard, J. (2010). Measuring health literacy: a pilot study of a new skills-based instrument. *Journal of Health Communication*, *15*(2), 51-71. https://doi.org/10.1080/10810730.2010.499987

Murdoch, B. (2021). Privacy and artificial intelligence: challenges for protecting health information in a new era. *BMJ Journal of Medical Ethics*, *22*, 122. https://doi.org/10.1186/s12910-021-00687-3

Norman, C. D., & Skinner, H. A. (2006). Eheals: The ehealth literacy scale. *Journal of Medical Internet Research*, *8*(4): e27. https://doi.org/10.2196/jmir.8.4.e27

Nutbeam, D. (2000). Health literacy as a public health goal: A challenge for contemporary health education and communication strategies into the 21st century. *Health Promotion International*, *15*(3), 259-267. https://doi.org/10.1093/heapro/15.3.259

Rubin, D. L., Parmer, J., Freimuth, V., Kaley, T., & Okundaye, M. (2011). Associations between older adults' spoken interactive health literacy and selected health care and health communication outcomes. *Journal of Health Communication*, *16*(3), 191-204. https://doi.org/10.1080/10810730.2011.604380

Schulenkorf, T., Sørensen, K., & Okan, O. (2022). International understandings of health literacy in childhood and adolescence-a qualitative-explorative analysis of global Expert interviews. *International Journal of Environmental Research and Public Health*, *19*(3), 1591. https://doi.org/10.3390/ijerph19031591

Smith, C., Goss, H. R., Issartel, J., & Belton, S. (2021). Health literacy in schools? A systematic review of health-related interventions aimed at disadvantaged adolescents. *Children*, *8*(3), 176. https://doi.org/10.3390/children8030176

Sørensen, K. (2019). Defining health literacy: Exploring differences and commonalities. O. Orkan, U. Bauer, D. Levin-Zamir, P. Pinhero & K. Sørensen (Eds.), *International Handbook of Health Literacy* içinde (ss. 5-20). Policy Press. https://doi.org/10.51952/9781447344520.ch001

Stormacq, C., Wosinski, J., Boillat, E., & Van den Broucke, S. (2020). Effects of health literacy interventions on health-related outcomes in socioeconomically disadvantaged adults living in the community: a systematic review. *JBI Evidence Synthesis*, *18*(7), 1389-1469. https://doi.org/10.11124/JBISRIR-D-18-00023

Tones, K. (2002). Health literacy: New wine in old bottles? *Health Education Research*, *17*(3), 287-290. https://doi.org/10.1093/her/17.3.287

van der Vaart, R. & Drossaert, C. (2017). Development of the digital health literacy instrument: Measuring a broad spectrum of health 1.0 and health 2.0 skills. *Journal of Medical Internet Research*, *19*(1), e27. https://doi.org/10.2196/jmir.6709

Yıldız, O., & Şahin, A. (2024). An analysis of the health literacy levels of students in a public university's faculty of health sciences. *International Journal of Health Management and Tourism*, *9*(3), 368-398. https://doi.org/10.31201/ijhmt.1572124

MEHMET ÂKİF ERSOY'UN "ACEM ŞAHI" ŞİİRİNDE ZULÜM VE İSTİBDAT

MEHMET AKİF ERSOY'S POEM "ACEM ŞAHI" CRİTİCİZES OPPRESSİON AND TYRANNY

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ABSTRACT

Mehmed Akif Ersoy was a figure who opposed oppression and tyranny throughout his life. Known as the poet of the Turkish National Anthem, his poem "I Cannot Applaud Tyranny" is an act of rebellion against injustice. In this poem, he speaks of his unwavering stance against tyranny: "I cannot applaud tyranny, I can never love the tyrant; / I cannot curse the past for the sake of the newcomer's pleasure." In his poem "Acem Şahı" (The Shah of Persia), Mehmet Akif criticizes Mohammad Ali Shah, who ruled Iran between 1907 and 1909 and was known for his tyranny. The first part of the poem "Acem Şahı" (The Shah of Persia) was written by Midhat Cemal, and the second part by Mehmed Akif. The first lines of the poem state, "O tyrant with a bloody destiny, hang the heavy mace of tyranny on your gold-adorned veranda, let it be your ornament!" Here, the poet criticizes a tyrant who displays his cruelty as an ornament. The poet then says, "Dress your tent with a bloody shroud; light torches with the lives of the people so that it may be a refuge in your tent of mourning!" Here, Akif depicts the Shah's palace as a tent of death. Later, the poet states that the name of this tyrant is a history written in blood. The poet expresses that the Shah has virtually turned his country into a graveyard, imprisoned it in darkness, and oppressed his people. Akif states that such regimes will eventually collapse. The aim of this study is to thematically analyze Mehmet Akif Ersoy's poem "Acem Şahı".

Keywords: Mehmed Akif Ersoy, Poem "Acem Şahı", Oppression, Tyranny.

Özet

Mehmed Âkif Ersoy, hayatı boyunca baskı ve zulme karşı çıkmış bir şahsiyettir. İstiklal marşı şairi olarak tanınan Mehmet Akif Ersoy'un "Zulmü alkışlayamam" şiiri onun haksızlığa karşı yaptığı bir başkaldırıdır. O, bu şiirde zulme karşı olan dik duruşundan bahseder: "Zulmü alkışlayamam, zalimi asla sevemem; / Gelenin keyfi için geçmişe kalkıp sövemem." Şair daha sonra, "Yumuşak başlı isem, kim dedi uysal koyunum? / Kesilir belki, fakat çekmeye gelmez boyunum!" der. Bu düşünceler Ersoy'un köleliğe, sömürüye ve baskıya karşı olduğu görülür. Akif ayrıca, "İstibdad" adlı şiirinde de baskıya karşı gelir. Mehmet Akif, "Acem Şahı" adlı şiirinde de zulme karşı gelmektedir. Bu şiirde, 1907-1909 yılları arasında İran'ı yöneten ve zalimliğiyle tanınan Muhammed Ali Şah eleştirilir. Acem Şâhı şiirinin birinci kısmı Midhat Cemâl, ikinci kısmı ise Mehmed Âkif tarafından kaleme alınmıştır. Şiirin ilk dizelerinde "Ey kanlı alın yazısına sahip zalim, ağır zulüm topuzunu altın süslemeli eyvanına as da süsün olsun! der. Şair burada, zulmünü bir süs gibi teşhir eden bir zalimi eleştirmektedir. Şair daha sonra, çadırını kanlı bir kefenle donat;

matem çadırına sığınak olsun diye insanların canlarıyla meşaleler yak! der. Akif burada şahın sarayını bir ölüm çadırı gibi tasvir etmektedir. Daha sonra ise şair, bu zalimin adının kanla yazılmış bir tarih olduğunu söyler. Şair, Şah'ın ülkesini adeta mezarlığa çevirdiğini, karanlığa hapsettiğini ve halkına zulmettiğini ifade eder. Akif, böyle iktidarların sonunda yıkılacağını ifade eder. Bu çalışmada amaç, Mehmet Akif Ersoy'un "Acem Şahı" adlı şiirini tematik bakımdan tahlil etmektir.

Anahtar Kelimeler: Mehmed Akif Ersoy, "Acem Şahı" Şiiri, Zulüm, İstibdat.

GİRİŞ

Mehmet Akif Ersoy (20 Aralık 1873, İstanbul - 27 Aralık 1936, İstanbul); sadece Türkiye Cumhuriyeti milli marşı olan İstiklâl Marşı'nın yazarıdır. O, sadece bir şair değil, aynı zamanda yazar, veteriner, öğretmen ve siyasetçidir. Türk milletinin var olma savaşında Millî Mücadele'ye destek vermiş, camilerde yaptığı konuşmalarda halkın kurtuluş umudunu artırmıştır. Akif, "İstiklal Şairi" ve "Millî Şair" unvanları ile de bilinir. Çanakkale Şehitlerine ve Bülbül şiirleri önemlidir. Şiirlerini Safahat adlı kitapta toplanmıştır. Sırat-ı Müstakim (daha sonraki ismi Sebilü'r-Reşad^dır.) dergisinin başyazarlığını yapmıştır. 1. TBMM'de milletvekili olarak görev yapmıştır Çanakkale Destanı, Bülbül ve 1911-1933 yılları arasında yayımladığı yedi şiir kitabındaki şiirleri bir araya getiren Safahat, en önemli eserlerindendir. II. Meşrutiyet döneminden itibaren Sırat-ı Müstakim (daha sonraki adıyla Sebilü'r-Reşad) dergisinin başyazarlığını yapmıştır. Kurtuluş Savaşı sırasında milletvekili olarak 1. TBMM'de yer almıştır.

Akif, İslâm milletinin temel yapısını, sorunlarını, çözümlerini vb. çok iyi bilen biridir. O, Türk milletinin duygu ve düşünce dünyasıyla İslami düşünce arasında güçlü ortak bağlar olduğunu ifade eder. O, hayallerle işi olmayan, realist biridir. "Akif, bir devrin, mahdut, kalem erbabı ile bizim fikri âlemimizin hudutlarını ve muhtevasını ustalıkla ortaya koyan mümtaz şahsiyetlerden biridir. Gerçekçidir. Ham hayallerle uğraşmaz." (Kahraman, 2018: 14). Manzumelerinde toplumsal konulara geniş yer veren Mehmet Âkif'in şiirlerinde en çok işlediği konu ve temaları şöyle ifade etmek mümkündür: "Vatan sevgisi, İslâmiyet, şehadet, dini yanlış anlama, bâtıl inançlar, insanın esas gayesi, taassup, kurtuluş, merhamet, yoksulluk, kimsesizlik, geçim sıkıntısı, çalışmak, vicdan, eğitim, medeniyet, yaşlılık, yalnızlık, hastalık, ölüm, yozlaşma, cehalet, taklitçilik, ahlaksızlık, terakki, inançsızlık, köksüzlük, aile, edebiyat, edebiyatçılar, yöneticilere isyan, adaletsizlik, gençlere tavsiyeler vb." (Karabulut, 2021: 38). İyi bir gözlemci olan Akif, bizzat gördüğü felaketleri tasvir etmede oldukça başarılıdır. "Akif, belli bir plan çerçevesinde nerede neyi söyleyeceğini çok iyi bilen ve derinden hissedip gözlemlediği durumlar üzerinde uzun uzadıya çalışan ve onu sanat haline getiren bir şairdir. Bu, onun eserlerindeki kompozisyonu sağlam kılar." (Baş, 2012: 201). Onun şiirlerinde tasvir önemli bir görev üstlenir.

Zulme ve zalimlere daima karşı olan şair, "Zulmü Alkışlayamam" şiirinde haksızlığa başkaldırıdır: *Zulmü alkışlayamam, zalimi asla sevemem; / Gelenin keyfi için geçmişe kalkıp sövemem.*" Şiirin devamında, "*Yumuşak başlı isem, kim dedi uysal koyunum? / Kesilir belki, fakat çekmeye gelmez boyunum!"* diyerek zalimlere karşı her zaman karşı koyacağını ifade eder. Şair, "İstibdad" adlı şiirinde de baskıcı yönetime karşı gelir. Mehmet Akif, "Acem Şahı" adlı şiirinde de zulüm ile halkı perişan eden anlayışa tepki gösterir. Bu şiirde, yine "Tarihsel olarak var olan ama doğrudan şairin hayatında yer almayan bir insan tasvir edilir. Mehmet Akif, bu şiirin birinci bölümünü Mithat Cemal Kuntay'ın ikinci bölümünü kendisinin yazdığını not eder." (Narlı, 2012: 26). Bu şiirin yazılış süreci ilginçtir. Mehmet Akif, İran'daki iç karışıklıktan dolayı üzgündür. Burada halkın çektiği acılara kayıtsız kalamaz. Mithat Cemal'e birlikte Acem Şahı adlı bir şiir yazmayı önerir. Mithat Cemal için Mehmet Akif'le ortak şiir yazmak büyük bir onur olur. "Onunla şiir mi yazmak? Latife mi ediyordu? O koşacaktı; ben arkasından bakacaktım." (Kuntay, 2005: 89) diye düşünür. Ama Akif ciddidir. Şiiri iki bölüm halinde kaleme almayı ve ortak isimle bastırmayı düşündüğünü söyleyince Mithat Cemal'in hayreti artar. Akif, Mithat Cemal'e büyük önem vermektedir. "Bütün

bunları kendisine hoşluk olsun diye söylediğini tasavvur ederken Mithat Cemal, Akif'in ısrarı üzerine şiirin ilk bölümünü yazar ve Akif kendi bölümünü de tamamladıktan sonra şiiri yayımlar. Mithat Cemal'i asıl mutlu eden şey ise bu şiirin Safahat'ın birinci kitabında da yer alıyor olmasıdır." (Yılmaz, 2021: 205). Şiirde insanlara zulmeden İran Şahı'nın şahsında zorbalıkla ülkesini yöneten hükümdarlara ağır eleştiriler yer alır.

ZULÜM İLE ÂBÂD OLUNAMAYACAĞININ ŞİİRİ: "ACEM ŞAHI"

"Acem Şahı" başlıklı şiirde bahsedilen hükümdar, 1907-1909 yılları arasında İran'da tahtta bulunan ve zalimliğiyle meşhur olan Muhammed Ali Şah'tır. "Bu şiir, "İstibdat" şiiriyle bazı yönleriyle benzerlik göstermektedir. Âkif iki şiirde de benzer ifadeler kullanmıştır." (Safi, 2021: 50). Şiirde zulüm ve istibdat eleştirilir. "23 Haziran 1908 tarihinde, 1906 yılında ilân edilen meşrutiyeti kaldırmış, millet meclisini de topa tutturmuştur (Özgüdenli 2005: 503). Şiir İranlı şair Sadi'den bir epigram ile başlar: "Be–merdî ki mülk–i serâser zemin Neyerzed ki hûnî çeked ber zemin". Sadi, bu mısralarda, "baştan başa bütün dünya, bir damla kanın yere dökülmesine değmez." Diyerek zulme ve savaşlara karşı olduğunu dile getirir. Şiirin ilk dizelerinde *"Gürz–i girân–ı zulmünü ey kanlı nâsiye; / Eyvân–ı zer–cidârına as ziynetin diye!"*[1](s.409). (Ey kanlı alın yazısına sahip zalim! / Ağır zulüm gürzünü (sopa, topuz) altın süslemeli eyvanına as da süsün olsun!) diyen şair, zalimliğini bir süs gibi gösteren bir zalimi eleştirir. Daha sonraki *"Al kanlı bir kefenle donat hayme–gâhını, / Canlarla yak meşâil–i mâtem–penâhını!"* (s.409). (Çadırını kanlı bir kefenle donat; / Matem çadırına sığınak olsun diye insanların canlarıyla meşaleler yak!) dizelerde ise şahın sarayının bir ölüm çadırı gibi olduğu ifade edilir. Şiiirn devamında *"Makberlerin hufeyre–i muzlim–dehanları, / Dendân–ı gayz u kahra şebîh üstühanları"* (s.409). (Mezarların karanlık, korkunç çukurları; / Öfke ve kahır dişlerine benzeyen kemiklerle dolu.) denilerek hükümdarın ülkeyi bir büyük mezarlığa çevirdiği dile getirilir. Akif daha sonra, *"Yâd eylesin mezâlimini tâ ebed senin, / Ey cebhesi kitabesi bin kanlı medfenin!"* (s.409). (Şair, her tarafı binlerce kanlı mezarın kitabesi gibi olan zulümlerin sonsuza dek hatırlansın!) diyerek zalimin adının tarihe kanla yazıldığını söyler.

Mehmet Akif Ersoy, şiirin sonraki kısımlarında yergilerine devam eder. Şair sonra, *"Ey bir hayale tuhfe kılan bin hakikati, / Ey âhenîn eliyle kazıp kabr–i milleti,"* (s.409). (Ey bir hayal uğruna bin gerçek fedâ eden! / Ey demir eliyle milletin mezarını kazan!) diyerek şahın milletin adeta mezarını kazdığını söyler. Daha sonra ise, *"Nûr–u hayat ufuklarını herc ü merc eden, / Leylin şedid zulmetini ruha meze eden!"* (s.409). (Hayat ışığının ufuklarını altüst eden, / Gecenin koyu karanlığını insanların ruhuna tattıran) diyerek milletin hayat ışığının söndüğünü, insanların karanlığa mahkum olduğunu ifade eder. Akif, *"Envâr–ı mihr–i fikri sen ey hâksâr eden, / Meyyitlerin izâmı gibi tarumar eden!"* (s.409). (Fikir güneşinin ışıklarını toza toprağa katan; / Ölülerin kemikleri gibi her şeyi darmadağın eden!" denilerek milletin kendi ülkesinde perişan olduğunu söyler. Şair daha sonra *"Ey hadimi serâçe–i mâtem–feşanların! / Rahş–ı akûr–u zulmüne pâmâl olanların / Gül gonce–i mezarı mıdır tâc–ı devletin? / Tutmuşsa da avâlim–i efkârı şöhretin,"* (s.409-410). (Ey matem saçan sarayın hizmetkârı!" / Zulmünün azgın atı altında ezilenlerin" / gül tomurcuğu gibi mezarları mı devlet tacındır? / Şöhretin halkın zihnini sarmış olsa bile,) diyerek bir istibdat eleştirisi yapar. Şair, "İstibdat, Hürriyet ve Acem Şahı şiirlerinde isim vermeden Abdülhamit yönetiminin istibdadını eleştirir." (Ozan, 2016: 157). Şair, milletin geleceğini yok eden, milleti karanlığa mahkûm eden yönetimi eleştirir. Saraylarının ihtişamı ölümler üzerine kurulmuştur. Bu metinde zorba yöneticilere tepki yer alır. Akif, daha sonra sözü Sadi'ye getirir:

"Zannetme ki hükümetinin efseriyledir...

[1] Şiir alıntıları Mehmet Akif Ersoy'un *Safahat* adlı eserinden yapılmıştır. Bkz. Kaynaklar.

Sadi'lerin mezâr–ı çemen–ber–sereyledir.

Sadi'lerin mezarı, evet bir avuç türâb...

Tahtınsa bir cihan ki senin âsüman–meâb!" (s.410)

Akif, yukarıdaki dizelerde Sadi'yi gerçek bir mütevazi olarak görür. Sadî gibi büyüklerin mezarı çimenlerle örtülü, bir avuç topraktır sadece. Şiirin anlatıcısı gerçek değer sahiplerinin mütevazı mezarlarda yattığını söyler. Daha sonra *"Lâkin o kabre bence feda taht ü efserin... / Makber–güzin olup da sükût eyleyenlerin / Feryâd–ı vâpesinine değmez bu velvelen..."* (s.410). Diyen Mehmet Akif, senin tahtın gökler kadar yüce görünse de bence bir büyük insanın mezarı, senin taht ve tacından daha değerlidir, der. Şiirin devamında *"Makber–güzin olup da sükût eyleyenlerin / Feryâd–ı vâpesinine değmez bu velvelen..."* (s.410) diyen şair, mezarı seçip susmuş olan büyük insanların son feryadına bu gösterişin değmez demek ister. Akif, şiirin devamında *"Mudhik gelir nigâh–ı temaşama hâilen!" / Bin mülkü, milleti yok eden pençe–i felek,"* (s.410) dizeleriyle senin bu hâlin, seyredenlerin gözünde gülünç görünür, bu bakımdan bu şahsı şüphesiz ebedi kılmamak gerek, demek ister. Şiirin anlatıcısı, "ülkeleri, milletleri yok eden felek (kader); elbet bir tek kişiyi de ebedî kılmaz" der. B bakımdan hiç kimsenin ölümsüz olmadığını ifade eder. Ersoy, daha sonra tarihe bakıldığında mezarlıkların göründüğünü söyler:

"Mâzi ki işte makbereler mâverâsıdır,

Milletlerin haziyre–i zâti–cüdâsıdır,

Atfeylesen nlgâhını ka'r–ı zalâmına:

Milletlere gözün ilişir na'ş nâmına!" (s.410).

Yukarıdaki dizelerde, "geçmiş dediğin, mezarların öte yanıdır; milletlerin ayrı ayrı aile mezarlıklarıdır. Bakışını o karanlık derinliğe çevirirsen, milletlerin cesetleri görünür." denilir. Bu bağlamda şair, tarihin ölüler âlemi olduğunu ve ibretle dolu olduğunu ifade eder. Tarihe dönüp bakıldığında milletlerin cesetleri görünecektir. Şair, geçmişte birçok milletin yok olup gittiğini belirtir. Şiirin sonraki dizelerinde *"Dâra'ların o nâsiye–i tarumarını, / Ecdadının izamını, çökmüş mezarını / Pîş–i nigâh–i ibretine al da bir düşün... / Çoktur bu rütbe dağdağa bir kabza hâk için!"* (s.410). denilerek dârâların, yani büyük hükümdarların darmadağın alın yazılarını ve atalarının çökmüş mezarlarını gözünün önüne al da düşün denir. Bu bakımdan bu kadar gösterişin, bir avuç toprak için çok olduğu ifade edilir. Şair, en büyük hükümdarlar bile yok olup gittiler, madem herkes bir avuç toprak olacaksa, bu kibir niye? diye sorar. Şair daha sonra Napolyon örneğini verir:

"İklimler alan o muazzam Napolyon'un

Bir hufredir kazandığı şey. İşte bak onun

En son seriri makbere–i mâtemisidir,"

Akreplerin nedimi, yılanlar enisidir!" (s.410).

Napolyon, birçok ülkeyi ele geçirmesine rağmen, onun kazandığı şey, bir mezar çukurudur. Şaire göre onun son yatağı matemli bir mezardır. Orada akrepler dostudur, yılanlar arkadaşı. En büyük fatih bile sonunda böceklerle baş başa kalır. Akif daha sonra, *"Yer kalmamış sarây–ı muallâna bak utan: / Matem–saraylarla dolu sâha–i vatan! / Emr–i cihan–mutâı bu dünyayı râm eden / Eslâfının –bugün düşünürsek– değil iken"* (s.410). der. Şair burada zalim hükümdara, yüce sarayına bakıp utanması gerektiğini, vatanın çevresi matem saraylarıyla, yani acı ve yasla dolu olduğunu, halk

yas içindeyken onların sarayının ihtişamının utanç verici olduğunu söyler. Akif, dünyaya hükmeden ataların bile bugün, ağızları toprakla dolu mezarlardadır ve artık feryat bile edemezler; buna göre hâlâ bu kibirli gürültün, bu gösterişin nedir? der. Şair, burada sana düşen tevazudur, çünkü sonun onlardan farklı olmayacak, diyerek herkesin ölümlü olduğunu hatırlatır.

"Acem Şahı" şiirinin ikincisi de Sâdî'nin bir beytiyle başlar: *"Riyaset be–dest–i kesânı hatâst / Ki ez–destşân– desthâ ber Hudâst"* (s.411). Şair, bu şiirin muhatabının, zulmüyle ülkesini kan gölüne çevirmiş bir hükümdar olduğunu ifade eder. Sadî, burada mazlumların Allah'a açılmış ellerini engelleyen -insanlara zulmeden- kimselerin eline, devlet yönetimini vermnin hata olduğunu söyler. Zalim birinin eline iktidar vermek büyük yanlıştır; çünkü zulme uğrayanlar Allah'a sığınır, duaları kabul bulur. Acem Şahı şiirinin ikinci kısmı, *"Bu müdhiş velvelen İran'ı daim inletir sanma. / 'Muzaffersin!' diyen sesler bütün hâindir, aldanma."* (s.411) dizesiyle başlar. Şair bu dizelerde bu korkunç gürültünün İran'ı sürekli sarsacağını sanma, zafer kazandın diye bağıranların hepsi haindir; onlara aldanma der. Şair, hükümdara, sana zafer nidaları atanlar sahtekârlardır; iktidarın kalıcı değil, der. "Zafer–yâb olduğun kimdir? Düşün bir kerre, millet mi? / Adalet isteyen bir kavmi vurmak galibiyyet mi?" (s.411) dizelerinde ise şair, hükümdara "Zafer kazandığın kim? Bir düşün. Millet mi? Adalet isteyen bir halkı ezmek zafer midir?" diye sorar. Akif, burada halka karşı kazanılan şey zafer değildir, zulümdür diyerek bir sultanın, şahın, hükümdarın kendi halkına karşı zalimce davranmaması gerektiğini, halka karşı zafer kazanmak diye bir şey olmadığını söylemek ister. Şair daha sonraki mısralarda da eleştirilerine devam eder:

"Nasibin yok mudur bir parça olsun âdemiyyetten?

Nasıl aldırmıyorsun yükselen feryada milletten?"

Emin ol bunca mazlumun yüreklerden kopan âhı,

Tependen indirir elbette bir gün lânetu'llahı!"

"Sığınmış olduğun şevket–sarây–ı zulmü pek muhkem

Hayal etmektesin... Lâkin ne bârûlar, ne müstahkem

Penâh–ı bî–amanlar, heybet–i kahhâr–ı Mutlak'la,

Kökünden devrilip bir anda yeksan oldu toprakla!" (s.411).

Mehmet Akif Ersoy, halkına eziyet eden hükümdarlara sert tavrını sürdürür. Yukarıdaki mısralarda söyle demek ister: İnsanlıktan hiç mi nasibin yok? Halktan yükselen çığlıklara nasıl kulak tıkıyorsun? Bil ki bunca mazlumun çektiği ah, bir gün Allah'ın lanetini tepene indirir! Sığınmış olduğun o görkemli zulüm sarayını çok sağlam sanıyorsun, ama unutma ne surlar, ne kaleler, ne sığınaklar mutlak güç sahibinin (Allah'ın) kahredici kudreti karşısında bir anda yerle bir olup toprağa karışmıştır! Şair, sonraki kısımlarda İran ülkesinden bahseder: *"Harâb olmaz mı? Kabristana dönmüşken bütün İran? / Evet, İran'ı kabristana döndürdün, helak ettin; / Kefen yaptın girîbân–ı ümidi çâk çâk ettin! / "Bütün dünya için bir damla kan çoktur" diyorlar, sen / Şu masûm ümmetin seller akıttın hûn–u pâkinden! / Yüzünden perde–i temkini artık kaldırıp attın: / Ne mâhiyyet, nasıl f irattasın, dünyaya anlattın!"* (s.411). Bu dizelerde şair şöyle söylemek ister: Kabristana dönmüşken bütün İran, o birçok memleket viran edip yaptırdığın eyvan harap olmaz mı? Evet, İran'ı bir mezarlığa çevirdin, perişan ettin. Halkın umutlarının yakasını yırtıp kefen ettin! Dünya için bir damla kan bile çoktur derler, ama sen bu masum halkın tertemiz kanını seller gibi akıttın! Artık yüzünden ihtiyat perdesini kaldırıp attın; ne olduğunu, nasıl bir tabiat taşıdığını dünyaya gösterdin. Akif, hükümdara gerçek yüzün, zalimliğin ortaya çıktı der. Şiirin devamında şair sözü İslam'a ve hürriyete getirir:

"Livâü'l–hamd–i hürriyet iken İslâm için gayet,

Nedir pâmâl–i istibdadın olmak öyle bir râyet?

Kazak celbeyleyip tâ Rusya'dan sâdâtı çiğnettin;

Yezid'in ruhu şâd olsun... Eminim çünkü şâd ettin!

Şehâmet gösterip binlerce Beytullâhı bastırdın;

Şecaat arz edip birçok ricâlullâhı astırdın!

Ne Allah'tan haya ettin, ne peygamberden âr ettin:

Devirdin Kâbe–i ulyâ–yı dini, hâk–sâr ettin!" (s.411).

Şair bu mısralarda hürriyet bayrağının İslam için övünç olduğunu, bu sebeple o bayrağın istibdadın ayağı altında ezilmemesi gerekir. Akif, dinin özgürlük ilkesini bile çiğnedin diyerek hükümdarın dini de zedelediğini söylemek ister. Daha sonra ise Rusya'dan Kazakları çağırıp büyük din âlimlerini çiğnettiğini, onun bu davranışının Yezid'in ruhunu sevindirdiğini, onu bile memnun ettiğini ifade eder. Mehmet Akif, hükümdarın zalimlikte en büyük zalimlerle bile yarıştığını söyler. Şair, onu sözde yiğitlik gösterip binlerce Allah evini bastığını, cesaret gösterisi yapar gibi birçok din büyüğünü astırdığını dile getirir. Daha sonra şair onun ne Allah'tan ne peygamberden utandığını, dinin yüce Kâbe'sini devirip yere çaldığını söyler. Akif, hükümdara İslâm'ın kutsal değerlerini ayaklar altına aldın der. *"Hamâset–perverân–ı kavmi tuttun bir bir öldürdün,"* (s.411) ve *"Umûmen Şark'ı ağlattın, umûmen Garb'ı güldürdün."* (s.412) diyerek onun milletin yiğitlik seven kahramanlarını tek tek öldürdüğünü, Doğu'nun tamamını ağlattığını, Batı'yı güldürdüğünü ifade eder. Şair burada, Acem Şahı'nın Ülkenin en değerli, cesur, onurlu insanlarını yok ettiğini, dış güçleri, yabancıları sevindirdiğini söylüyor. Şair, Şah'ın kendi milletine kötülük, karşı tarafa ise iyilik yaptığını, yanlışlarla kendi dünyasını mahvederken rakiplerini sevindirdiğini ifade eder. Akif, sonraki dizlerde Batı'nın bile bu duruma vicdanının sızladığını söyler: *Hayır, hiçbir gülen yok, sızlıyor Garb'ın da vicdanı, / Görüp ecsâd–ı mazlûmîne meşher hâk-i İran'ı!"* (s.412). Ersoy, bu kadar zulüm ve katliam karşısında, Batı'nın bile sevinemediğini, bu durumun insanlığın vicdanını yaralıdığını ifade etmektedir. Şair daha sonra İran'ın yetiştirdiği önemli sanat ve ilim adamlarına sözü getirir:

"O Sadi'ler, o Hafız'lar, o Firdevsi, o Râzi'ler,

Gazâli'ler, o Kutbüddin, o Sadüddin, o Kaadi'ler

Yetiştirmiş; o Örfi'nin, o birçok şems–i irfanın

Ziyasından tenevvür eylemiş iklimi dünyanın,

Bugün makhûr–u nâdânîsidir bir fırka haydudun!

Nedir pinhân olan esrarı, bilmem bunda Mabûd'un?

Hayır, Mabûd'a ircâında yoktur bunların ma'nâ:

Yataklık eylemez caniye –hâşâ– bir zaman Mevlâ.

Şehâmet–perverâ Şâhâ! Zaman bî–dâdı kaldırmaz;

Hata etmektesin şayet diyorsan "Kimse aldırmaz."

Bu istibdada artık bir nihayet ver ki: İstikbâl

Karanlık derler amma işte pek meydanda: İzmihlal!" (s.412)

Akif, Sadi, Hafız, Firdevsi, Râzi'ler vb. değerlerinden söz eder. Bu kişiler gibi nice irfan güneşlerinin ışıklarıyla dünya aydınlanmıştır. Şair, İran'ın bir zamanlar dünyayı kültür ve ilimle aydınlatan bir merkez olduğunu ifade etmektedir. Bu ülke, bugün ise bir grup haydutun cehaletiyle ezilmiş durumdadır. Şair, bu durumun Allah katındaki gizli sırrının ne olduğunu bilemediğini

söyler. Akif, Zulmü yapan yöneticileri "haydut" olarak ifade eder. Şiirin anlatıcısı, ilâhî hikmeti anlamakta güçlük çektiğini dile getirir. Daha sonra ise bütün bunları Allah'a bağlamanın bir anlamının olmadığını söyler. Çünkü Allah hiçbir zaman bir caniye yataklık yapmaz, onu desteklemez! "Bu zulüm Allah'ın takdiri" demek yanlıştır; zalimi Allah desteklemez. Eğer, "kimse aldırmaz" dersen hata yaparsın. Halkın suskunluğu, zulmün sonsuza dek süreceği anlamına gelmez. Bu istibdata artık bir son ver; yoksa geleceğin karanlık olacaktır. Aslında durum çok açıktır: Çöküş kapıdadır. Zorbalık sürerse devletin yıkılışı kesindir.

SONUÇ

Mehmet Akif Ersoy, birçok şiirinde adaletsizliğe, sömürüye, zulme, yöneticilerin yanlışlarına, toplumsal problemlere vb. yer verir. "Acem Şahı" adlı şiirinde de zulme karşı gelmektedir. Bu şiirde, 1907-1909 arasında İran'ın başında bulunan ve kötü yönetimiyle tanınan Muhammed Ali Şah'ı eleştirir. Şair, zalimliğini bir süs gibi gösteren hükümdara tepki gösterir. Ona göre şahın sarayı bir ölüm çadırı gibidir. Ülke adeta büyük bir mezarlığa dönüşmüştür. Akif, zalimin adının tarihe kanla yazıldığını, milletin hayat ışığının söndüğünü, insanların karanlığa mahkûm olduğunu, halkın kendi ülkesinde perişan olduğunu söyler. Şair, milletin geleceğini yok eden, milleti karanlığa mahkûm eden yönetimi eleştirir. Saraylarının ihtişamı ölümler üzerine kurulmuştur. Bu metinde zorba hükümdarlaratepki yer alır. Akif, daha sonra sözü Sadi'ye getirir. Akif, yukarıdaki dizelerde Sadi'yi gerçek bir mütevazi olarak görür. Mehmet Akif, bu kadar gösterişin sonunun bir avuç toprak olduğunu belirtir. Daha sonra Napolyon örneği verilir. Napolyon, birçok ülkeyi ele geçirmesine rağmen, o da sonunda mezara girmiştir, yani ölmüştür. Bu bakımdan ölümlü olan bu dünyada zalim olmamak gerekir. Şiirin anlatıcısı, mezarda zalimlerin dostunun akrepler, yılanlar ve böcekler olduğunu söyler. Buna göre bir yönetici veya iktidar, halkına zulüm etmemelidir. Zorbalıkla yönetilen ülkelerin yıkılması muhakkaktır. Mehmet Akif Ersoy, "Acem Şahı" şiirinde İran'ın mazlum cesetleriyle dolduğunu, zulümle devletin yönetilemeyeceğini, İran'ın bir mezarlığa çevrildiğini, halkın kanının aktığını ve özgürlüğün yok edildiğini söyleyerek zalim hükümdarı ağır şekilde eleştirir.

KAYNAKLAR

BAŞ, Selma (2012), "Bir Merhamet Şairi Olarak Mehmet Âkif", *Turkish Studies - International Periodical For The Languages, Literature and History of Turkish or Turkic*, Volume: 7(2), 193-217.

ERSOY, Mehmet Akif (2021), *Safahat,* İstiklâl Marşı'nın 100. Yılına Armağan-1, Yayına Hazırlayan: Necmettin Turinay, Ankara: TBMM Yayını.

KAHRAMAN, Ayşe (2018), *Mehmet Akif ve Müslüman Vakarı, Vefatının 80. Yılında Akif'i Anlamak Asım'ı Yaşamak*, Bildiriler Kitabı, Anadolu Mektebi Mehmet Akif Okumaları, Burdur Mehmet Akif Ersoy Üniversitesi, ISBN 978-9944-729-21-5, MAKÜ Yayınları, Burdur.

KARABULUT, Mustafa (2021), *Mehmet Âkif Ersoy ve İstiklâl Marşı*, İstanbul: Hiperyayın.

KUNTAY, Mithat Cemal (2005). *Mehmet Akif*, İstanbul: L&M Yayınları

NARLI, Mehmet (2012), "Safahat'ın Suretleri", *Türk Dili*, 2(729), 24-29

OZAN, İbrahim Halil (2016), "II. Abdülhamid Döneminde İslâmcı Muhalefet ve Mehmet Âkif Ersoy", *Yüzüncü Yıl Üniversitesi İlahiyat Fakültesi Dergisi*, 4(4-5), 145-163.

ÖZGÜDENLİ, Osman Gazi (2005), "Muhammed Ali Şah", TDV İslâm Ansiklopedisi, C.30, İstanbul: Türkiye Diyanet Vakfı Yayınları.

SAFİ, İhsan (2021), "Mehmet Âkif Ersoy ve II. Abdülhamid Meselesi-1", *Recep Tayyip Erdoğan Üniversitesi Fen-Edebiyat Fakültesi Türk Dili ve Edebiyatı Dergisi*, 2(2), 23-58.

YILMAZ, Mehmet (2021). "Eski ile Yeni Arasında Mithat Cemal Kuntay'la Mehmet Akif'in Dostluğu", *Academic Knowledge*, 4(2), 200-212.

THE EFFECT OF NEEM (*STYRAX OFFICINALIS* L.) SEED AND PHYTOSTEROL SUPPLEMENTATION ON WEIGHT GAINS IN RATS WITH EXPERIMENTALLY INDUCED BENIGN PROSTATIC HYPERPLASIA

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ABSTRACT

Benign prostatic hyperplasia (BPH) is one of the most common urological diseases in elderly patients. It is a histological diagnosis characterized by an increase in the number of epithelial and stromal cells in the prostate gland. When BPH symptoms begin to appear, traditional treatment methods are used. Phytotherapy is one of the leading methods. β-Sitosterol, a phytosterol, has been shown to have effective positive results in many clinical studies related to BPH. *Styrax officinalis* L. (S. officinalis) is also one of the traditionally used medicinal plants. Extracts obtained from *S. officinalis* have been shown to have beneficial biological effects such as anticancer, antifungal, antibacterial, and antioxidant properties. In this study, 14-week-old Sprague Dawley rats were fed a herbal diet consisting of *Styrax officinalis* L. and phytosterols. The effects of herbal and phytosterol diets on weight gains in the rats were investigated. In this study, rats were divided into Control, SOI, SOII, BPH, BPH+SOI, BPH+SOII, BPH+F, BPH+BS, and BS groups. Rats other than the Control, SOI-II, and BS groups received 5 mg/kg sidenafil twice a week via gavage. The BPH+BS and BS groups received 100 mg/kg β-Sitosterol three times a week via gavage, the BPH+F group received 1 mg/kg finasteride three times a week, and the SO and BPH+SO groups received 100 (I) and 200 (II) mg/kg *S. officinalis* seed content via gavage. All groups were fed for 45 days.

The rats' initial weights were measured before the start of the experiment, and their final weights were measured at the end of the experiment. Weight gain percentages (%) were calculated from the initial and final weight data. Looking at the results, the highest weight gain was observed in the SOI group (41.26%) compared to the control group (37.15%). The lowest weight gain was observed in the BPH+SOII group (30.10%). Although the weight gain was lower in some groups compared to the control group, the weight gain was higher in the groups given the plant alone

compared to the groups given sildenafil together (BPH+SOI 32.44%, BPH+BS 34.18%). In conclusion, it was observed that *S. officinalis* plant and phytosterol feeding were effective in reducing the weight gain in rats. However, giving the plant together with sildenafil in high doses reduced the weight gain rates. It was observed that the groups containing plant and β-sitosterol were beneficial for the weight gain of rats.

Keywords: Benign prostatic hyperplasia, *Styrax officinalis* L, Phytotherapy, β-Sitosterol

INTRODUCTION

Benign prostatic hyperplasia (BPH) is one of the most common urological disorders affecting older men (Untergasser et al., 2005; Parsons and Kashefi, 2008). It is a non-cancerous hyperplasia of the prostate gland resulting from the overgrowth of prostatic epithelial and stromal cells (Roehrborn, 2008; Dhingra and Bhagwat, 2011). Over the years, an increase in cases of benign prostatic hyperplasia (BPH) has been observed worldwide. In 2019, it was reported that more than 90 million cases of BPH were recorded worldwide; this figure is quite high compared to the more than 50 million cases recorded in 2000, and most of these figures come from developing countries where the prevalence is high (Awedew et al., 2022). According to histopathology, BPH is characterized by an increase in the number of stromal and epithelial cells in the periurethral area of the prostate gland. It is unclear exactly what causes this hyperplastic process. The observed increase in cell number may result from cell proliferation or impaired natural cell death leading to cell accumulation (Irani et al., 2003). A number of studies have linked the etiology of BPH to systemic inflammation and oxidative stress, and an imbalance in the metabolism of steroid hormones (Madersbacher et al., 2019). Current treatment options for BPH include medical treatment with α-blockers or 5α-reductase inhibitors, surgery, and phytotherapy (Kim et al., 2019; Miernik and Gratzke, 2020). 5α-reductase inhibitors prevent the conversion of testosterone to dihydrotestosterone (DHT), thus leading to a reduction in prostate size (Miernik and Gratzke, 2020). Common 5α-reductase inhibitors include pharmacological agents such as dutasteride and finasteride (Ogbu et al., 2020). Unfortunately, many side effects associated with current BPH medications include decreased libido, erectile dysfunction, dizziness, retrograde ejaculation, and low sperm count (Yu et al., 2020; Winner et al., 2016).

For years, herbal extracts have been among the most popular medications for the medical treatment of lower urinary tract symptoms (LUTS) associated with benign prostatic hyperplasia/benign prostatic hyperplasia (BPH). In countries with a long-standing tradition of phytotherapy, such as Austria, Germany, and France, the market share of herbal extracts reaches 30-50% (Madersbacher et al., 2007). Over the last two decades, there has been considerable interest in the use of herbal extracts to treat BPH, including Seronoa repens (Saw Palmetto), Equisitum (Field or Common Horsetail), and Epilobium (Fireweed). In Europe, particularly in Germany, Austria, Italy, and France, phytotherapy is often the first-line treatment for BPH symptoms (Coulson et al., 2013).

Styrax officinalis L. is a plant that grows in the Mediterranean and Central Black Sea regions of Türkiye, the tropical parts of America, and some parts of Southeast Asia. It is a perennial shrub-type oilseed plant with a relatively high oil content (approximately 50%) (Moser, 2016). This means that if cultivated, the plant can provide significant economic and ecological benefits. From an industrial value perspective, this plant is important because it can grow in non-agricultural environments, on barren, degraded surfaces, and in wooded areas (Yesilyurt and Cesur, 2017; Chuah et al., 2016). In India, the entire S. officinalis plant has traditionally been used for its antibacterial, antifungal, and wound-healing properties. It is also used to treat skin ulcers, amenorrhea, and scabies. Its tincture is used as a mouthwash and against asthma, cough, gonorrhea, tuberculosis, and edema (Chopra et al., 1986; Heywood, 1993).

Furthermore, in traditional Jordanian and Palestinian medicine, *S. officinalis* seeds are used in cases of skin rashes, leprosy, and many other skin diseases (Jaradat, 2005; Lev and Amar, 2002). Infusions made from its leaves and flowers are used in traditional medicine against coughs and in the treatment of diphtheria and leukorrhea (Al-Qura'n, 2009; Al-Qura'n, 2015).

Materials and Methods

Materials

Styrax officinalis plants were collected from Osmaniye province. *S. officinalis* was peeled and ground into a powder using a blender. Then, 2 grams of plant powder was mixed with 20 ml of 0.9% NaCl and 20 ml of DMSO and left to stand for 12 hours. The sildenafil used in the study was purchased commercially: Combo brand (Biofarma, Istanbul), Urorec brand finasteride (Recortadı, Italy), and Sigma-Aldrich brand β-sitosterol. The 14-week-old Sprague Dawley rats used in the study were obtained from the Fırat University Experimental Animal Research Center (FÜDAM, Elazığ, Turkey). The Fırat University (Elazığ, Turkey) Local Ethics Committee for Animal Experiments approved all animal experiments with session number 2024/02-12.

Method

Sprague Dawley rats were randomly divided into Control, SOI, SOII, BPH, BPH+SOI, BPH+SOII, BPH+F, BPH+BS, and BS groups. The rats were cared for and fed at the Fırat University Experimental Animal Research Center (FÜDAM). Seven animals were placed in plastic cages in each group. Their feed and water were given ad libitum. Rats other than the Control, SOI-II, and BS groups were administered 5 mg/kg sidenafil twice a week via gavage. The BPH+BS and BS groups were administered 100 mg/kg β-Sitosterol three times a week via gavage, the BPH+F group was administered 1 mg/kg finasteride three times a week, and the SO and BPH+SO groups were administered 100(I) and 200(II) mg/kg *S. officinalis* seed content via gavage. All groups were fed for 45 days. Animals were kept at room temperature (22±3 ˚C) under standard laboratory conditions with a 12-hour light/dark period.

Weight gain measurement

The initial weights of the rats were measured immediately before the experiment and their final weights were measured at the end of the experiment. Weight gain (WG, %) was calculated with the following formula (1):

Weight gain (WG, %) = [(final weight - initial weight) / initial weight] ×100 (1)

Statistical analysis

The obtained data were expressed as mean ± SEM. Statistical analysis was performed using SPSS 22.0 (IBM, USA). Tukey's HSD test and one-way ANOVA were performed to analyze the change between groups. Significant differences between results were indicated with different letters ($P<0.05$).

Results and Discussion

Before the experiment began, the initial weights of the rats were measured, and after 45 days, their final weights were measured. Weight changes in rats were measured after 45 days of phytosterol-supplemented feeding with *S. officinalis*, β-sitosterol, and finasteride, and additionally, sildenafil was administered to the BPH groups. Weight gain rates for the groups are shown in Figure 1. According to the results, the differences between the groups were statistically significant ($P<0.05$). Compared to the control group (37.15%), weight gain increased in rats fed with 100 mg/kg of *S. officinalis* (SOI) (41.26%) ($P<0.05$). When the dose of the plant was increased to 200 mg/kg (SOII), weight gain (36.52%) was similar to the control group. Plants contain minerals, which are

essential components of a healthy human diet, as well as various primary and secondary metabolites that affect nutrition and human health (Gürbüz et al., 2018). Vegetable and fruit consumption is recommended because they are a rich source of natural antioxidants, such as vitamin E (tocopherols) and vitamin C (ascorbic acid). Antioxidants provide various health benefits, including the regulation of immune function, reduction of DNA damage, and improvement of lipid peroxidation. Vitamin C exists as ascorbic acid and dehydroascorbic acid, with the former being the dominant form in plants (Gropper and Smith, 2020, Kim et al., 2016). In a study with marjoram (*Origanum majorana* L.), forty adult male Wistar rats were injected with two doses (250 and 500 mg/kg/day) of an ethanolic extract of *O. majorana* for 28 days. In BPH groups, testosterone propionate (TP) was injected subcutaneously for one week (0.5 mg/kg/day). In the study, the BPH and *O. majorana* 250 groups showed less body weight gain compared to the finasteride and *O. majorana* 500 groups, while the finasteride and O. majorana 500 groups showed significantly greater body weight gain compared to the control (carrier) group (Elsherbini et al., 2022). In another study, rats were given testosterone propionate (TP) (3 mg/kg ip), finasteride (FIN) (10 mg/kg po), and methyl jasmonate (MeJA) (50 mg/kg ip) daily for 4 weeks. As a result of this study, BPH rats treated with methyl jasmonate (126%), finasteride (116%), and a combination of methyl jasmonate and finasteride (211%) showed significantly higher weight gains ($p < 0.05$) compared to untreated BPH rats (Adaramoye et al, 2017).

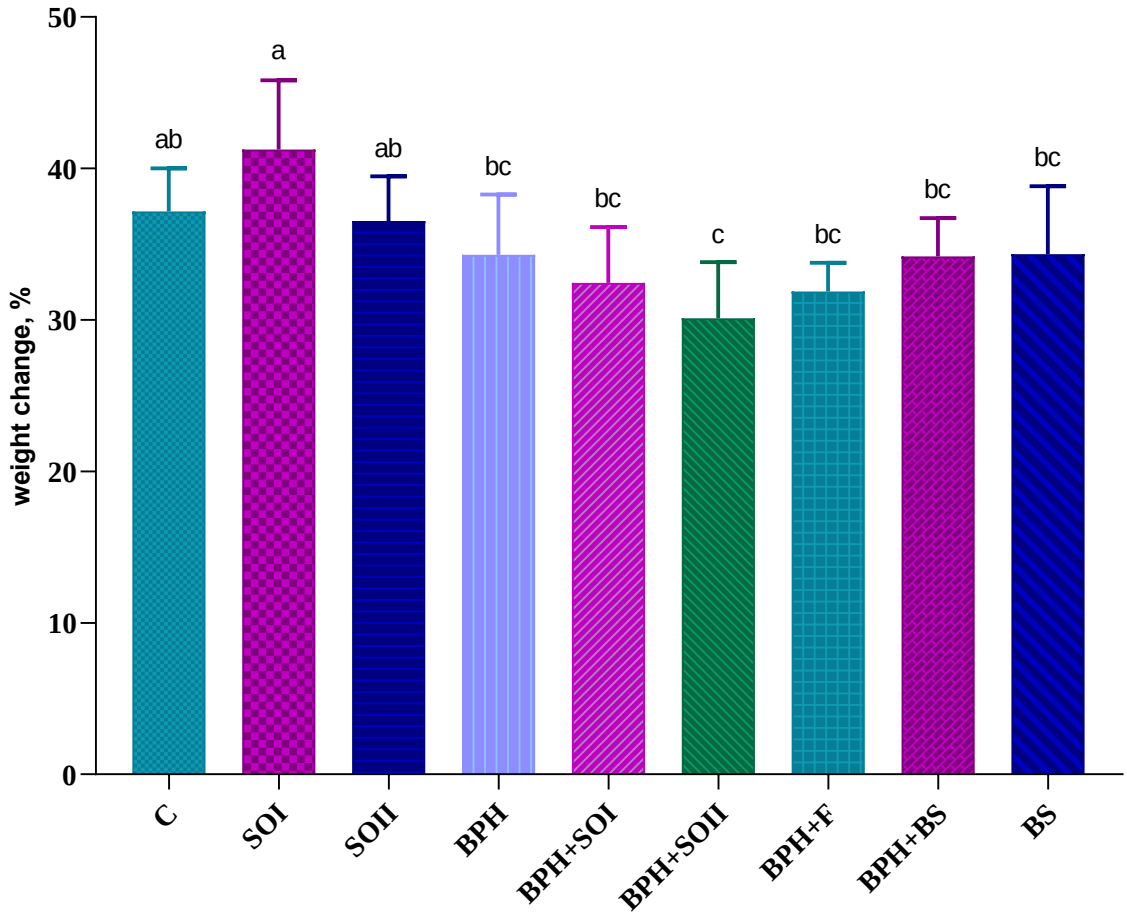


Figure 1: Weight gain rates in rats fed with *S. officinalis*, finasteride, and β-sitosterol (Each letter (a, b, c) represents the difference between groups (P<0.05)).

Looking at the BPH groups, the BPH group treated only with sildenafil (34.31%) showed a decrease in weight gain compared to the control group. The BPH+SOI (32.44%) and BPH+SOII (30.10%) groups, which also received *S. officinalis*, also showed a decrease compared to the control group. The lowest weight gain was observed in the BPH+SOII group (30.10%) treated with 200 mg/kg *S. officinalis* + 5 mg/kg sildenafil. Numerous studies have shown that long-term sildenafil citrate use is associated with oxidative stress, matorial responses, and structural changes in the testicular environment (Huang et al., 2024). *Styrax officinalis* is a medicinal plant used in folk medicine in Palestine and is used to treat some infections, diseases, and oxidative stress (Jaradat et al., 2018; Jaradat, 2020, Paşa, 2023). In one study, *Uvaria rufa* ethyl acetate extract (UR-EtOAc) and BPH group male rats were induced by subcutaneous injection of testosterone propionate (3 mg/kg) for 30 days. Thirty days after oral administration of UR-EtOAc at doses of 10 and 20 mg/kg and finasteride at a dose of 1 mg/kg, rat body weight gain and body weight change did not differ significantly between the normal control, BPH model, and finasteride and UR-EtOAc treated groups ($P > 0.05$) (Buncharoen et al., 2016). In a study with *Thymelaea hirsuta* extract (THE), 28 days of testosterone and THE treatment in Wistar rats did not show a significant effect on body weight in the BPH group compared to the control group (Feki et al., 2025).

When weight gain was examined in the BPH+BS, BS, and BPH+F groups fed with supplemental phytosterols such as β-sitosterol and finasteride, a decrease was observed in these groups compared to the control group (34.18%, 34.33%, and 31.87%, respectively). Similar results were obtained when these groups were compared with the BPH group fed only with sildenafil (34.30%). Phytosterols (including plant sterols and stanols) cannot be synthesized by humans, and all plant sterols and stanols in the human body therefore originate from the diet (Jong et al., 2003). They are known to have several bioactive qualities with possible implications for human health (Normen et al., 2002). In a study by Kanu et al. (2024), a weight gain of 11.24% was recorded in the normal control group and 8.28% in the positive control group treated with testosterone prepionate and finasteride in Wistar rats. In a study comparing the effectiveness of saw palmetto oil enriched with β-sitosterol (VISPO) and conventional saw palmetto oil (SPO) obtained using supercritical fluid extraction, prostate weights were significantly reduced in the groups treated with finasteride and VISPO ($p < 0.001$) (Sudeep et al., 2019).

Conclusion

Plants and phytosterols support cell proliferation and growth due to their antioxidant capacity. According to the study results, *S. officinalis* and phytosterols were found to be effective in the weight changes of rats fed with them. However, in the groups treated with sildenafil and those given sildenafil, rat weight changes decreased. It is thought that the groups containing plant-based and β-sitosterol are beneficial to the weight changes of rats and that the cultivation and commercial presentation of this plant will be beneficial to humans.

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References

Adaramoye, O. A., Akanni, O. O., Abiola, O. J., Owumi, S. E., Akinloye, O., & Olapade-Olaopa, E. O. (2017). Methyl jasmonate reduces testosterone-induced benign prostatic hyperplasia through

regulation of inflammatory and apoptotic processes in rats. Biomedicine & Pharmacotherapy, 95, 1493-1503.

Al-Qura'n, S. (2009). Ethnopharmacological survey of wild medicinal plants in Showbak, Jordan. Journal of Ethnopharmacology, 123(1), 45-50.

Al-Quran, S. (2015). Ethnobotany of analgesic/stimulant plants used by the inhabitants of Ajloun, Northern Jordan. Arnaldoa, 22(1).

Awedew, A. F., Han, H., Abbasi, B., Abbasi-Kangevari, M., Ahmed, M. B., Almidani, O., ... & Dirac, M. A. (2022). The global, regional, and national burden of benign prostatic hyperplasia in 204 countries and territories from 2000 to 2019: a systematic analysis for the Global Burden of Disease Study 2019. The Lancet Healthy Longevity, 3(11), e754-e776.

Buncharoen, W., Saenphet, K., Saenphet, S., & Thitaram, C. (2016). *Uvaria rufa* Blume attenuates benign prostatic hyperplasia via inhibiting 5α-reductase and enhancing antioxidant status. Journal of ethnopharmacology, 194, 483-494.

Chopra, R. N., Nayar, S. L., & Chopra, I. C. (1986). Glossary of Indian medicinal plants (including the supplement). Council of scientific and industrial research, New Delhi, 89, 77-100.

Chuah, L. F., Yusup, S., Aziz, A. R. A., Klemeš, J. J., Bokhari, A., & Abdullah, M. Z. (2016). Influence of fatty acids content in non-edible oil for biodiesel properties. Clean Technologies and Environmental Policy, 18(2), 473-482.

Coulson, S., Rao, A., Beck, S. L., Steels, E., Gramotnev, H., & Vitetta, L. (2013). A phase II randomised double-blind placebo-controlled clinical trial investigating the efficacy and safety of ProstateEZE Max: a herbal medicine preparation for the management of symptoms of benign prostatic hypertrophy. Complementary therapies in medicine, 21(3), 172-179.

Dhingra, N., & Bhagwat, D. (2011). Benign prostatic hyperplasia: An overview of existing treatment. Indian journal of pharmacology, 43(1), 6-12.

Elsherbini, D. M. A., Almohaimeed, H. M., El-Sherbiny, M., Mohammedsaleh, Z. M., Elsherbiny, N. M., Gabr, S. A., & Ebrahim, H. A. (2022). *Origanum majorana* L. extract attenuated benign prostatic hyperplasia in rat model: effect on oxidative stress, apoptosis, and proliferation. Antioxidants, 11(6), 1149.

Feki, I., Hadrich, F., Mahmoudi, A., Llorent-Martínez, E. J., Bouallagui, Z., Souilem, S., ... & Sayadi, S. (2025). *Thymelaea hirsuta* extract attenuates testosterone-induced benign prostatic hyperplasia in rats: Effect on oxidative stress, inflammation and apoptosis. Journal of Ethnopharmacology, 342, 119373.

Gropper S.S., Smith J.L. Advanced Nutrition and Human Metabolism Cengage Learning. [(accessed on 22 October 2020)]

Gürbüz, N., Uluişik, S., Frary, A., Frary, A., & Doğanlar, S. (2018). Health benefits and bioactive compounds of eggplant. Food chemistry, 268, 602-610. doi: 10.1016/j.foodchem.2018.06.093

Heywood, V.H. (1993). Flowering Plants of the World. Oxford University Press UK.

Huang, S., Huang, D., Su, X., Yang, R., Shao, C., Jiang, J., ... & Wu, J. (2024). Sildenafil citrate induces prostatic hyperplasia in BPH model rats and aged rats. Toxicology and Applied Pharmacology, 493, 117147.

Jaradat, N. A. (2005). Medical plants utilized in Palestinian folk medicine for treatment of diabetes mellitus and cardiac diseases. Al-Aqsa University Journal (Natural Sciences Series), 9(1), 1-28.

Jaradat, N. (2020). Phytochemistry, traditional uses and biological effects of the desert plant Styrax officinalis L. Journal of Arid Environments, 182, 104253.

Jaradat, N., Al-Masri, M., Zaid, A. N., Hussein, F., Shadid, K. A., Al-Rimawi, F. and Eid, A. (2018). Assessment of the antimicrobial and free radical scavenging activities of *Moluccella spinosa*, *Helichrysum sanguineum*, and *Styrax officinalis* folkloric medicinal plants from Palestine. Oriental Pharmacy and Experimental Medicine, 18(2), 107-114.

Jong, A., Plat, J., & Mensink, R. P. (2003). Metabolic effects of plant sterols and stanols. The Journal of Nutritional Biochemistry, 14(7), 362-369.

Irani, J., Lefebvre, O., Murat, F., Dahmani, L., & Dore, B. (2003). Obesity in relation to prostate cancer risk: comparison with a population having benign prostatic hyperplasia. BJU international, 91(6), 482-484.

Kanu, S. C., Ejezie, F. E., Ejezie, C. S., & Eleazu, C. O. (2024). Effect of methanol extract of *Plectranthus esculentus* NE Br tuber and its fractions on indices of benign prostatic hyperplasia in Wistar rats. Journal of Ethnopharmacology, 331, 118301.

Kim, J. H., Park, K. M., & Lee, J. A. (2019). Herbal medicine for benign prostatic hyperplasia: A protocol for a systematic review of controlled trials. Medicine, 98(1), e14023.

Kim, M. J., Moon, Y., Tou, J. C., Mou, B., & Waterland, N. L. (2016). Nutritional value, bioactive compounds and health benefits of lettuce (*Lactuca sativa* L.). Journal of Food Composition and Analysis, 49, 19-34. doi: 10.1016/j.jfca.2016.03.004.

Lev, E., & Amar, Z. (2002). Ethnopharmacological survey of traditional drugs sold in the Kingdom of Jordan. Journal of Ethnopharmacology, 82(2-3), 131-145.

Madersbacher, S., Ponholzer, A., Berger, I., & Marszalek, M. (2007). Medical management of BPH: role of plant extracts. eau-ebu update series, 5(5), 197-205.

Madersbacher, S., Sampson, N., & Culig, Z. (2019). Pathophysiology of benign prostatic hyperplasia and benign prostatic enlargement: a mini-review. Gerontology, 65(5), 458-464.

Miernik, A., & Gratzke, C. (2020). Current treatment for benign prostatic hyperplasia. Deutsches Ärzteblatt International, 117(49), 843. https://doi.org/10.3238/ arztebl.2020.0843.

Moser, B. R. (2016). Fuel property enhancement of biodiesel fuels from common and alternative feedstocks via complementary blending. Renewable Energy, 85, 819-825.

Normen, L., Bryngelsson, S., Johnsson, M., Evheden, P., Ellegård, L., Brants, H., ... & Dutta, P. (2002). The phytosterol content of some cereal foods commonly consumed in Sweden and in the Netherlands. Journal of Food Composition and Analysis, 15(6), 693-704.

Ogbu, P. N., Ugota, E. O., Onwuka, R. U., Ogbu, I. M., & Aloke, C. (2020). Effect of acetogenin fraction of *Annona muricata* leaves on antioxidant status and some indices of benign prostatic hyperplasia in rats. Redox Report, 25(1), 80-86.

Paşa, C. (2023). The use of *Styrax officinalis* L. in folk medicine and chemical composition. GSC Advanced Research and Reviews, 17(03), 086-089.

Parsons, J. K., & Kashefi, C. (2008). Physical activity, benign prostatic hyperplasia, and lower urinary tract symptoms. European urology, 53(6), 1228-1235.

Roehrborn, C. G. (2008). Pathology of benign prostatic hyperplasia. International journal of impotence research, 20(3), S11-S18.

Sudeep, H. V., Venkatakrishna, K., Amrutharaj, B., Anitha, & Shyamprasad, K. (2019). A phytosterol-enriched saw palmetto supercritical CO2 extract ameliorates testosterone-induced

benign prostatic hyperplasia by regulating the inflammatory and apoptotic proteins in a rat model. BMC complementary and alternative medicine, 19(1), 270.

Untergasser, G., Madersbacher, S., & Berger, P. (2005). Benign prostatic hyperplasia: age-related tissue-remodeling. Experimental gerontology, 40(3), 121-128.

Winner, K., Polycarp, O., Ifeoma, I., & Chinedum, E. (2016). Effect of fractions of kolaviron on some indices of benign prostatic hyperplasia in rats: identification of the constituents of the bioactive fraction using GC-MS. RSC advances, 6(97), 94352-94360.

Yesilyurt, M. K., & Cesur, C. (2020). Biodiesel synthesis from *Styrax officinalis* L. seed oil as a novel and potential non-edible feedstock: A parametric optimization study through the Taguchi technique. Fuel, 265, 117025.

Yu, Z. J., Yan, H. L., Xu, F. H., Chao, H. C., Deng, L. H., Xu, X. D., ... & Zeng, T. (2020). Efficacy and side effects of drugs commonly used for the treatment of lower urinary tract symptoms associated with benign prostatic hyperplasia. Frontiers in Pharmacology, 11, 658.

GROTESQUE STRUCTURE IN İHSAN OKTAY ANAR'S NOVEL "PUSLU KITALAR ATLASI"

İHSAN OKTAY ANAR'IN "PUSLU KITALAR ATLASI" ROMANINDA GROTESK YAPI

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ABSTRACT

The word grotesque generally refers to a decorative style composed of bizarre and ridiculous elements. This concept is used in various fields such as theater, architecture, and literature. Grotesque depictions and narratives hold a significant place in literary works with horror themes. In literary works, the crude and ridiculous aspects of the characters are highlighted. Furthermore, deformities made to the characters' bodies are also referred to as grotesque. In modern literature, the grotesque structure is generally associated with deformities, repulsion, ugliness, and horror. One of the authors who most frequently uses the grotesque structure in Turkish literature is İhsan Oktay Anar. The author explicitly employs it in his novels *Puslu Kıtalar Atlası*, *Efrrâsiyâb'ın Hikâyeleri* and *Galiz Kahraman*. *Puslu Kıtalar Atlası*, is a work in which Uzun İhsan Efendi and his son Bünyamin are prominent figures. Uzun İhsan drinks a sleeping potion to see unknown places in his dreams. Uzun İhsan Efendi gives his son the book he has prepared, *Puslu Kıtalar Atlası*. Bünyamin engages in a conflict to rescue a spy named Zülfiyar. Zülfiyar is wounded and gives Bünyamin a valuable magnetic coin. This is "black money" and brings bad luck. Bünyamin is severely injured in the face during the conflict and becomes unrecognizable. Meanwhile, Uzun İhsan Efendi has been captured, his eyes gouged out, and his ears cut off. Bünyamin, arriving at the beggars' guild, cannot recognize his father. Similarly, Uzun İhsan Efendi cannot recognize his son Bünyamin. Both characters possess a grotesque appearance. The aim of this study is to reveal the grotesque structure in İhsan Oktay Anar's novel *Puslu Kıtalar Atlası*.

Keywords: İhsan Oktay Anar, Novel Puslu Kıtalar Atlası, Grotesque.

Özet

Grotesk sözcüğü, genel olarak tuhaf, gülünç unsurlardan meydana gelmiş bir süsleme üslubudur. Bu kavram, tiyatroda, mimaride, edebiyatta vb. farklı alanlarda kullanılmaktadır. Korku temalı edebi eserlerde grotesk tasvirler ve anlatımlar önemli yer tutar. Edebi eserlerde karakterlerin kaba ve gülünç tarafları öne çıkar. Bununla beraber karakterlerin vücutlarında yapılan deformasyonlar da grotesk olarak adlandırılır. Modern edebiyatta grotesk yapı, genel olarak biçimsiz, iğrenç, çirkin ve korku yönleriyle bağlantılıdır. Türk edebiyatında grotesk yapıyı en çok kullanan yazarlardan biri İhsan Oktay Anar'dır. Yazar, Puslu Kıtalar Atlası, Efrrâsiyâb'ın Hikâyeleri ve Galiz Kahraman romanlarında bunu açıkça kullanır. Puslu Kıtalar Atlası, Uzun İhsan Efendi ve oğlu Bünyamin'in ön planda olduğu bir eserdir. Uzun İhsan, rüyasında bilinmeyen yerleri görmek için uyku şurubu içip uykuya yatar. Uzun İhsan Efendi, hazırladığı Puslu Kıtalar Atlası kitabını oğluna verir.

Bünyamin, Zülfiyar adlı casusu kurtarmak için çatışmaya girer. Zülfiyar yaralanır ve elindeki değerli mıknatıslı parayı Bünyamin'e verir. Bu, "kara para"dır ve uğursuzluk getirir. Bünyamin, çatışmada yüzünden ağır yaralanır ve tanınmaz hale gelir. Bu arada Uzun İhsan Efendi yakalanmış, gözleri oyulmuş ve kulakları kesilmiştir. Dilenciler loncasına giden Bünyaöin, babasını tanıyamaz. Ayrıca Uzun İhsan Efendi de oğlu Bünyamin'i tanıyamaz. Her iki karakter de grotesk bir görüntüye sahiptir. Bu çalışmada amaç, İhsan Oktay Anar'ın Puslu Kıtalar Atlası romanındaki grotesk yapıyı ortaya koymaktır.

Anahtar Kelimeler: İhsan Oktay Anar, Puslu Kıtalar Atlası Romanı, Grotesk.

GİRİŞ

İhsan Oktay Anar, romanlarında dil, imge ve anlatım tekniklerini; metinlerarasılık, üst kurmaca, grotesk yapı, fantastik, ironi vb. birçok unsuru çok iyi kullanan bir yazardır. Anar'ın romanları, "Adlarından kullandıkları dile, doğaüstü olaylara dinsel ve alegorik unsurlara yer veren içeriklerine, düşünsel derinliğine, kişilerin simgesel kimliklerine, geleneksel formlara ve söz kalıplarına yer veren üsluplarına, ilk bakışta bağımsız gibi görünen ama sonradan ustaca birbirine bağlanan iç içe geçmiş öykülerine, mizahi ögelerle beslenen" (Gündüz, 2012: 40) ironik üsluba sahip eserlerdir. "Onun romanlarındaki belirsizleşen zaman ve mekân, dili kullanma biçimindeki radikal tercihler, yeni tarihselciliğe yaklaşan tarihi yorumlama biçimi; onu postmodernin Türk romanındaki en önemli temsilcilerinden biri konumuna getirir." (Hüküm, 2017: 40).

İhsan Oktay Anar'ın 1995 yılında yayımlanan ilk romanı olan *Puslu Kıtalar Atlası*, fantastik unsurların yoğun olduğu, tarihi bir arka plan içinde kurgulandığı, felsefi derinliği olan, varoluşun sorgulandığı, hayal ve hakikatin zaman zaman iç içe girdiği bir eserdir. Romanın merkezinde, Uzun İhsan Efendi bulunur. Uzun İhsan Efendi, tuhaf davranışları, ilginç düşünceleri ve hayal gücüyle dikkat çeker. O, içtiği bir şurupla uykuya yatar, uyandığında rüyada gördüklerini bir deftere not alır ve buna "Puslu Kıtalar Atlası" adını verir. Durağan bir yapıya sahip olan Uzun İhsan Efendi, bu atlas sayesinde yeni dünyaları keşfetmek isteyen bir kişidir. Bu atlasta hayal ile gerçeği sorgulayan Uzun İhsan, hayatın adeta bir rüya olduğunu düşünür. Esere farklı karakterlerin katılmasıyla kalabalık bir şahıs kadrosu ortaya çıkar. Romanda sadece fiziki yolculuk değil, aynı zamanda içsel yolculuklar da yer alır. Eserin sonlarında dünyanın aslında bir rüyadan ibaret olduğu, gerçekliğin ise bir yanılsama olduğu kanaatine varılır.

Puslu Kıtalar Atlası, bütün bunların yanı sıra grotesk unsurlar bakımından da zengin bir romandır. Roman, "*Ulema, cühela ve ehli dubara; ehli namus, ehli işret ve erbab-ı livata rivayet ve ilan, hikâyet ve beyan etmişlerdir ki kun-ı Kâinattan 7079 yıl, İsa Mesih'ten 1681 ve Hicretten dahi 1092 yıl sonra, adına Konstantiniye derler tarrakası meşhur bir kent vardı*." (Anar, 2019; 13) cümlesiyle başlar. Bu ilk cümleden hareketle yazarın okuru masalımsı, gizemli ve fantastik bir dünyaya davet ettiğini söylemek mümkündür. Romanın ismi de bunu doğrular niteliktedir. Yazar, hayal-hakikat, akıl-duygu, uyanıklık-rüya hali tezatlarında yeni bir dünya kurar.

Uzun İhsan Efendi uyku şurubundan içerek düşler âlemine dalar. Uyandığında ise rüyada gördüklerine göre bir dünya atlası hazırlar. "O, bilgiyi düşlerinde arayıp bir Dünya Atlası hazırlarken oğlu Bünyamin daha gerçekçidir ve bilgiyi hayaller âleminde değil dünyada aramaktadır. Bir sefer dönüşü Arap İhsan'a ganimet olarak düşen yedi yaşındaki Alibaz, uykusuzluk illeti çekmektedir. Rüyasında gördüğü kişiyi rahatsız eden tüccara bir daha uyumama dolayısıyla düş görmeme cezası verilmektedir. Tüccarın yeniden uyuyabilmesi için senelerdir uyuyan han bekçisini uyandırması gerekmektedir. Bütün bunlar romanın genelinde düşler âlemine açılan kapı olarak uykuyu işaret etmektedir. Bu yüzden, uyku, gerçekler ile hayaller arasında önemli bir bağlantı noktası oluşturmaktadır." (Yeşilyurt, 2008: 1820).

Kubelik, Venedik balyosunun kâtipliğini yapar. Bir gün Galata meyhanelerinin birinde Arap İhsan'la karşılaşır. "Arap İhsan, Frenk lisanına vakıf olan Kubelik'e bir kitap verir ve onu tercüme etmesini söyler. Kubelik bu kitabın yazarının Rendekâr adında bir feylesof, kitabın adının ise Galata meyhanelerinde kazandığı argo kültürünün etkisiyle ZAGON ÜZERİNE ÖTTÜRME olduğunu belirtir. Bu kitap Descartes'in Yöntem Üstüne Söylev isimli eserinden başkası değildir." (Yeşilyurt, 2008: 1815). Romanın ilk sayfalarından itibaren hayal-hakikat çatışması kendini gösterir.

Romanın önemli imgelerinden biri paradır. "Roman boyunca para; arayışı, merakı neticede bilgiye ulaşma arzu ve ihtirasını temsil etmektedir. Bilgiye sahip olmak zordur. Nitekim gerek yurt içindeki gerekse yurt dışındaki istihbarat teşkilatlarının faaliyetleri bütünüyle puslu ve gizemlidir." (Yeşilyurt, 2008: 1820). Roman bu şekilde gizemli yapısını üst seviyeye çıkarır. "Teşkilat-ı İstihbarat-ı Humayûn'un adamları, Büyük Efendi hariç hiçbiri, ne yaptıklarını bilmeksizin zamanda yolculuğu gerçekleştirmek için çalışıyorlardı." (Anar, 2019: 183).

GROTESK YAPI ÜZERİNE

Grotesk sözcüğü, genel olarak tuhaf, gülünç unsurlardan meydana gelmiş bir süsleme üslubudur. "Grotesk imgeler yoluyla ve tarımsal üretimden günümüze kadar halkın ürettiği kolektif bilincin yansıması olarak var olur. Rabelais'nin eserleri üzerine yapmış olduğu çalışmalarda Bakhtin, Ortaçağ ve Rönesans halk kültürü içinde bedene atfedilen imgelerin ve temsillerin izini sürer. Bedenin bu şekilde karnaval gerçekçiliğin merkezinde yer almasının önemli nedeni tarihsel, ütopik, toplumsal ve kozmik öğeleri özünde barındırıyor olmasında gizlidir." (Koçyiğit, 2017: 20). Bu kavram, tiyatroda, mimaride, edebiyatta vb. farklı alanlarda kullanılmaktadır. Korku temalı edebi eserlerde grotesk tasvirler ve anlatımlar önemli yer tutar. Edebi eserlerde karakterlerin kaba ve gülünç tarafları öne çıkar. Bununla beraber karakterlerin vücutlarında yapılan deformasyonlar da grotesk olarak adlandırılır. Grotesk ile karnaval arasında yakın ilişki vardır. Grotesk, karnavalın ön planda olduğu eserlerde daha belirgin yer alır.

Mikhail Bakhtin, "karnavalesk" veya "karnavallaştırma" teorisi ile karnavalı edebiyat diline aktarır. Postmodern yapı yer yer karnaval durumdan da yararlanır, çünkü burada postmodern anlatının kural tanımazlığı yine devreye girer. Bakhtin'in "diyaloglaştırma ve karnavallaştırma" anlayışı, postmodern yapıtın çoğulcu algısında önemli bir yere sahiptir. (Karabulut, Sarıtaş: 2018: 5). Karnaval yapıda karmaşa ve uyumsuzluk öne çıkar. Karnaval herkese açık olup sınırsız bir özgürlük alanı verir. Ayrıca karnaval boyunca yasaklar kalkar. Bakhtin, karnaval boyunca yasakların ve insanlar arasındaki tüm mesafe ve kısıtlamaların askıya alındığını, özel bir karnaval kategorisinin yürürlüğe girdiğini (Bakhtin, 2001: 238) ifade eder. "Karnavallaşma, eserlerde birbiriyle uyumsuz olarak görülen konuların, imgelerin, kişilerin yan yana getirilerek, bunların uyumsuzluğunun rahatlıkla vurgulanmasından kaynağını alan bir özgürlük ortamının ürünüdür" (Yaprak, 2012: 47). Bu husus roman karakterine hareket özgürlüğü sağlar.

Modern edebiyatta grotesk yapı, genel olarak biçimsiz, iğrenç, çirkin ve korku yönleriyle bağlantılıdır. Türk edebiyatında grotesk yapıyı en çok kullanan yazarlardan biri İhsan Oktay Anar'dır. Bu anlayışa göre karnaval bir tören havası olup izleyiciler dâhil herkese açıktır.

PUSLU KITALAR ATLASI'NDA GROTESK

İhsan Oktay Anar'ın romanlarındaki bedenler genellikle grotesk yapıdadırlar. Grotesk beden denildiğinde yarım kalmışlık, tamamlanmamıştık ve eksiklik akla gelir. Bu yapıda bedenin bazı organları bulunmayabilir. "Anar'ın bütün romanlarında deforme olmuş, melezleşmiş, canavarsı ve eksik bedenlere rastlamak mümkündür. İlk olarak insan bedeninin hayvan ve cansız nesnelerle

difüzyona uğrayarak başkalaştığı ve iki farklı formu aynı bedende vücuda getiren grotesk beden örnekleri" (Koçyiğit, 2017: 27) en çok rastlanılan melez beden imgeleridir

Yazar, Puslu Kıtalar Atlası, Efrrâsiyâb'ın Hikâyeleri ve Galiz Kahraman romanlarında bunu açıkça kullanır. Puslu Kıtalar Atlası, Uzun İhsan Efendi ve oğlu Bünyamin'in ön planda olduğu bir eserdir. Uzun İhsan, rüyasında bilinmeyen yerleri görmek için uyku şurubu içip uykuya yatar. Uzun İhsan Efendi, hazırladığı Puslu Kıtalar Atlası kitabını oğluna verir. Bünyamin, Zülfiyar adlı casusu kurtarmak için çatışmaya girer. Zülfiyar yaralanır ve elindeki değerli mıknatıslı parayı Bünyamin'e verir. Bu, "kara para"dır ve uğursuzluk getirir. Bünyamin, çatışmada yüzünden ağır yaralanır ve tanınmaz hale gelir:

"Kılınçsız kalan adam, demir halkalardan örülme zırh gömleğini çıkarıp Bünyamin'e atıldı. Delikanlı, elindeki kargıyı hasmının kafasına tam indirecekti ki adam zırh gömleğini elinde döndüre döndüre onun yüzüne doğru fırlattı. Demir halkalardan örülmüş zırh o soğukta Bünyamin'in yüzüne yapışıverdi. Adam ise eldivenli eliyle zırhın öbür ucuna yapışmış, delikanlıyı sağa sola savurmaya başlamıştı. Sonunda zırhı öyle bir çekti ki, demir halkalar Bünyamin'in yüzünden et parçaları koparıp ayrılıverdi. Yüzü kanlar içinde, delikanlı yere yığıldı." (Anar, 2019: 83).

Bu arada Uzun İhsan Efendi yakalanmış, gözleri oyulmuş, burnu ve kulakları kesilmiştir: *"Sakladığı sırrı vermediği için Et Meydanı'ndaki yeniçeri odalarında adamın gözleri oyulmuş, kulakları ve burnu kesilmişti."* (Anar, 2019: 104). Uzun İhsan Efendi bu bakımdan grotesk bir bedene dönüşmüştür. Dilenciler loncasına giden Bünyamin, babasını tanıyamaz. Ayrıca Uzun İhsan Efendi de oğlu Bünyamin'i tanıyamaz. Her iki karakter de grotesk bir görüntüye sahiptir.

SONUÇ

Varlıkların absürt, eksik, yarım kalmış, korku verici vb. yönlerini ifade eden grotesk, mimari, tiyatro, sinema, edebiyat vb. birçok sanat dalında kullanılır. Edebi metinlerde karakterlerin kaba ve gülünç, eksik, iğrenç, çirkin ve korku verici tarafları genel olarak grotesk yapı içerisinde verilir. İhsan Oktay Anar, birçok romanında grotesk yapıyı fantastik ve karnavalesk ile birlikte kullanır. İhsan Oktay Anar, *Puslu Kıtalar Atlası* romanında fantastik unsurlarla grotesk yapıyı bir arada kullanır. Romanda grotesk yapı en belirgin olarak Uzun İhsan Efendi ve oğlu Bünyamin'de görülür. Uzun İhsan, rüyasında bilinmeyen yerleri görmek için uyku şurubu içip uykuya yatar. Uzun İhsan Efendi, daha sonra adının Puslu Kıtalar Atlası olduğunu öğrendiğimiz bir kitap hazırlamaktadır. Romanın ilerleyen kısımlarında Bu arada Uzun İhsan Efendi yakalanır, gözleri oyulur, burnu ve kulakları kesilir. Uzun İhsan Efendi bu bakımdan grotesk bir bedene dönüşür. Bünyamin, Zülfiyar adlı casusu kurtarmak için çatışmaya girer. Zülfiyar yaralanır ve elindeki değerli mıknatıslı parayı Bünyamin'e verir. Bu, "kara para"dır ve uğursuzluk getirir. Bünyamin, çatışmada yüzünden ağır yaralanır ve tanınmaz olur. O da grotesk yapıya dönüşür. Dilenciler loncasına giden Bünyamin, babasını tanıyamaz. Ayrıca Uzun İhsan Efendi de oğlu Bünyamin'i tanıyamaz. Artık her iki karakter de grotesk bir yapıya dönüşmüştür.

KAYNAKLAR

HÜKÜM, Muhammed (2017), "İhsan Oktay Anar'ın 'Puslu Kıtalar Atlası' Romanının Metinlerarası İlişkiler Açısından Değerlendirilmesi", *Akademik Matbuat*, C:1, S:1.

KARABULUT, Mustafa; SARITAŞ, Ufuk (2018), Postmodern Bir Roman İncelemesi: Galîz Kahraman, DÜSBED - Dicle Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, Yıl: 10, Sayı: 20.

YEŞİLYURT, Şamil (2008). “Kurgusal Gerçeğin Gücü: Yeni Tarihselcilik ve Puslu Kıtalar Atlası” 38. ICANAS Uluslararası Asya ve Kuzey Afrika Çalışmaları Kongresi. Ankara: Atatürk Kültür, Dil ve Tarih Yüksek Kurumu Yayınları. s. 1813-1826.

ANAR, İhsan Oktay (2019), Puslu Kıtalar Atlası, (66. Baskı), İletişim Yayınları: İstanbul.

KOÇYİĞİT, Mesut (2017), İhsan Oktay Anar’ın Romanlarında “Karnaval”ın İzleri, YüksekLisans Tezi, İhsan Doğramacı Bilkent Üniversitesi, Ekonomi ve Sosyal Bilimler Enstitüsü, Ankara.

YAPRAK, Tahsin (2012), Postmodernizmin Orhan Pamuk’un Romanlarındaki Yansımaları, Yüksek Lisans Tezi, Adıyaman Üniversitesi, Sosyal Bilimler Enstitüsü, Adıyaman.

BAKHTİN, Mikhail (2001), Karnaval’dan Romana, (Çev.: Cem Soydemir), Ayrıntı Yayınları,

NONLINEAR BEHAVIOUR OF MASONRY ARCHES STRENGTHENED WITH TOPOLOGY-OPTIMISED GFRP

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ABSTRACT

Masonry arches mainly resist loads through compression; however, under lateral actions, tensile cracking and joint opening may trigger a four-hinge collapse mechanism. For this reason, the effectiveness of fibre-reinforced polymer (FRP) strengthening depends strongly on the placement of reinforcement relative to the zones governing hinge formation and tensile demand. This study employs a classical strain-energy-based topology optimisation procedure to design a material-efficient glass-FRP (GFRP) layout for a thin masonry arch case adopted from literature. A three-dimensional finite-element model was implemented in Abaqus, and masonry was represented using the Concrete Damage Plasticity formulation. The global response and hinge development were assessed through load-displacement curves and the equivalent plastic strain output, used as an indicator of inelastic localisation. Three configurations were analysed: the unreinforced masonry arch (URM), the intrados-strengthened configuration reported in the reference study, and an alternative topology-optimised strengthening layout obtained using a Solid Isotropic Material with Penalisation-based formulation by minimising compliance under a prescribed GFRP volume fraction. The URM model reproduced the reference mechanism and capacity trend satisfactorily. With approximately the same amount of GFRP, the topology-optimised layout reached the highest peak load (4.60 kN), exceeding both the URM case (1.43 kN) and the reference intrados strengthening (3.88 kN), while also maintaining higher stiffness over a broader load range, thus demonstrating the capability of compliance-based topology optimisation to generate efficient strengthening layouts for masonry arches.

Keywords: Masonry arch; GFRP strengthening; Compliance-based topology optimisation.

INTRODUCTION

Masonry arches are among the most characteristic structural forms in historic masonry construction and remain structurally important well beyond monument-scale applications. For example, European railways alone are reported to contain more than 200,000 masonry arch bridges and culverts, representing nearly half of their total bridge stock (UIC, 2018). Their assessment and strengthening therefore remain relevant not only for heritage preservation, but also for the safe management of still-active infrastructure. From a mechanical point of view, the response of masonry arches is governed by a pronounced tension-compression asymmetry: compressive forces are transmitted efficiently through the curved geometry, whereas tensile stresses are accommodated through cracking and joint opening. Under unsymmetrical or lateral loading, this response commonly develops into a four-hinge collapse mechanism. Accordingly, the effectiveness of strengthening depends not only on the amount of strengthening material, but also on its placement relative to the zones controlling hinge initiation, propagation, and final mechanism formation (Oliveira et al., 2010; Borri et al., 2011; Basilio et al., 2014).

Experimental and analytical studies have shown that externally bonded FRP strips can substantially improve the response of masonry arches and vaults, while also altering the associated collapse mechanism. Oliveira et al. (2010) provided experimental reference studies for FRP-strengthened masonry arches. Basilio et al. (2014) later combined experiments and limit-analysis modelling for masonry arches reinforced with GFRP, showing satisfactory agreement in terms of peak load and failure mechanism. Borri et al. (2011) highlighted the importance of intrados strengthening details and local debonding phenomena, while Rovero et al. (2013) showed that strip length affects the balance between maximum load and ultimate displacement. Limit-analysis studies by Caporale and Luciano (2012), and optimisation-oriented comparative work on masonry arch bridges by Daryadel and Cunningham (2017), further clarified how reinforcement position, bonded extent, interface behaviour, and reinforcement amount influence the structural efficiency of FRP-strengthened arches.

Optimisation-based reinforcement design has become increasingly relevant for masonry structures. Bruggi et al. (2013) introduced topology optimisation as a rational tool for positioning fibre reinforcement in masonry structures, showing that the optimal layout is not always equivalent to a direct alignment with principal tensile stresses. This line of work was then extended to out-of-plane masonry walls through compliance-based and homogenisation-assisted formulations (Bruggi et al., 2014; Bruggi and Milani, 2015). More recently, the scope of optimisation-based strengthening has expanded toward masonry barrel vaults (Tarhan and Uysal, 2023), cost-oriented reinforcement planning for masonry structures (Sberna et al., 2024), and the nonlinear in-plane behaviour of masonry walls strengthened with optimally distributed fibre reinforced polymer (Tarhan, 2025). Tarhan et al. (2025) presented the first study in which a topology-optimised carbon (C)-FRP strengthening layout for masonry arches was not only defined numerically but also applied and experimentally validated through tilting-table tests. Nevertheless, further studies based on nonlinear static analysis are still needed to directly compare the resulting optimum geometry existing FRP layouts and thereby demonstrate the effectiveness of the proposed method.

The aim of the present paper is to assess whether a strain-energy-based topology optimisation procedure can identify a more efficient GFRP strengthening geometry for a thin masonry arch than a conventional continuous intrados layout. For this purpose, first, a thin masonry arch case reported in the literature is re-modelled in Abaqus and calibrated against published results in the unstrengthened and intrados-strengthened states. Second, a classical strain-energy-based Solid Isotropic Material with Penalisation (SIMP) formulation is used to generate an alternative GFRP layout under a prescribed material fraction. Finally, the literature intrados layout and the optimised layout are compared in terms of capacity, stiffness development, and hinge localisation.

MATERIALS AND METHODS

Reference geometry, loading scheme and analysed cases

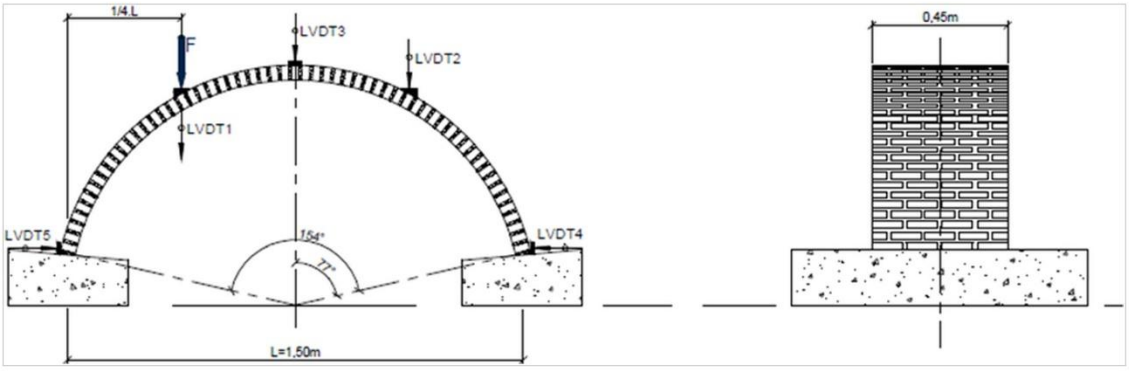
The analysed structure is a thin circular masonry arch case reported in the literature by Oliveira et al. (2010) and later discussed numerically by Basilio et al. (2014). The adopted geometry corresponds to an arch with a span of 1500 mm, a radius of 750 mm, an arch ring thickness of 50 mm, and an out-of-plane width of 450 mm. In the reference study, the response is investigated under a concentrated load applied at quarter span (L/4), which is known to promote an unsymmetrical collapse mechanism in this type of geometry. The support conditions were modelled as fully restrained abutments, consistent with the idealised numerical reproduction adopted here. Loading was applied in displacement control, and the response was traced up to 1.7 mm vertical displacement at the loading point in order to reproduce the reference behaviour and enable a consistent comparison among strengthening layouts.

Three configurations were considered: (i) the unreinforced masonry arch (URM), (ii) an intrados GFRP-strengthened arch reproducing the strengthening arrangement reported in the reference study (Oliveira et al., 2010; Basilio et al., 2014), where two continuous longitudinal GFRP strips, each 50 mm wide, were applied symmetrically along the full arc length on the intrados surface of the arch ring, and (iii) an alternative topology-optimised intrados GFRP layout proposed in this paper. The optimised case was defined using a prescribed intrados volume fraction of $V_f = 0.22$over the entire intrados design surface. This value was selected so that the total amount of FRP in the optimisation problem remained approximately equivalent to that of the reference strengthening configuration: the two reference strips provide a combined width of 100 mm, which corresponds to 22.2% of the total intrados width of 450 mm. This ensures that the comparison between the reference and optimised layouts reflects a redistribution problem rather than a reinforcement-quantity problem. Figure 1 shows the reference geometry and loading arrangement of the thin masonry arch, together with the three-dimensional finite-element model adopted in the present study.

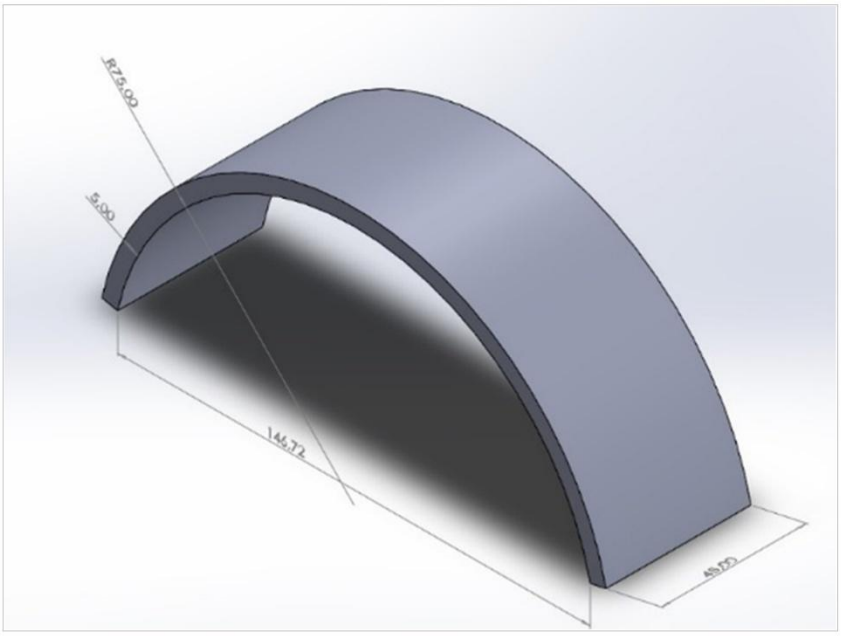
Constitutive modelling and numerical interpretation

A three-dimensional finite-element model was implemented in Abaqus (Abaqus, 2022) to reproduce both the global response of the arch and the localisation pattern associated with hinge formation. The modelling philosophy adopted here is structural rather than meso-scale: the objective is not to reproduce the detailed cracking of individual bricks and mortar joints, but to capture the nonlinear redistribution of stresses and the progressive concentration of inelastic deformation into hinge-governing regions. Masonry was represented using the Concrete Damage Plasticity (CDP) formulation, selected here as a practical macro-modelling approach capable of reproducing the essential cracking-crushing asymmetry while remaining computationally manageable. The adopted material parameters were taken from benchmark studies (Table 1).

As illustrated in Fig. 2, the reference intrados strengthening arrangement was reproduced numerically, using the same strip configuration reported in the literature. The masonry arch was discretised using C3D8R three-dimensional solid elements, whereas the intrados GFRP strips were modelled using S4R shell elements. A perfect bond was assumed between the masonry substrate and the GFRP strips; therefore, no relative slip or interfacial debonding was allowed in the numerical model. This modelling choice was adopted deliberately, since the main objective of the present study is to investigate the influence of FRP layout on the structural response and to identify an efficient strengthening geometry through topology optimisation. Introducing interface debonding into the optimisation framework would considerably increase the modelling complexity and could also lead to additional convergence difficulties, thereby obscuring the primary objective of the study. For this reason, the same ideal bond assumption was consistently adopted in both the reference strengthened configuration and the topology-optimised configuration, so that the comparison remains directly attributable to the distribution of FRP rather than to interface-related effects. The results should therefore be interpreted as corresponding to an ideal fully bonded strengthening condition.



(a)



(b)

Figure 1. Reference geometry and three-dimensional representation of the thin masonry arch adopted in the present study: (a) geometry, loading and measurement layout (Oliveira et al. 2010; Basilio et al. 2014) ; (b) 3D model.

The nonlinear response was interpreted through the global load-displacement curves and the equivalent plastic strain field (PEMAG). The load-displacement curve was used to evaluate initial stiffness, progressive stiffness degradation, peak resistance and post-peak behaviour. PEMAG was used as an indicator of inelastic localisation and of the regions associated with hinge development along the arch.

Accordingly, the three configurations were compared using three response measures: (i) peak load, (ii) stiffness development from the load–displacement curves, and (iii) localisation pattern inferred from PEMAG distributions. This comparison makes it possible to assess not only whether a strengthening layout increases resistance, but also whether it changes the way in which the arch approaches collapse.

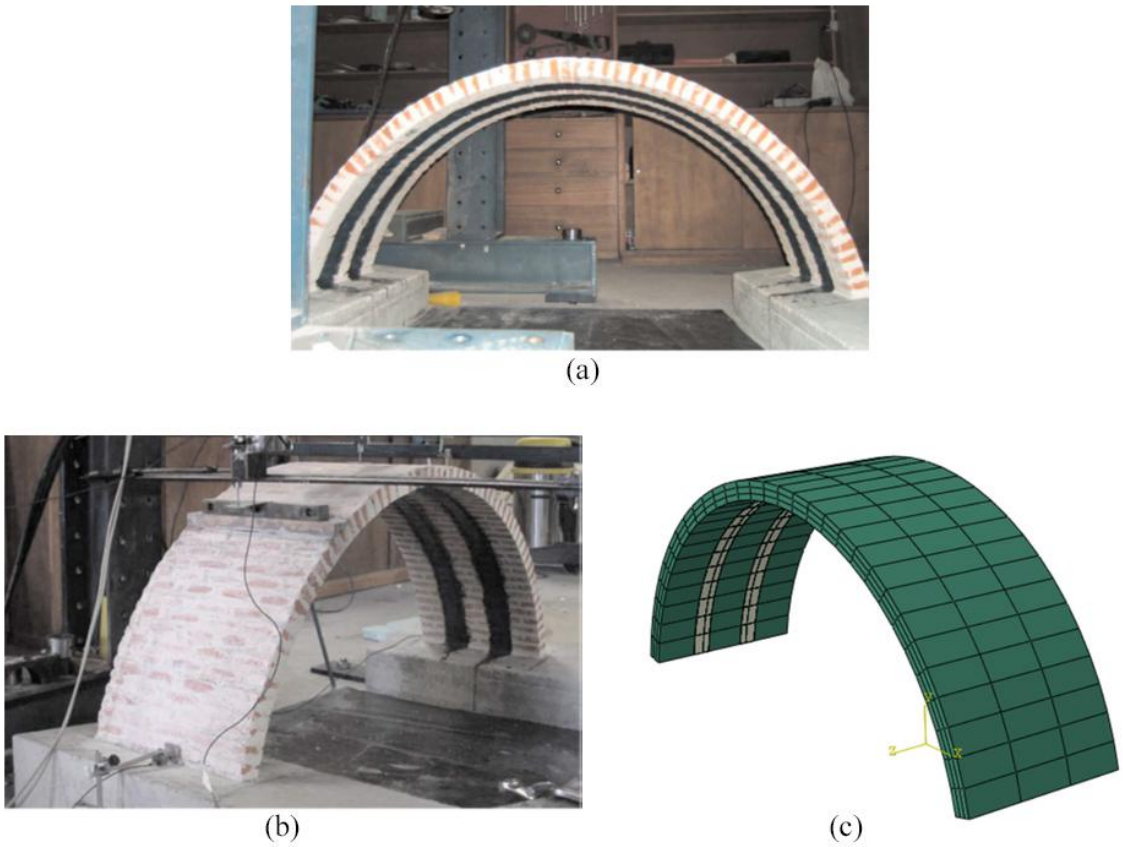


Figure 2. Reference intrados GFRP strengthening configuration and corresponding 3D finite-element model adopted in the present study: (a,b) strengthened arch reported in the literature (Oliveira et al. 2010; Basilio et al. 2014); (c) FE representation.

Table 1. Material and constitutive parameters adopted in the numerical model.

Parameter	**Value**
Masonry Young's modulus, E	2040 MPa
Poisson's ratio, ν	0.20
Compressive strength, f_c	7.8 MPa
Tensile strength, f_t	0.25 MPa
Dilation angle	10°
Eccentricity	0.10
fb_0/fc_0	1.16
K	0.667
Viscosity parameter	0.001
GFRP elastic modulus	80000 MPa

Strain-energy-based topology optimisation

The strengthening design problem was formulated using the classical density-based **Solid Isotropic Material with Penalisation (SIMP)** approach. In this formulation, each candidate reinforcement region is assigned a density variable $x_i \in [0,1]$, where $x_i = 0$ represents the absence

of GFRP contribution and $x_i = 1$ corresponds to full reinforcement participation. The stiffness contribution of each element is expressed as

$$K(x_i) = K_{M,i} + x_i^p K_{F,i}$$

where $K_{M,i}$is the masonry contribution, $K_{F,i}$is the reinforcement contribution, and $p$is the penalisation exponent. The optimisation objective is to minimise compliance, equivalently the total strain energy, under a prescribed reinforcement fraction. The problem can be written as

$$\min\ c(x) = F^T U = U^T K U$$

subject to

$$KU = F$$

and

$$\frac{\sum_{i=1}^{N} x_i^p V_i}{\sum_{i=1}^{N} V_i} \leq V_f$$

where is the compliance, F is the global load vector, U is the global displacement vector, and K is the global stiffness matrix of the reinforced arch system. In the volume constraint, $V_i$is the volume of the i-th design element, N is the total number of design elements, and V_f is the prescribed GFRP volume fraction. In the present study, the optimisation converged to a reinforcement fraction of approximately 0.22. From a structural point of view, this means that a limited amount of GFRP is redistributed toward the regions that contribute most strongly to stiffness loss and hinge development. The purpose of the optimisation stage is therefore not to increase reinforcement quantity, but to improve its distribution efficiency relative to the mechanism governing the response.

RESULTS AND DISCUSSION

Unstrengthened benchmark response

The first step of the study was the reproduction of the unstrengthened arch reported in the reference study. As shown in Fig. 3(a-c), the current numerical model captures both the global load-displacement response and the characteristic four-hinge collapse mechanism with satisfactory accuracy. The computed peak load was 1.43 kN, compared with 1.40 kN for the reference numerical curve and 1.50-1.93 kN for the experimental results. Although the present model slightly underestimates the upper experimental response, it reproduces the reference numerical trend very closely and correctly identifies the localisation zones governing collapse, namely two hinge regions near the supports and two internal hinge regions along the arch span. The agreement between the capacity curve in Fig. 3(a), the schematic hinge pattern in Fig. 3(b), and the PEMAG localisation field in Fig. 3(c) confirms that the adopted numerical model provides a reliable basis for the subsequent assessment of the strengthened configurations.

Benchmark intrados GFRP strengthening

The intrados GFRP-strengthened configuration exhibits a pronounced increase in both load capacity and deformation capacity relative to the unreinforced case. As shown in Fig. 3(d-f), the current numerical model reached a peak load of 3.88 kN, compared with 3.75 kN for the reference numerical result and 4.26–4.62 kN for the experimental curves reported in the literature. This corresponds to a substantial increase over the URM numerical peak load of 1.43 kN and confirms the beneficial role of intrados GFRP strips in enhancing the structural response of the arch. The capacity-curve comparison in Fig. 3(d) further shows that the strengthened arch maintains a

significantly higher load level over a much wider displacement range than the URM configuration. In the present model, the overall response trend is reproduced satisfactorily, while the hinge mechanism inferred from Fig. 3(e) and the PEMAG localisation field in Fig. 3(f) indicate that some differences remain in the final localisation pattern compared with the experimental benchmark. Nevertheless, the numerical model captures the main strengthening effect convincingly and provides a suitable reference configuration for evaluating the topology-optimised layout

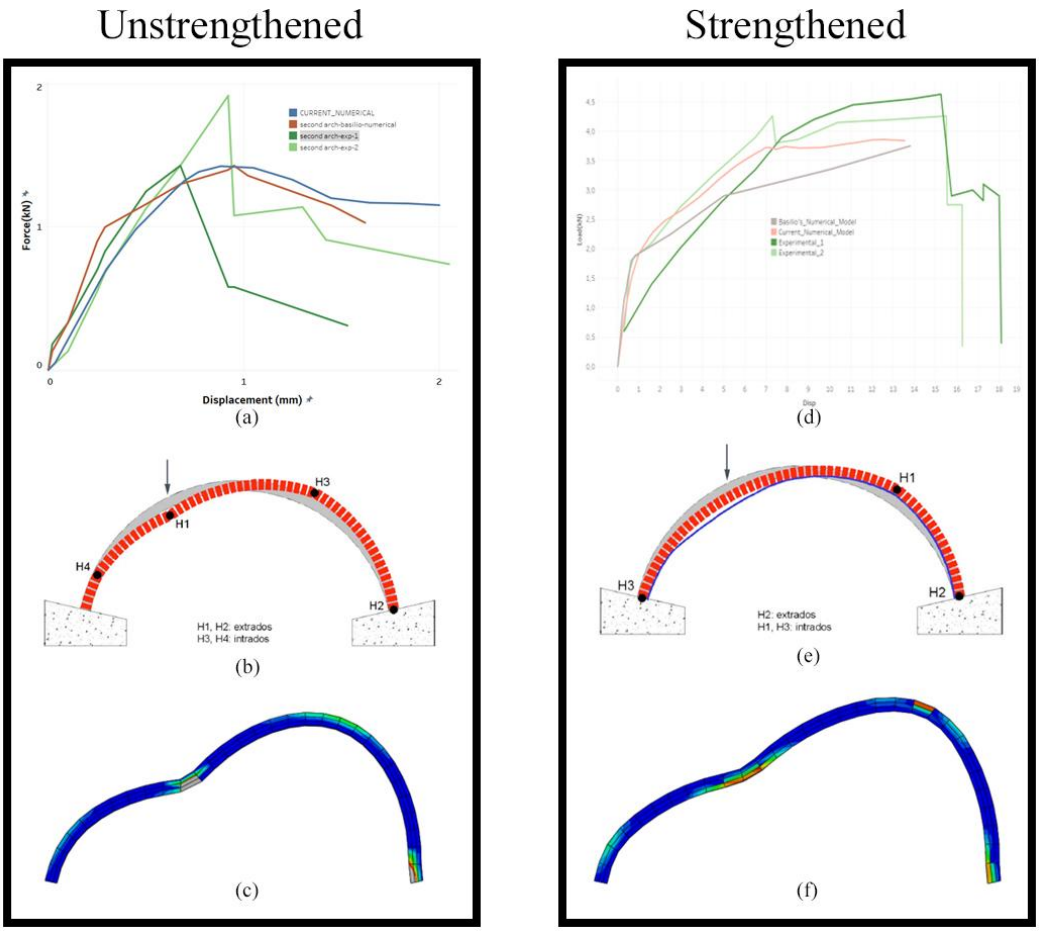


Figure 3. Numerical and reference comparison for the unstrengthened and intrados-strengthened arch configurations: (a-c) Unstrengthened case: capacity curves, hinge mechanism, and PEMAG localisation pattern, (d-f) Intrados GFRP-strengthened case: capacity curves, hinge mechanism, and PEMAG localisation pattern.

Topology-optimised GFRP strengthening

The topology-optimised strengthening layout differs fundamentally from the reference intrados configuration, which applies GFRP continuously along the full arc length. Instead, the SIMP procedure redistributes the available reinforcement toward discrete high-demand regions, particularly near the loaded quarter-span zone and in the zones associated with mechanism development on the opposite side of the arch. As shown in Fig. 4(a,b), this distribution is mechanically consistent with the objective of minimising strain energy under a prescribed reinforcement fraction and reflects the non-uniform demand pattern governing the arch response. The structural consequence of this redistribution can be observed in the comparative load–displacement curves in Fig. 4(c), where the optimised layout provides the most favourable overall numerical response for approximately the same amount of GFRP.

To compare stiffness development more meaningfully, the numerical models were evaluated in terms of the displacement required to reach selected load levels. This is particularly important because the URM model reaches failure at a relatively small displacement, making comparisons at larger common displacements physically less meaningful. As shown in Table 3, at 1.0 kN the current numerical URM model required a displacement of 0.46 mm, whereas the reference intrados-strengthened and topology-optimised models required only 0.34 mm and 0.33 mm, corresponding to reductions in displacement demand of 26.1% and 28.3%, respectively. The distinction becomes much clearer at higher load levels. At 3.0 kN, the reference intrados-strengthened model required 4.95 mm, while the optimised model reached the same load at only 1.38 mm, corresponding to a 72.1% reduction in displacement demand. In terms of peak resistance, the current numerical peak load increased from 1.43 kN in the URM case to 3.88 kN in the reference intrados-strengthened case and to 4.60 kN in the optimised configuration, representing increases of 171.3% and 221.7%, respectively, relative to the URM model. Therefore, the advantage of the optimised layout is better described not simply as a higher initial stiffness at the origin, but as a more favourable stiffness development with increasing load, together with the highest peak resistance and the most favourable overall response envelope among the numerical cases.

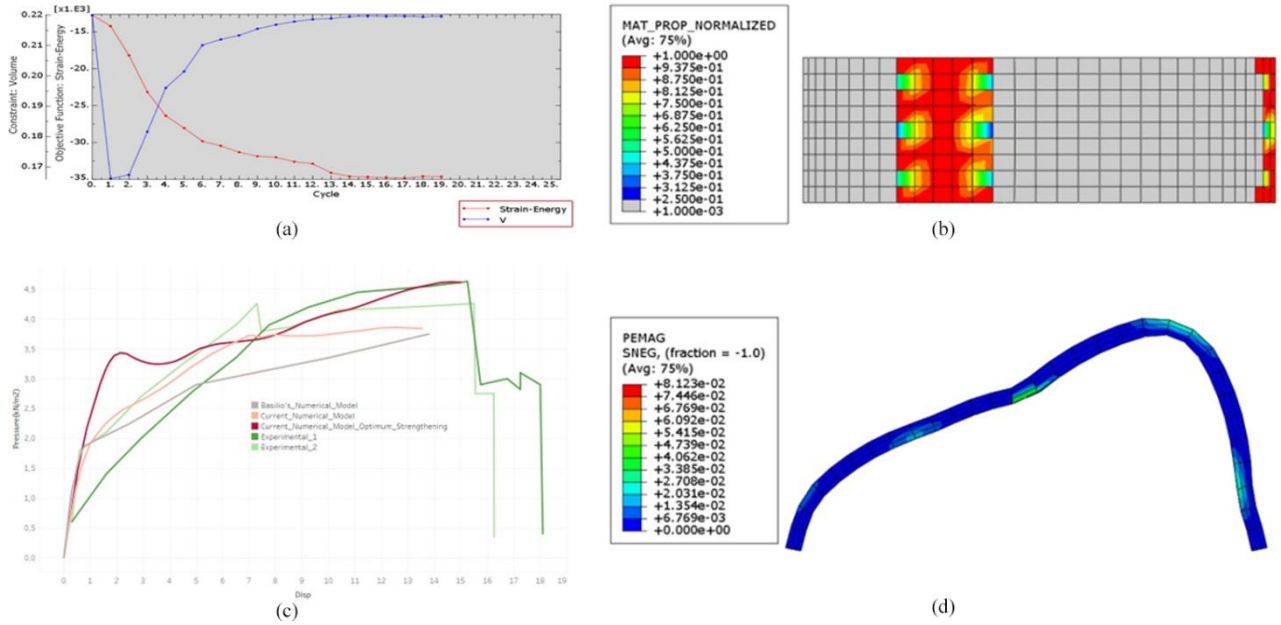


Figure 4. Topology-optimisation outputs and structural response of the optimised strengthening layout. (a) Convergence history of the optimisation problem in terms of objective function and prescribed reinforcement fraction; (b) final topology-optimised GFRP distribution on the intrados design surface; (c) comparison of load–displacement curves for the reference intrados-strengthened and topology-optimised configurations; (d) PEMAG-based localisation pattern of the topology-optimised strengthened arch.

Table 2. Comparative response indicators for the analysed configurations

Model ID	Peak load, experimental reference (kN)	Peak load, reference numerical (kN)	Peak load, current numerical (kN)	Increase in peak load vs URM, current numerical (%)	Displacement at 1.0 kN, current numerical (mm)	Reduction in displacement demand at 1.0 kN vs URM (%)	Displacement at 3.0 kN, current numerical (mm)	Reduction in displacement demand at 3.0 kN vs reference intrados (%)	Mechanism / remarks
URM	1.50–1.93	1.4	1.43	-	0.46	-	-	-	Four-hinge mechanism reproduced; good agreement with the reference numerical trend
Reference intrados GFRP	4.30–4.60	3.75	3.88	171.3	0.34	26.1	4.95	-	Marked increase in load and deformation capacity; hinge pattern broadly consistent with the reference study
Optimised GFRP	-	-	4.6	221.7	0.33	28.3	1.38	72.1	Highest peak load and most favourable overall response envelope for approximately the same amount of GFRP

CONCLUSION

The main findings can be summarised as follows:

- The Abaqus 3D CDP model reproduced the unstrengthened reference arch satisfactorily in terms of both capacity trend and four-hinge collapse mechanism.

- The benchmark intrados GFRP strengthening significantly increased load capacity and deformation capacity, but the strengthened mechanism remained more sensitive than the URM case to modelling assumptions.
- The strain-energy-based topology-optimisation procedure converged successfully and generated a non-uniform GFRP arrangement concentrated in the critical high-energy regions controlling the collapse mechanism.
- For a comparable amount of GFRP, the optimisation framework identified a local strengthening geometry that was structurally more efficient than the continuous reference intrados layout within the adopted numerical setting.

In practical applications, however, a continuous and symmetric strengthening arrangement may provide a more robust solution under reversed cyclic seismic loading and other loading scenarios involving load reversals. In this sense, the optimum geometry identified in the present study may also be interpreted as a mechanically informed basis for a symmetric strengthening layout applied along the arch span. It should also be noted that the present results were obtained under an ideal bond assumption between masonry and GFRP; therefore, interfacial slip and debonding were not explicitly considered. This simplification was adopted intentionally to keep the optimisation problem manageable and to isolate the effect of FRP layout. Accordingly, the proposed layouts should be regarded as preliminary structural solutions requiring further numerical and experimental validation, including interface-sensitive modelling, before practical implementation.

REFERENCES

Abaqus. ABAQUS [Computer Software] (Waltham, MA: Dassault Systèmes, 2022).

Basilio I, Fedele R, Lourenço PB, Milani G 2014. Numerical and experimental analysis of full scale arches reinforced with GFRP materials. Key Engineering Materials, 624: 502-509.

Borri A, Castori G, Corradi M 2011. Intrados strengthening of brick masonry arches with composite materials. Composites Part B: Engineering, 42(5): 1164-1172.

Caporale A, Luciano R 2012. Limit analysis of masonry arches with finite compressive strength and externally bonded reinforcement. Composites Part B: Engineering, 43(8): 3131-3145.

Daryadel M, Cunningham L 2017. Optimisation of FRP strengthening systems for masonry arch bridges. Masonry International, 29(2): 61-72.

Oliveira DV, Basilio I, Lourenço PB 2010. Experimental behavior of FRP strengthened masonry arches. Journal of Composites for Construction, 14(3): 312-322.

Bruggi M, Milani G, Taliercio A 2013. Design of the optimal fiber-reinforcement for masonry structures via topology optimization. International Journal of Solids and Structures, 50: 2087-2106.

Bruggi M, Milani G, Taliercio A 2014. Simple topology optimization strategy for the FRP reinforcement of masonry walls in two-way bending. Computers & Structures, 138: 86-101.

Bruggi M, Milani G 2015. Optimal FRP reinforcement of masonry walls out-of-plane loaded: A combined homogenization-topology optimization approach complying with masonry strength domain. Computers & Structures, 153: 49-74.

Rovero L, Focacci F, Stipo G 2013. Structural behavior of arch models strengthened using fiber-reinforced polymer strips of different lengths. Journal of Composites for Construction, 17(2): 249-258.

Sberna AP, Demartino C, Vanzi I, Marano GC, Di Trapani F 2024. Cost-effective topology optimization of masonry structure reinforcements by a linear static analysis-based GA framework. Bulletin of Earthquake Engineering, 22(8): 4143-4167.

Tarhan İH, Uysal H 2023. Topology optimization of the FRP for strengthening of masonry barrel vaults. Engineering Failure Analysis, 151: 107390.

Tarhan İH, Savalle N, Uysal H, da Silva LCM, Lourenço PB 2025. Seismic capacity of unstrengthened and FRP strengthened masonry arches: Tilting test and nonlinear numerical analysis. Earthquake Engineering & Structural Dynamics, 54: 1009-1027.

Tarhan İH 2025. Nonlinear in-plane behavior of masonry walls strengthened with optimally distributed fiber reinforced polymer. Engineering Failure Analysis, 182A: 110035.

UIC 2018. Workshop on Masonry Arch Bridges 2018. International Union of Railways (UIC), Paris, France. Available at: UIC website [08.02.26].

ON BI-PARA-COMPLEX STRUCTURES ON WALKER-4 MANIFOLDS

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ABSTRACT

In this study, we investigate bi-para-complex structures on four-dimensional Walker manifolds and analyze their geometric consequences. Walker-4 manifolds constitute an important class of pseudo-Riemannian manifolds characterized by the existence of a parallel null distribution, and they naturally arise in the context of neutral signature geometry. We construct bi-para-complex structures on (M^4, g) by introducing a pair of tensor fields (F, P) satisfying the defining relations of a bi-para-complex geometry, namely

$$F^2 = P^2 = I \quad \text{and } F \circ P + P \circ F = 0,$$

together with compatibility conditions with the Walker metric. The integrability of these structures is examined via the corresponding Nijenhuis tensors N_F and N_P. We derive explicit expressions for N_F and N_P in Walker coordinates and obtain necessary and sufficient conditions on the metric functions ensuring $N_F = 0$ and $N_P = 0$. Consequently, we characterize the class of Walker-4 manifolds admitting integrable bi-para-complex structures. Next, we study the curvature characteristics of Walker-4 manifolds equipped with these structures. In particular, we compute the Levi-Civita connection and derive curvature tensors under the imposed geometric constraints. The resulting curvature relations allow us to classify the manifolds with respect to their Ricci and scalar curvature behaviors, and we discuss special cases in which the curvature exhibits simplified or distinguished patterns.

Finally, we focus on the Ricci soliton equation on the resulting manifolds. Ricci solitons generalize Einstein metrics and play a fundamental role in the analysis of geometric flows. We formulate the Ricci soliton condition in the Walker-4 setting and obtain the corresponding system of differential equations. By analyzing these equations, we provide conditions under which the manifolds admit shrinking, steady, or expanding Ricci solitons compatible with the constructed bi-para-complex structures.

Keywords: Walker-4 manifolds, Nijenhuis tensors, bi-para-complex structures.

References

[1] F. Etayo, R. Santamaria, U. R. Trias., The geometry of a bi-Lagrangian manifold., Differantial geometry an its Applications, 24 (2006) 33-59,

[2] M. Tekkoyun, M. Sari., Bi-para-mechanical systems on the bi-Lagrangian manifold., Physica B, 405 (2010) 2390-2393

TAXATION TECHNIQUE IN THE INDIVIDUAL PENSION SYSTEM

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ABSTRACT

With Law No. 4632 on the Individual Pension Savings and Investment System (Official Gazette, Date: 07.04.2001, No: 24366; Law No. 4632), the normative framework of the individual pension system, based on voluntary savings through private pension companies, was established. The individual pension system constitutes a field of regulation that also produces consequences in terms of tax law. For although the system operates as a savings mechanism within the framework of private law relationships, it is also a legal structure that affects the technique of taxation. In this respect, the transformation undergone by the individual pension system in terms of tax technique is directly related to the change in the nature of the fiscal incentive mechanism upon which the system is based. In this regard, the amendments introduced to Law No. 4632 by Law No. 6327 on the Amendment of the Individual Pension Savings and Investment System Law and Certain Laws and Decree Laws (Official Gazette, Date: 29 June 2012, No: 28338), which entered into force as of 1 January 2013, have been determinative.

It should first be noted that the tax deduction principle adopted prior to 2013 was replaced by the principle of state contribution under the new legal framework. This amendment signifies, from the perspective of legal technique, a transition within the individual pension system from tax expenditure to transfer expenditure. Nevertheless, the taxation of retirement savings at the stage of exit from the system manifests itself in the form of tax deferral and, in this respect, the individual pension system continues to embody an element of tax expenditure. Accordingly, the individual pension system as currently implemented bears the character of a composite fiscal incentive incorporating both tax expenditure and transfer expenditure elements within its structure.

Keywords: Taxation Technique, Individual Pension System, Tax Expenditure, Transfer Expenditure

WHEN ABDOMINAL PAIN MASKS TESTICULAR TORSION: A CASE SERIES FOR PEDIATRIC EMERGENCY CARE

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ABSTRACT

Testicular torsion is a time-critical pediatric surgical emergency in which early diagnosis is crucial for testicular salvage. Although acute scrotal pain is the classic presentation, atypical manifestations such as isolated abdominal pain may obscure the diagnosis and delay intervention. Delay in recognition significantly increases the risk of irreversible ischemic damage and orchiectomy. We report two adolescent cases presenting primarily with abdominal pain to the Pediatric Emergency Department of the University Hospital Center “Mother Teresa” in Tirana, Albania, resulting in delayed recognition and testicular loss. The first patient presented after four days of abdominal pain initially treated as gastroenteritis. The second patient presented within 24 hours of symptom onset but with dominant abdominal findings that diverted initial diagnostic focus. In both cases, Doppler ultrasonography demonstrated absent vascular flow in the affected testis, and surgical exploration confirmed advanced torsion requiring orchiectomy. Contralateral orchiopexy was performed in both patients according to standard surgical recommendations. These cases highlight the diagnostic challenge of atypical presentations and emphasize the necessity of systematic genital examination in adolescent boys presenting with abdominal pain. Even in tertiary referral centers, delayed diagnosis may occur when genital examination is omitted or when abdominal symptoms predominate. Early clinical suspicion, prompt imaging, and urgent surgical intervention remain essential to prevent testicular loss and preserve future fertility.

Keywords: testicular torsion, abdominal pain, pediatric emergency, orchiectomy, orchiopexy

INTRODUCTION

Testicular torsion represents one of the most urgent surgical emergencies in pediatric and adolescent males. It occurs when the spermatic cord twists around its axis, leading to obstruction of venous outflow followed by arterial compromise and rapid progression to ischemia. Without prompt surgical intervention, irreversible testicular damage may develop within hours. Testicular salvage rates are highly time-dependent and decrease significantly after 6–8 hours of compromised blood flow.The annual incidence of testicular torsion is estimated at approximately 3–4 cases per 100,000 males under 25 years of age, with peak occurrence during adolescence. Despite its relatively low incidence, torsion remains a leading cause of acute scrotum requiring emergency surgery.

Classically, patients present with sudden onset of severe unilateral scrotal pain, swelling, nausea, and vomiting. However, atypical presentations may occur, particularly in children and adolescents. Abdominal pain may predominate due to shared embryological innervation between the testis and lower abdominal structures. In such cases, the absence of initial scrotal complaints may lead clinicians toward gastrointestinal or appendicular diagnoses. If genital examination is not systematically performed, the diagnosis may be delayed, resulting in testicular infarction and orchiectomy. The aim of this report is to emphasize the importance of genital examination in adolescent boys presenting with abdominal pain and to highlight diagnostic challenges associated with atypical presentations.

MATERIALS AND METHODS

This descriptive case series includes two 13-year-old boys who presented with acute abdominal pain to the Pediatric Emergency Department of the University Hospital Center "Mother Teresa" in Tirana, Albania. Clinical evaluation in both cases included detailed medical history, physical examination, laboratory investigations, abdominal ultrasonography, and Doppler ultrasonography of the scrotum. Particular attention was given to identifying atypical symptoms and documenting the timing of symptom onset and presentation. Intraoperative findings, surgical management, and postoperative outcomes were recorded. Ethical principles for case reporting were followed. Written informed consent for publication of anonymized clinical data and images was obtained from the patients' parents.

RESULTS

Case 1

A 13-year-old boy presented with a four-day history of progressively worsening left-sided abdominal pain associated with nausea and reduced appetite. Initial evaluation at a primary care facility resulted in a diagnosis of acute gastroenteritis, and symptomatic treatment was initiated. Due to persistence and worsening of symptoms, the patient was referred to the tertiary pediatric emergency department. On admission, physical examination revealed suprapubic tenderness and mild discomfort in the left hemiscrotum, which had not been previously reported by the patient. Laboratory tests showed leukocytosis and elevated inflammatory markers. Abdominal ultrasonography was unremarkable. Subsequent scrotal Doppler ultrasonography demonstrated absent vascular flow in the left testis. Left orchiectomy was performed due to irreversible ischemic damage. Prophylactic contralateral orchiopexy was carried out during the same procedure.(Figure 1)

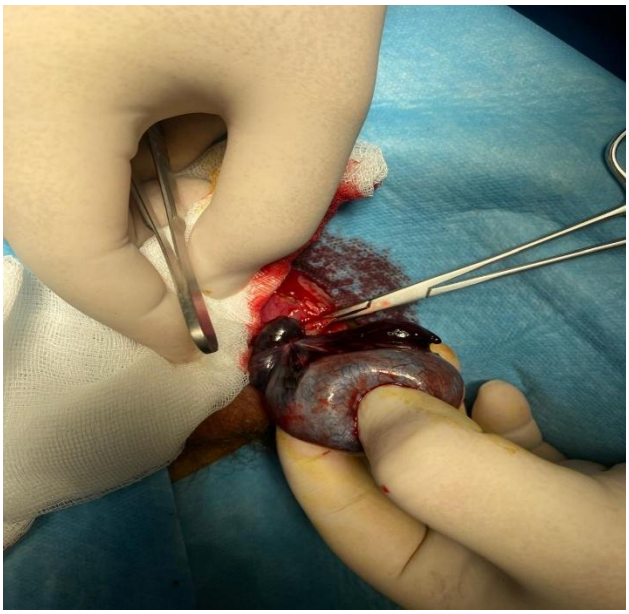


Figure 1. Intraoperative view of the left testis. Severely congested, dark, and non-viable left testis with marked edema and hemorrhagic infarction consistent with prolonged torsion of approximately four days.

Case 2

Another 13-year-old boy presented with acute abdominal pain and persistent vomiting of approximately 24 hours duration. The pain was initially localized to the periumbilical region and later migrated to the right lower abdomen, raising suspicion of appendicitis. The patient adopted a protective posture and reported difficulty walking due to pain. Physical examination demonstrated right iliac fossa tenderness. A careful genital examination revealed mild right testicular swelling and tenderness. Doppler ultrasonography showed absent vascularization of the right testis. Due to irreversible ischemic injury, right orchiectomy was required. Contralateral orchiopexy was performed during the same operation.



Figure 2. Intraoperative image of the right testis. Advanced torsion with marked enlargement, cyanosis, and a tightly twisted spermatic cord.

DISCUSSION

Time to surgical intervention remains the most critical determinant of testicular viability in cases of torsion. Testicular salvage rates approach 90–100% when surgical detorsion occurs within six hours of symptom onset but decline significantly after 12 hours and become very low beyond 24 hours. Delayed diagnosis therefore directly correlates with increased risk of orchiectomy and long-term reproductive consequences.

Both cases presented in this series illustrate the diagnostic challenge of atypical presentations. In the first case, a four-day delay due to misdiagnosis as gastroenteritis resulted in complete infarction and inevitable orchiectomy. In the second case, despite presentation within approximately 24 hours, the predominance of abdominal symptoms initially diverted clinical suspicion toward appendicitis, delaying definitive diagnosis and management. Abdominal pain as the primary manifestation of testicular torsion has been documented in pediatric populations. Shared sensory pathways between the testis and abdominal structures may lead to referred pain, nausea, and vomiting without prominent scrotal symptoms. Younger adolescents may also hesitate to report scrotal discomfort, further complicating diagnosis.

Failure to perform systematic genital examination in boys presenting with abdominal pain remains a significant contributor to delayed diagnosis. Even in tertiary referral centers with experienced clinicians, omission of genital examination may occur when gastrointestinal symptoms dominate the clinical picture. These cases emphasize that genital examination must be considered mandatory in all adolescent males presenting with acute abdominal pain, regardless of the presumed primary diagnosis. Doppler ultrasonography plays a crucial role in confirming diagnosis by demonstrating reduced or absent testicular blood flow. However, imaging should not delay surgical exploration when clinical suspicion is high. Early urological consultation and prompt operative intervention remain essential.

Both patients in this series underwent contralateral orchiopexy during surgery. This preventive procedure is widely recommended because anatomical predisposition to torsion is often bilateral. Fixation of the contralateral testis reduces the risk of future torsion and is considered standard practice.

CONCLUSION

Testicular torsion may present primarily as abdominal pain leading to dangerous diagnostic delays. Atypical presentation can result in misdiagnosis and irreversible ischemic damage even in tertiary care settings. Systematic genital examination in all adolescent males presenting with abdominal pain is mandatory. Early clinical suspicion, prompt Doppler ultrasonography, and urgent surgical exploration are essential to optimize outcomes, preserve testicular function, and reduce the need for orchiectomy. Increased awareness among emergency physicians and pediatric clinicians regarding atypical presentations of testicular torsion is necessary to improve diagnostic accuracy and patient outcomes.

ACKNOWLEDGEMENTS

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REFERENCES

Barbosa JA, Tiseo BC, Barayan GA, Rosman BM, Torricelli FCM, Passerotti CC, Srougi M 2013. Development and initial validation of a scoring system to diagnose testicular torsion in children. Journal of Urology, 189(5): 1859–1864.

Ringdahl E, Teague L 2006. Testicular torsion. American Family Physician, 74(10): 1739–1743.

THE BLACK BOX IN THE CLASSROOM: A SYSTEMATIC REVIEW OF AI ETHICS IN K-12

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ABSTRACT

AI is quickly being integrated into K-12 education, offering key benefits like personalized learning and real-time feedback (Chen et al., 2020; Crompton et al., 2024). However, this acceleration has outpaced ethical regulatory frameworks, creating a critical gap between innovation and the safeguarding of students' rights (Holmes et al., 2021; UNESCO, 2021). While the existing literature foregrounds pedagogical benefits, the invisible ethical costs such as, data privacy violations, algorithmic bias, and the erosion of human agency remain insufficiently examined within compulsory education contexts (Akgun & Greenhow, 2022).

This study conducts a thematic synthesis derived from a systematic literature review of studies indexed in Web of Science, ERIC, and DergiPark databases. From the broader corpus, studies that empirically or theoretically address ethical concerns, specifically data privacy, algorithmic bias, and teacher/student autonomy, were selected and synthesized under three thematic risk categories. The first theme, Data Privacy and Surveillance, reveals that data privacy is the most frequently cited ethical challenge, identified in over 20% of reviewed studies as the foremost concern (Mustafa et al., 2024), while fewer than 30% of countries possess comprehensive data protection legislation applicable to educational AI (UNESCO, 2021). The second theme, Algorithmic Bias and Fairness, demonstrates that AI systems trained on historically imbalanced datasets risk perpetuating inequalities related to gender, socioeconomic status, and ethnicity (Holstein et al., 2019). A critical cultural dimension further emerges, as AI tools frequently fail to recognize local cultural codes (Filiz et al., 2025), raising concerns about technological cultural imperialism. The third theme, Human Agency and Teacher Autonomy, highlights the tension between algorithmic recommendation and professional judgment; teachers exhibit confirmation bias and algorithm aversion toward automated systems (Nazaretsky et al., 2022), while the "assistance dilemma" suggests that excessive AI scaffolding may undermine students' critical thinking (Koedinger & Aleven, 2007).

The synthesis argues that AI integration in K-12 education constitutes not merely a technical infrastructure issue but a human rights concern. The study advocates for the mandatory adoption of "human-in-the-loop" principles and the establishment of dedicated "Ethical AI Literacy" programs for teachers, distinct from technical upskilling, to ensure that the classroom remains a space of pedagogical sovereignty rather than algorithmic governance.
Keywords: AI Ethics, K-12 Education, Data Privacy, Algorithmic Bias, Human Agency.

Introduction

Artificial intelligence (AI) is rapidly being integrated into K-12 education systems worldwide, offering benefits such as personalized learning pathways and real-time feedback mechanisms (Chen et al., 2020; Crompton et al., 2024). However, this acceleration has significantly outpaced the development of ethical regulatory frameworks, creating a widening gap between technological innovation and the safeguarding of students' fundamental rights (Holmes et al., 2021; UNESCO, 2021). While the expansion of AI-powered tools in compulsory education continues at an unprecedented pace, the ethical infrastructure necessary to govern these systems remains critically underdeveloped. UNESCO (2021) has noted that fewer than 30% of countries possess comprehensive data protection legislation applicable to educational contexts, leaving millions of learners vulnerable to the misuse of their personal data. Furthermore, Holmes et al. (2021) have pointed out that virtually no research has been undertaken, no guidelines have been agreed upon, and no regulations have been enacted to address the specific ethical issues raised by AI in education. This regulatory vacuum is particularly concerning in K-12 settings, where the end users are minors who cannot be expected to provide genuinely informed consent to data collection practices embedded within AI-driven platforms.

A central concern underlying these ethical challenges is what may be described as the "black box" problem, a concept that serves as the guiding metaphor for this study. In the field of artificial intelligence, the term "black box" refers to systems whose internal decision-making processes are opaque, meaning that the inputs and outputs are observable but the mechanisms through which conclusions are reached remain hidden from scrutiny (UNESCO, 2021). Deep neural networks, which power many contemporary educational AI applications, exemplify this opacity: it is usually not possible to interrogate these systems to determine how they arrived at a particular recommendation or assessment (UNESCO, 2021). When such systems are deployed in classrooms, this opacity acquires a distinctly pedagogical and ethical dimension. UNESCO (2023) has explicitly cautioned that generative AI systems operate as black boxes, making it difficult or even impossible to understand why specific content is produced. Consequently, teachers, students, and parents find themselves subject to algorithmically mediated decisions, ranging from adaptive content sequencing to automated grading, without meaningful insight into how those decisions are generated. This lack of transparency not only undermines trust (Nazaretsky et al., 2022) but also constrains the capacity of educational stakeholders to critically evaluate, contest, or override algorithmic outputs. The UNESCO Recommendation on the Ethics of Artificial Intelligence (2021) emphasizes that explainability and transparency are essential preconditions for the protection of human rights, and that a lack of transparency could undermine the possibility of effectively challenging decisions based on AI-generated outcomes.

The existing literature on AI in education has predominantly foregrounded the pedagogical benefits of these technologies, while the invisible ethical costs, specifically data privacy violations, algorithmic bias, and the erosion of human agency, remain insufficiently examined within compulsory education contexts (Akgun & Greenhow, 2022). Data privacy constitutes the most frequently cited ethical challenge, identified in over 20% of reviewed studies as the foremost concern (Mustafa et al., 2024). Algorithmic bias represents a second critical dimension: AI systems

trained on historically imbalanced datasets risk perpetuating and amplifying existing inequalities related to gender, socioeconomic status, and ethnicity (Holstein et al., 2019). A further cultural concern arises from the observation that many AI tools fail to recognize local cultural codes and contexts (Filiz et al., 2025), raising questions about what might be characterized as a form of technological cultural imperialism. The third ethical dimension, human agency and teacher autonomy, highlights the tension between algorithmic recommendation and professional pedagogical judgment. Research has demonstrated that teachers exhibit confirmation bias and algorithm aversion toward automated assessment systems (Nazaretsky et al., 2022), while the "assistance dilemma" suggests that excessive AI-mediated scaffolding may ultimately undermine students' capacity for critical and independent thinking (Koedinger & Aleven, 2007). Taken together, these three thematic areas constitute an interconnected web of ethical risks that demand systematic examination rather than piecemeal analysis.

This study conducts a thematic synthesis derived from a systematic literature review of studies indexed in Web of Science, ERIC, and DergiPark databases. From the broader corpus, studies that empirically or theoretically address ethical concerns in K-12 AI implementation were selected and synthesized under three thematic risk categories: data privacy and surveillance, algorithmic bias and fairness, and human agency and teacher autonomy. The central argument advanced by this review is that AI integration in K-12 education constitutes not merely a technical infrastructure issue but fundamentally a human rights concern. Accordingly, the study advocates for the mandatory adoption of "human-in-the-loop" principles and the establishment of dedicated "Ethical AI Literacy" programs for teachers, distinct from technical upskilling, to ensure that the classroom remains a space of pedagogical sovereignty rather than algorithmic governance.

Materials and Methods

This study employs a systematic literature review combined with thematic synthesis as its research design. Systematic review methodology enables the comprehensive, transparent, and replicable identification, evaluation, and synthesis of existing research on a defined topic (Page et al., 2021). Thematic synthesis, in turn, allows for the integration of findings from qualitative, quantitative, and mixed-methods studies under overarching analytical categories, making it particularly suited to examining a multifaceted phenomenon such as AI ethics in education. The adoption of this approach was informed by the recognition that ethical concerns surrounding AI in K-12 education span multiple dimensions that require an integrative analytical framework rather than a narrow, single-study perspective.

The literature search was conducted across three databases: Web of Science and ERIC (Education Resources Information Center) for the international literature, and DergiPark Akademik for the national (Turkish) literature. These databases were selected for their established relevance to educational research and their complementary coverage of international and Turkish scholarly output. In addition to database searches, policy documents published by international organizations, notably UNESCO, and by national institutions such as the Turkish Ministry of National Education (MEB) were also included in the review corpus. The search was carried out using both English and Turkish keywords, including "artificial intelligence in K-12 education," "AI ethics in education," "data privacy in educational AI," "algorithmic bias in education," "teacher autonomy and AI," and their Turkish equivalents. The search strategy targeted title, ABSTRACT, and keyword fields to maximize the retrieval of relevant studies.

The selection of studies followed a two-stage screening process. In the first stage, titles and ABSTRACTs were reviewed against predefined inclusion criteria: studies had to address AI applications at the K-12 level, empirically or theoretically engage with ethical concerns, specifically data privacy, algorithmic bias, or teacher/student autonomy, and be published in peer-reviewed journals, books, or as official policy documents. Exclusion criteria eliminated studies

that focused exclusively on higher education, lacked direct relevance to AI ethics in educational contexts, or were not available in full text. In the second stage, the full texts of studies that passed the initial screening were evaluated against the same criteria to determine final inclusion. This process yielded a corpus of studies that both empirically and theoretically address ethical dimensions of AI deployment in compulsory education settings.

The selected studies were analyzed through thematic synthesis, a method that involves the systematic coding and organization of findings under inductively and deductively derived thematic categories (Boyatzis, 1998). Drawing on the ethical concerns identified in both the reviewed literature and international policy frameworks, three overarching thematic risk categories were established: Data Privacy and Surveillance, encompassing issues related to the collection, storage, and potential misuse of student data; Algorithmic Bias and Fairness, addressing the ways in which AI systems trained on imbalanced datasets may perpetuate or amplify existing inequalities; and Human Agency and Teacher Autonomy, examining the tension between algorithmic decision-making and the professional judgment of educators. Each study in the final corpus was coded according to its primary and secondary engagement with these themes, and the findings were synthesized to This an integrated analysis of the ethical landscape of AI in K-12 education.

Findings and Discussion

The systematic examination of the reviewed literature reveals that the ethical challenges associated with AI in K-12 education are not isolated technical shortcomings but rather interconnected manifestations of a deeper structural problem: the deployment of opaque, algorithmically driven systems within educational environments that serve vulnerable populations. The "black box" metaphor, introduced in the preceding sections as a descriptor of AI's internal opacity, proves to be not merely a technical characteristic but an analytically productive lens through which the full scope of ethical risk becomes visible. When the decision-making logic of AI systems remains hidden from the educators, learners, and families who are most directly affected by their outputs, the consequences extend across multiple domains simultaneously, from the erosion of data privacy to the entrenchment of algorithmic bias and the displacement of professional pedagogical judgment. The following thematic analysis traces these consequences through three interrelated risk categories, demonstrating how opacity functions as a common thread that binds seemingly disparate ethical concerns into a coherent and urgent problem space.

Data Privacy and Surveillance

Data privacy emerges from the reviewed literature as the most frequently cited and arguably the most consequential ethical challenge posed by AI in K-12 education. Mustafa et al. (2024), in their comprehensive review of 132 systematic reviews and meta-analyses, identified data privacy as the foremost concern within the ethics and security category, cited in over 20% of the studies reviewed. This finding is consistent with the broader international policy discourse: UNESCO (2021) has reported that fewer than 30% of countries outside Europe possess comprehensive data protection legislation, leaving the vast majority of the world's learners without adequate legal safeguards against the misuse of their personal information. The scale of data collection in AI-driven educational platforms is substantial, encompassing not only academic performance records but also behavioral patterns, interaction logs, emotional states detected through facial recognition or keystroke dynamics, and, in some cases, biometric data (UNESCO, 2021). This extensive data harvesting has been characterized as "dataveillance," a term that captures the surveillance-like quality of continuous digital monitoring within educational settings (UNESCO, 2021, Akt: Lupton & Williamson, 2017).

The black box nature of AI systems significantly compounds the data privacy challenge. When the internal workings of an AI platform remain opaque, it becomes exceedingly difficult for teachers, parents, and students to understand what data is being collected, how it is processed, by whom it

is accessed, and for what purposes it is ultimately used. UNESCO (2021) has raised critical questions in this regard: what criteria should govern the ethical boundaries of learner data collection, and how might schools, students, and teachers opt out from or challenge their representation in large datasets? These questions acquire particular urgency in K-12 contexts, where the end users are minors who, as UNESCO (2021) acknowledges, may not be capable, either developmentally or legally, of providing genuinely informed consent to the data practices embedded within AI-driven platforms. The opacity of these systems thus creates an asymmetry of knowledge between the technology providers who design and control the algorithms and the educational stakeholders who are subject to their outputs.

The international policy framework has responded to these concerns with increasing specificity. The Beijing Consensus on Artificial Intelligence and Education (UNESCO, 2019) called upon member states to be mindful of the dilemmas of balancing between open access to data and data privacy protection, and urged the adoption of ethics, privacy, and security-by-design principles. The UNESCO Recommendation on the Ethics of Artificial Intelligence (2021) further emphasized that privacy is a right essential to the protection of human dignity, autonomy, and agency, and that adequate data protection frameworks and governance mechanisms should be established through multi-stakeholder approaches. More recently, the European Union's General Data Protection Regulation (GDPR) has emerged as a reference framework, with cases such as the Italian Data Protection Authority's ruling against the use of AI-powered e-proctoring systems in educational settings illustrating the practical complexities of implementing data governance in heavily regulated environments (Bai et al., 2022). These developments underscore the need for K-12 education systems to develop context-specific data protection protocols that account for the unique vulnerabilities of young learners, rather than relying on generic data governance frameworks designed for adult users.

Algorithmic Bias and Fairness

The second thematic category addresses the ways in which AI systems may perpetuate, amplify, or introduce biases that have direct consequences for educational equity. Holstein et al. (2019) have demonstrated that AI models trained on historically imbalanced datasets produce outputs that reflect and reinforce the biases present in their training data. In educational contexts, this means that a predictive model built on data that underrepresents certain demographic groups, whether defined by gender, socioeconomic status, ethnicity, or geographic location, will systematically produce less accurate or less favorable outcomes for those groups. The implications are far-reaching: automated assessment systems may undervalue the work of students from underrepresented backgrounds, adaptive learning platforms may channel students into inappropriate learning pathways, and predictive analytics may generate misleading risk profiles that reinforce existing patterns of educational disadvantage (Akgun & Greenhow, 2022).

The black box character of algorithmic decision-making renders these biases particularly insidious in K-12 settings. When an AI system generates an assessment score, recommends a learning pathway, or flags a student as "at risk," the reasoning behind that output is typically inaccessible to the teachers and students affected by it. UNESCO (2021) has noted that algorithms are not as neutral as they are often presented, and that they can automate biases with varying degrees of negative consequences for individuals. The inability to interrogate how an AI system arrives at its conclusions means that biased outputs may go undetected, unchallenged, and ultimately normalized within educational practice. This opacity transforms what might otherwise be identifiable and correctable errors into systemic features of the educational infrastructure. The UNESCO Recommendation on the Ethics of Artificial Intelligence (2021) has emphasized the importance of transparency and explainability as essential preconditions for identifying and mitigating such biases, yet the current generation of deep learning models used in many educational AI applications remains resistant to meaningful explanation.

A critical cultural dimension further complicates the algorithmic bias landscape. Blanchard (2015) has documented significant sociocultural imbalances in AI in Education (AIED) research, demonstrating a pronounced dominance of Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies in both the authorship and the sample populations of AIED studies. This imbalance carries direct consequences for the universality of AI systems deployed in non-Western educational contexts: AI tools developed primarily within and for WEIRD populations embed culturally specific assumptions about learning processes, assessment criteria, and pedagogical norms that may not translate meaningfully to other cultural settings. Filiz et al. (2025), in their study of 66 K-12 teachers in Türkiye, found that AI tools frequently failed to recognize local cultural codes, with one foreign language teacher reporting that humor generated by AI for English lessons did not resonate with the local cultural context. This finding echoes the broader concern raised by Blanchard (2015) that the AIED community may adopt an approach close to neo-imperialism if it fails to develop guidelines and practices that respect cultural diversity and specificities. The Beijing Consensus (UNESCO, 2019) has affirmed the commitment to developing AI applications that are free from gender bias and that ensure gender-sensitive data practices, yet the broader challenge of cultural and contextual bias in educational AI remains inadequately addressed.

Human Agency and Teacher Autonomy

The third thematic category examines the tension between algorithmically mediated decision-making and the professional autonomy of teachers, a tension that lies at the heart of the black box problem in educational AI. When AI systems generate recommendations, assessments, or instructional sequences that teachers cannot fully understand or critically evaluate, the relationship between human judgment and algorithmic output becomes distorted. Nazaretsky et al. (2022), in their experimental study with biology teachers in Israel, documented two complementary manifestations of this distortion: confirmation bias, in which teachers uncritically accepted AI-generated assessments that aligned with their existing expectations, and algorithm aversion, in which teachers rejected algorithmic recommendations precisely because they distrusted the opaque system producing them. One teacher in the study expressed this tension directly, observing that an algorithm operates in binary categories whereas a human teacher can perceive nuanced understanding that lies beyond categorical classification. These findings reveal that the black box nature of AI systems does not merely create a technical problem of transparency; it fundamentally disrupts the epistemic relationship between teachers and the tools they are expected to use.

The implications extend beyond teacher-system interaction to the broader question of student learning. Koedinger and Aleven (2007), in their foundational work on the "assistance dilemma," demonstrated that the optimal balance between providing and withholding instructional support remains a fundamental open problem in learning science. Excessive assistance, they argued, can deprive learners of the productive struggle necessary for deep understanding, effectively substituting algorithmic scaffolding for genuine cognitive engagement. When this principle is applied to AI-powered learning environments, the concern becomes acute: adaptive systems that continuously intervene to smooth the learning pathway may inadvertently undermine students' capacity for critical thinking, self-regulation, and independent problem-solving. UNESCO (2021) has echoed this concern, cautioning that the increasing use of adaptive AI in education may weaken learner agency by reducing interaction between students, shifting more decisions to machines, and focusing on the types of knowledge that are easiest to automate. This perspective suggests that students may lose opportunities to develop resourcefulness, self-efficacy, metacognition, and independent thought, competencies that are widely regarded as essential for 21st-century education. Kazu and Deniz (2024), in their adaptation of the Learner Autonomy Scale for high school and secondary school students (n = 870) in Türkiye, identified two core dimensions of learner autonomy, self-management ability and psychological tendency, and demonstrated that

both dimensions function as distinct yet complementary capacities that students must actively develop. Their measurement invariance analysis confirmed that these autonomy constructs operate consistently across different age groups within compulsory education, indicating that learner autonomy is not an incidental trait but a structured developmental capacity that requires deliberate pedagogical support. When situated within the present discussion, this finding reinforces the concern that AI systems designed to optimize learning efficiency through continuous adaptive intervention may, paradoxically, erode the very self-management and psychological dispositions that constitute the foundation of autonomous learning.

The convergence of these concerns points toward a fundamental question about the governance of AI in educational spaces. If the algorithms that shape learning experiences, assess student performance, and recommend pedagogical pathways remain opaque to the very professionals charged with guiding student development, then the classroom risks being transformed from a space of pedagogical sovereignty into one of algorithmic governance. The UNESCO Recommendation on the Ethics of Artificial Intelligence (2021) has articulated the principle that humans should always retain the capacity to override AI-generated decisions, and that life-altering determinations should not be ceded to automated systems. In the K-12 context, this "human-in-the-loop" principle acquires particular significance: it demands not merely that teachers retain nominal veto power over AI outputs, but that they possess the conceptual tools, the institutional support, and the professional autonomy necessary to exercise that power meaningfully. Nazaretsky et al. (2022) have demonstrated that well-designed professional development programs can reduce algorithmic distrust and enhance teachers' capacity to engage critically with AI-generated assessments, suggesting that the cultivation of what this study term "Ethical AI Literacy" may be a prerequisite for preserving human agency in AI-augmented classrooms.

Conclusion and Recommendations

This systematic review sets out to examine the ethical dimensions of AI deployment in K-12 education through the analytical lens of the "black box" problem. The thematic synthesis revealed that the three categories of ethical risk investigated, data privacy and surveillance, algorithmic bias and fairness, and human agency and teacher autonomy, are not discrete challenges amenable to isolated solutions but rather interlocking facets of a single structural condition: the embedding of opaque, algorithmically governed systems within educational environments that serve minors. Data privacy concerns are amplified when neither educators nor families can ascertain what information is collected or how it is used. Algorithmic biases become entrenched when the decision-making processes that produce inequitable outcomes are shielded from scrutiny. Teacher autonomy is eroded when professional judgment is subordinated to algorithmic recommendations whose underlying logic cannot be interrogated. In each case, it is the opacity of the system, its black box character, that transforms a manageable technical issue into a systemic ethical failure. The central argument of this study, therefore, stands confirmed: AI integration in K-12 education constitutes not merely a question of technical infrastructure but fundamentally a human rights concern that demands governance frameworks commensurate with the vulnerability of the populations it affects.

The study's principal conceptual contribution lies in demonstrating the analytical value of treating opacity as a unifying thread across otherwise disparate ethical debates. Much of the existing literature addresses data privacy, algorithmic bias, and human agency as separate research domains, each with its own disciplinary vocabulary and policy prescriptions (Akgun & Greenhow, 2022; Mustafa et al., 2024). This review argues that such compartmentalization obscures the structural interconnection among these challenges and, in doing so, risks producing fragmented policy responses that address symptoms rather than root causes. By foregrounding the black box as both a technical reality and an ethical condition, this study offers an integrative framework that can inform more coherent and comprehensive approaches to AI governance in compulsory

education. The framework aligns with and extends the principles articulated in the UNESCO Recommendation on the Ethics of Artificial Intelligence (2021), which identifies transparency, explainability, and human oversight as foundational requirements for the ethical deployment of AI systems across all domains, including education.

Based on these findings, several recommendations are advanced. First, the adoption of "human-in-the-loop" principles should be rendered mandatory, not merely aspirational, in all AI systems deployed within K-12 educational settings. This entails ensuring that no consequential decision affecting a student's learning trajectory, assessment outcome, or behavioral classification is made solely by an automated system without meaningful human review and the genuine possibility of overriding. Second, and perhaps most critically, this study advocates for the establishment of dedicated "Ethical AI Literacy" programs for teachers. Such programs must be understood as distinct from, and complementary to, technical upskilling initiatives: whereas technical training equips teachers to operate AI tools, Ethical AI Literacy cultivates the capacity to critically evaluate the outputs, assumptions, and limitations of those tools, to recognize when algorithmic recommendations may be biased or inappropriate, and to exercise professional judgment with confidence in the face of automated suggestions. Third, policymakers at both national and international levels should develop context-sensitive data protection protocols specifically designed for K-12 populations, acknowledging the unique vulnerabilities of minors and the limitations of consent-based governance models when applied to children. Fourth, the development of AI tools intended for educational use should be subject to mandatory bias audits and cultural sensitivity assessments prior to deployment, with particular attention to the documented tendency of AIED systems to embed WEIRD-centric assumptions that may not transfer meaningfully to diverse cultural contexts (Blanchard, 2015; Filiz et al., 2025).

This study is subject to several limitations that should be acknowledged. The literature search was confined to the Web of Science, ERIC, and DergiPark databases; the inclusion of additional databases such as Scopus and Google Scholar might have yielded further relevant studies. The review was limited to publications in English and Turkish, which may have resulted in the exclusion of pertinent research published in other languages, particularly from Asian and continental European contexts where significant AI-in-education initiatives are underway. As a systematic review, the study synthesizes existing findings rather than generating primary empirical data, and its conclusions are therefore contingent upon the scope and quality of the reviewed literature. Future research should address these gaps through empirical investigations, including experimental and longitudinal designs, that examine the real-world ethical impacts of AI systems on K-12 students and teachers. Studies that foreground the perspectives of students themselves, who are the ultimate subjects of the black box yet whose voices remain conspicuously absent from the ethical discourse, would be particularly valuable. Finally, the development and empirical validation of culturally responsive ethical frameworks for educational AI, informed by non-WEIRD epistemologies and pedagogical traditions, represents an urgent and largely uncharted research frontier.

Information Note

This study employed artificial intelligence tools to assist with literature organization, reference management, and linguistic enhancement, encompassing grammar, coherence, and proofreading. The author assumes complete responsibility for the intellectual content, analysis, and conclusions contained in this work.

References

Akgun, S., & Greenhow, C. (2022). Artificial intelligence in education: Addressing ethical challenges in K-12 settings. *AI and Ethics*, *2*(3), 431-440. https://doi.org/10.1007/s43681-021-00096-7

Bai, J. Y. H., Zawacki-Richter, O., & Muskens, W. (2024). Re-examining the future prospects of artificial intelligence in education in light of the GDPR and ChatGPT. *Turkish Online Journal of Distance Education*, *25*(1), 20-29.

Blanchard, E. G. (2015). Socio-cultural imbalances in AIED research: Investigations, implications and opportunities. *International Journal of Artificial Intelligence in Education*, *25*(2), 204-228. https://doi.org/10.1007/s40593-014-0027-7

Boyatzis, R. E. (1998). *Transforming qualitative information: Thematic analysis and code development*. Sage Publications.

Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *IEEE Access*, *8*, 75264-75278. https://doi.org/10.1109/ACCESS.2020.2988510

Crompton, H., Jones, M. V., & Burke, D. (2024). Affordances and challenges of artificial intelligence in K-12 education: A systematic review. *Journal of Research on Technology in Education*, *56*(3), 248-268. https://doi.org/10.1080/15391523.2022.2121344

Filiz, O., Kaya, M. H., & Adiguzel, T. (2025). Teachers and AI: Understanding the factors influencing AI integration in K-12 education. *Education and Information Technologies*, *30*, 17931-17967. https://doi.org/10.1007/s10639-025-13463-2

Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Shum, S. B., Santos, O. C., Rodrigo, M. T., Cukurova, M., Bittencourt, I. I., & Koedinger, K. R. (2021). Ethics of AI in education: Towards a community-wide framework. *International Journal of Artificial Intelligence in Education*, *32*(3), 504-526. https://doi.org/10.1007/s40593-021-00239-1

Holstein, K., Wortman Vaughan, J., Daume III, H., Dudik, M., & Wallach, H. (2019). Improving fairness in machine learning systems: What do industry practitioners need? *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, 1-16. https://doi.org/10.1145/3290605.3300830

Kazu, H., & Deniz, E. (2024). Measurement invariance and construct validity of the Turkish version of the learner autonomy scale in a sample of high and secondary school students. *International Journal of Contemporary Educational Research*, 11(1), 1-19. https://doi.org/10.52380/ijcer.2024.11.1.477

Koedinger, K. R., & Aleven, V. (2007). Exploring the assistance dilemma in experiments with cognitive tutors. *Educational Psychology Review*, *19*(3), 239-264. https://doi.org/10.1007/s10648-007-9049-0

Mustafa, M. Y., Tlili, A., Lampropoulos, G., Huang, R., Jandric, P., Zhao, J., Salha, S., Xu, L., Panda, S., Kinshuk, Lopez-Pernas, S., & Saqr, M. (2024). A systematic review of literature reviews on artificial intelligence in education (AIED): A roadmap to a future research agenda. *Smart Learning Environments*, *11*(59), 1-33. https://doi.org/10.1186/s40561-024-00350-5

Nazaretsky, T., Ariely, M., Cukurova, M., & Alexandron, G. (2022). Teachers' trust in AI-powered educational technology and a professional development program to improve it. *British Journal of Educational Technology*, *53*(4), 914-931. https://doi.org/10.1111/bjet.13232

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hrobjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. https://doi.org/10.1136/bmj.n71

UNESCO. (2019). *Beijing consensus on artificial intelligence and education*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000368303

UNESCO. (2021). *AI and education: Guidance for policy-makers*. UNESCO. https://doi.org/10.54675/PCSP7350

UNESCO. (2021). *Recommendation on the ethics of artificial intelligence*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000381137

UNESCO. (2023). *Guidance for generative AI in education and research*. UNESCO. https://doi.org/10.54675/EWZM9535

THE DIGITAL ARCHITECTURE OF MODERN CONSUMPTION: A COMPREHENSIVE INVESTIGATION INTO MARKETING PARADIGMS AND CONSUMER DECISION-MAKING

MODERN TÜKETİMİN DİJİTAL MİMARİSİ: PAZARLAMA PARADİGMALARI VE TÜKETİCİ KARAR ALMA SÜREÇLERİ ÜZERİNE KAPSAMLI BİR İNCELEME

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ABSTRACT

Digital transformation has fundamentally shaken traditional marketing paradigms, shifting the focus from one-way messages to real-time interaction strengthened by data analytics and cost efficiency. Today, consumption has gone beyond merely meeting functional needs and has gained symbolic, aesthetic, and experiential dimensions; in this context, hedonic gratification has become the main determinant of sustainable competitive advantage.

The traditional linear funnel model has been replaced by a dynamic and personalized network defined by "4S behaviors" (Streaming, Scrolling, Searching, Shopping). Digitalization has transformed the decision-making process into a cyclical journey, increasing consumers' expectations for speed and transparency. While artificial intelligence and big data enable the prediction of needs before they are even recognized through digital footprints, post-purchase processes create transparent feedback loops that feed future consumption cycles.

Algorithmic precision and Machine Learning (ML) enable the interpretation of purchasing patterns with unique accuracy. Models such as CatBoost and XGBoost, reaching a ROC AUC value of 0.985, identify hidden relationships in high-dimensional data and optimize personalized recommendations and dynamic pricing. These technologies make "precision marketing" possible by segmenting consumers into behavior-oriented cohorts rather than simple demographic information.

Achieving sustainable competitive advantage (SCA) requires balancing technical precision with a trust architecture based on radical transparency, user control, and ethical data governance. Agile frameworks such as Scrum, Kanban, or McKinsey's "Customer-Centric Business Model" (CBM) increase organizational resilience by breaking down interdepartmental silos. These models can reduce supply–demand balancing time by 80%.

In conclusion, digital marketing is now the main architect of modern consumption. The transition from linear models to the fragmented reality of 4S behaviors necessitates integrated operational structures prioritizing customer centricity. Businesses that combine algorithmic power with ethical transparency and agility can transform digital fluctuations into strategic advantage and build deep consumer loyalty in the experience-oriented global market.

Keywords Digital Transformation, Precision Marketing, Consumer Behavior, Artificial Intelligence, Sustainable Competitive Advantage, 4S Behaviors

Özet

Dijital dönüşüm, geleneksel pazarlama paradigmalarını temelden sarsarak, tek yönlü mesajlardan veri analitiği ve maliyet verimliliğiyle güçlendirilmiş gerçek zamanlı etkileşime odaklanmayı sağlamıştır. Günümüzde tüketim, yalnızca işlevsel ihtiyaçları karşılamanın ötesine geçerek sembolik, estetik ve deneyimsel boyutlar kazanmıştır; bu bağlamda, haz alma, sürdürülebilir rekabet avantajının ana belirleyicisi haline gelmiştir.

Geleneksel doğrusal huni modeli, “4S davranışları” (Akış, Kaydırma, Arama, Alışveriş) ile tanımlanan dinamik ve kişiselleştirilmiş bir ağ ile değiştirilmiştir. Dijitalleşme, karar verme sürecini döngüsel bir yolculuğa dönüştürerek tüketicilerin hız ve şeffaflık beklentilerini artırmıştır. Yapay zeka ve büyük veri, dijital ayak izleri aracılığıyla ihtiyaçların henüz tanınmadan önce tahmin edilmesini sağlarken, satın alma sonrası süreçler, gelecekteki tüketim döngülerini besleyen şeffaf geri bildirim döngüleri oluşturmaktadır.

Algoritmik hassasiyet ve Makine Öğrenimi (ML), satın alma kalıplarının benzersiz bir doğrulukla yorumlanmasını sağlar. 0,985'lik bir ROC AUC değerine ulaşan CatBoost ve XGBoost gibi modeller, yüksek boyutlu verilerdeki gizli ilişkileri belirler ve kişiselleştirilmiş önerileri ve dinamik fiyatlandırmayı optimize eder. Bu teknolojiler, tüketicileri basit demografik bilgiler yerine davranış odaklı gruplara ayırarak "hassas pazarlama"yı mümkün kılar.

Sürdürülebilir rekabet avantajı (SCA) elde etmek, teknik hassasiyeti radikal şeffaflık, kullanıcı kontrolü ve etik veri yönetimine dayalı bir güven mimarisiyle dengelemeyi gerektirir. Scrum, Kanban veya McKinsey'nin "Müşteri Odaklı İş Modeli" (CBM) gibi çevik çerçeveler, departmanlar arası siloları kırarak organizasyonel direnci artırır. Bu modeller, arz-talep dengeleme süresini %80 oranında azaltabilir.

Sonuç olarak, dijital pazarlama artık modern tüketimin ana mimarıdır. Doğrusal modellerden 4S davranışlarının parçalı gerçekliğine geçiş, müşteri merkezliliğine öncelik veren entegre operasyonel yapıları gerektirir. Algoritmik gücü etik şeffaflık ve çeviklikle birleştiren işletmeler, dijital dalgalanmaları stratejik avantaja dönüştürebilir ve deneyim odaklı küresel pazarda derin tüketici sadakati oluşturabilir.

Anahtar Kelimeler: Dijital Dönüşüm, Hassas Pazarlama, Tüketici Davranışı, Yapay Zeka, Sürdürülebilir Rekabet Avantajı, 4S Davranışları

Giriş: Pazarlama Epistemolojisinde Paradigma Kayması

Küresel pazar dinamikleri, eşsiz bir hız ve evrim geçirerek sanayi sonrası üretim odaklı dönemden, veri güdümlü algoritmik karar alma çağına geçiş yapmıştır. Pazarlama disiplini, tarihsel olarak kitle iletişim araçlarının (televizyon, radyo, basılı yayın) asimetrik ve tek yönlü doğasından beslenirken, günümüzde veri analitiği, anlık etkileşim ve hiper-kişiselleştirme yetenekleriyle donatılmış çok boyutlu bir davranış bilimine dönüşmüştür. Geleneksel teorilerde tüketici, pazarlama mesajlarının pasif bir alıcısı olarak konumlandırılırken; modern dijital mimaride

tüketici, değer yaratım sürecinin aktif bir eş-yaratıcısı (co-creator) ve sistemin merkezindeki veri üreticisidir.

Modern tüketicinin dijital ekosistemle kurduğu ilişki, basit bir ticari takas eyleminin ötesine geçerek ontolojik bir kimlik inşası ve deneyim arayışına dönüşmüştür. E-ticaret platformları, sosyal medya ağları ve artırılmış gerçeklik ortamları (metaverse vb.), fiziksel ve dijital dünyalar arasındaki sınırları bulanıklaştırmış, bu durum "fizital" (phygital) yepyeni bir tüketim evreninin doğmasına yol açmıştır. İşletmelerin bu yeni gerçeklikte hayatta kalabilmeleri ve sürdürülebilir bir rekabet avantajı (SCA) inşa edebilmeleri; devasa veri yığınlarını (Big Data) anlamlandırabilme, tüketici davranışlarındaki mikro dalgalanmaları makine öğrenmesi modelleriyle öngörebilme ve kurumsal operasyonlarını bu hıza entegre edebilecek çevik (agile) bir iş modeline geçiş yapabilmelerine bağlıdır.

Geleneksel pazarlama hunisi (marketing funnel), tüketicinin marka farkındalığından başlayıp doğrusal bir çizgi üzerinde değerlendirme, niyet ve nihai satın alma aşamalarına doğru ilerlediğini varsayar. Oysa bugün mobil cihazların sürekliliği, sosyal ticaretin (social commerce) yükselişi ve dijital temas noktalarının parçalanmışlığı, bu statik modelleri işlevsiz kılmıştır (Boston Consulting Group, 2025). Tüketiciler, gün içinde ortalama 130'dan fazla mobil çevrimiçi temas noktasıyla etkileşime girmekte; video izleme, sosyal medyada kaydırma, arama motorlarında araştırma yapma ve anında ödeme adımlarını öngörülemez bir sırayla, çoğu zaman eşzamanlı olarak gerçekleştirmektedir (Google & BCG, 2025).

Bu bağlamda, dijital pazarlama stratejilerinin salt bir "iletişim ve tutundurma" çabası olmaktan çıkıp; büyük veri mimarisi, istatistiksel algoritmalar (CatBoost, XGBoost), etik veri yönetişim protokolleri ve operasyonel çeviklik (McKinsey CBM modeli) gerektiren mühendislik tabanlı bir işletme fonksiyonuna dönüştüğü görülmektedir (McKinsey & Company, 2024). Bu bildirge, bahsi geçen dijital tüketim mimarisini oluşturan bu dört temel sütunu (Hedonik tüketim psikolojisi, 4S davranışsal çerçevesi, Yapay zeka tabanlı hassas pazarlama ve Operasyonel çeviklik/etik) ampirik araştırmalar ve güncel kuramsal yaklaşımlar ışığında derinlemesine incelemeyi hedeflemektedir.

Modern Tüketimin İtici Gücü: Hedonik Tatmin ve Sürdürülebilir Rekabet Avantajı

Ekonomi ve pazarlama teorileri uzun yıllar boyunca "rasyonel insan" (homo economicus) varsayımı üzerinden şekillenmiş; tüketicinin, maliyet-fayda analizi yaparak faydayı (utility) maksimize edecek en rasyonel satın alma kararını verdiği kabul edilmiştir. Batra ve Ahtola (1991) gibi araştırmacıların öncülüğünü yaptığı çalışmalar ise tüketim eyleminin temelde iki ana motivasyona dayandığını ortaya koymuştur: Araçsal (utilitarian) nedenler ve hedonik (consummatory/hedonic) nedenler (Batra & Ahtola, 1991). İçinde bulunduğumuz dijital çağda, ürün özellikleri ve fiyatlandırma stratejilerindeki şeffaflık nedeniyle salt işlevsel (utilitarian) fayda üzerinden rekabet etmek imkânsızlaşmıştır. Tüketim davranışının doğası, psikolojik, sosyal ve duygusal tatmin üreten bir yapıya doğru evrilmiştir.

Kullanımlar ve Doyumlar Teorisi (Uses and Gratifications Theory - UGT) perspektifinden bakıldığında, dijital platformlardaki tüketici etkileşimlerinin temelinde bireyin psikolojik ve sosyal ihtiyaçlarını karşılama güdüsü yatmaktadır (Li vd., 2015). Modern tüketici, dijital mağazalarda veya sosyal medya ağlarında yalnızca ihtiyaç duyduğu bir ürünü aramakla kalmamakta, aynı zamanda estetik bir haz, sembolik bir aidiyet, eğlence ve gerçeklikten kaçış (escapism) deneyimi talep etmektedir (Li vd., 2015).

Dijital Ekosistemde Hedonik Doyumun Anatomisi

"Hedonik Tatmin" (Hedonic Gratification), dijital pazarlamada markalar için sürdürülebilir rekabet avantajının (SCA) en önemli ayrıştırıcı gücü haline gelmiştir (Batra & Ahtola, 1991;

Sookbumroong & Phornlaphatrachakorn, 2023). Dijital ortamlarda hedonik tüketim; fantezi, uyarılma, zaman geçirme, oyunlaştırma (gamification) unsurlarından zevk alma ve duyusal uyaranlarla çevrelenme gibi tamamen duygusal motivasyonlara dayanır (Li vd., 2015).

Örneğin, tüketicilerin oyunlaştırılmış sadakat programları, TikTok gibi platformlardaki sürükleyici (immersive) video kampanyaları veya sanal gerçeklik (VR/AR) destekli meta-evren (metaverse) mağazaları ile etkileşime girdiğinde yaşadıkları 'akış deneyimi' (flow experience), son derece güçlü bir hedonik değer yaratır (Sookbumroong & Phornlaphatrachakorn, 2023). Dijital ortamda ulaşılan bu tatmin düzeyi, sadece anlık veya dürtüsel (impulsive) satın alma oranlarını (kısa vadeli dönüşüm) maksimize etmekle kalmaz; aynı zamanda markaya karşı derin bir duygusal bağ ve uzun vadeli sadakat (brand loyalty) inşa eder (Sookbumroong & Phornlaphatrachakorn, 2023). Literatür, e-ticaret sitelerindeki zenginleştirilmiş ürün içeriklerinin (enriched product content), estetik arayüzlerin ve sürtünmesiz (frictionless) gezinme imkânlarının kullanıcıda yarattığı keyif duygusunun, o kullanıcının siteye tekrar dönme ve sistemi kullanmaya devam etme (continuance intention) olasılığını doğrudan artırdığını göstermektedir (Li vd., 2015).

Sürdürülebilir Rekabet Avantajı (SCA) Aracı Olarak Deneyim Yönetimi

Rekabet stratejilerinde Sürdürülebilir Rekabet Avantajı (SCA), rakipler tarafından kolayca taklit edilemeyen, işletmeye özgü ve sürekli değer üreten yetenekler bütünü olarak tanımlanır. Dijitalleşme, ürünleri meta (commodity) seviyesine indirgerken, algoritmalar aracılığıyla sağlanan "kişiselleştirilmiş hedonik deneyimi" biricik kılmıştır.

Müşteri etkileşimi (customer engagement) teorilerine göre, yüksek hedonik tatmin sağlayan platformlar, tüketicinin o platformla psikolojik bir sözleşme kurmasını sağlar. Müşterinin marka topluluğuna katılması, kullanıcı türetimli içerik (User Generated Content - UGC) üretmesi ve marka elçiliği yapması, rakip markalara geçiş maliyetini (switching cost) rasyonel olmaktan çıkarıp psikolojik ve duygusal bir maliyete dönüştür (Li vd., 2015). Araştırmalar, etkileşimi yüksek tüketicilerin bulunduğu platformların kalıcı bir rekabet avantajı elde ettiğini doğrulamaktadır. Markalar, tüketicinin yalnızca işlevsel amacına değil, sosyal statü inşasına ve keyfi tüketim arzularına da hitap edebildikleri ölçüde küresel pazardaki dalgalanmalara karşı bağışıklık kazanmaktadır.

Doğrusal Huni (Funnel) Modelinin Çöküşü ve 4S Davranış Çerçevesi

Pazarlama biliminin temel metodolojik kurgusu uzun on yıllar boyunca AIDA (Attention, Interest, Desire, Action) adı verilen huni (funnel) modeline dayanmıştır. Bu geleneksel model, tüketicinin bir uyaranla karşılaştığında farkındalık yaşadığını, ilgisinin giderek arzuya dönüştüğünü ve nihayetinde rasyonel bir kararla satın alma eylemini gerçekleştirdiğini savunan, sıralı ve statik bir yaklaşımdır (Google & BCG, 2025). Ancak, yapay zeka entegrasyonlu arama motorlarının, çoklu ekran kullanımının ve algoritmik sosyal akışların egemen olduğu modern çağda, bu huni varsayımı geçerliliğini yitirmiştir (Google & BCG, 2025).

Boston Consulting Group (BCG) ve Google iş birliğiyle gerçekleştirilen kapsamlı tüketici araştırmaları, tüketici yolculuğunun (customer journey) artık lineer bir rota izlemediğini, bunun yerine sürekli, öngörülemez ve çoklu temas noktalarından oluşan karmaşık bir ağ biçimini aldığını kanıtlamıştır (Google & BCG, 2025). Bu yeni yapı, "4S Davranış Çerçevesi" (4S Behaviors) olarak kavramsallaştırılmıştır: İzleme (Streaming), Kaydırma (Scrolling), Arama (Searching) ve Alışveriş (Shopping) (Google & BCG, 2025).

Günümüz tüketicileri bu 4S eylemlerini eşzamanlı ve döngüsel olarak gerçekleştirmektedir. Örneğin bir tüketici; akıllı televizyonunda YouTube üzerinden içerik tüketirken (Streaming), aynı anda akıllı telefonunda Instagram akışını kontrol edebilmekte (Scrolling), gördüğü bir ürün üzerine

Google'da aktif bir sorgu yürütebilmekte (Searching) ve tek tıkla dijital cüzdanı üzerinden siparişi tamamlayabilmektedir (Shopping) (Google & BCG, 2025). Huni yaklaşımı, her eylemin bir öncekini takip ettiğini varsayarken; 4S modeli, tüketicinin bu evreler arasında istediği an sıçrama (jump), geri dönme (backtrack) veya döngüye girme (loop) eğiliminde olduğunu kabul eder (Boston Consulting Group, 2025).

4S Davranışsal Boyutlarının Analizi

4S modelinin her bir bileşeni, tüketicinin farklı bir psikolojik ve bilişsel durumunu temsil eder. Etkili bir dijital pazarlama stratejisi, tüketicinin hangi 'S' durumu içerisinde olduğunu saptayarak o ana uygun algoritmik bir tepki verebilme kapasitesini gerektirir (Google & BCG, 2025).

İzleme (Streaming): Pasif Keşiften Derin Güven İnşasına

Tüketicilerin YouTube, Netflix, bağlantılı TV (Connected TV) veya podcast platformlarında gerçekleştirdiği uzun veya kısa formlu görsel-işitsel içerik tüketimidir (Google & BCG, 2025). İzleme eylemi, geleneksel televizyon izleme alışkanlığının dijital ve isteğe bağlı (on-demand) versiyonudur. Streaming esnasında tüketicinin "dikkat değeri" (attention value) oldukça yüksektir (Boston Consulting Group, 2025). Doğrudan satın alma niyeti olmasa dahi, ürün incelemeleri, kutu açılış videoları (unboxing) veya güvenilir içerik üreticilerinin (creators) entegre marka mesajları, tüketicinin bilinçaltında derin bir güven ve marka aşinalığı (brand affinity) yaratır (Google & BCG, 2025). Bu pasif keşif evresi, video platformlarına entegre edilen "shoppable video" (alışveriş yapılabilir video) eklentileri ile saniyeler içerisinde eyleme dönüştürülebilir hale gelmiştir (Google & BCG, 2025).

Kaydırma (Scrolling): Tesadüfi Keşif ve Dürtüsel Etkileşim

Sosyal medya akışlarında (TikTok, Instagram, X) veya içerik derleyicilerde gerçekleştirilen, bilişsel yükü düşük, sürekli içerik tarama eylemidir (Google & BCG, 2025). Kaydırma eylemi, modern tüketimin "vitrin gezinme" (window shopping) pratiği olarak nitelendirilebilir (Google & BCG, 2025). Kullanıcı genellikle belirli bir niyet gütmeden (serendipitous discovery) hareket eder (Google & BCG, 2025). Ancak bu aşama, algoritmaların gücünü en net gösterdiği alandır. Yapay zeka; kullanıcının önceki tıklamalarını, ekranda duraklama süresini (dwell time) ve demografik-psikografik eşleşmelerini analiz ederek anlık, hedonik tatmini en yüksek ve dürtüsel (impulsive) satın almayı tetikleyecek görsel reklamları mikrosaniyeler içinde kullanıcının akışına yerleştirir (Google & BCG, 2025; Lin, 2025).

Arama (Searching): Niyet Sinyalleri ve Aktif Doğrulama

Arama eylemi, tüketicinin karar verme sürecindeki "niyet sinyalinin" (intent signal) en somut göstergesidir. Geleneksel olarak Google gibi arama motorlarına yazılan anahtar kelimelerden ibaret olan arama pratiği; günümüzde görsel arama (Google Lens), pazar yeri içi aramalar (Amazon search) ve Üretken Yapay Zeka özetleriyle (Generative AI Overviews) desteklenen çok yönlü bir bilgi toplama sürecine evrilmiştir (Google & BCG, 2025). Tüketici bu aşamada analitik bir zihin yapısındadır; fiyat kıyaslaması yapar, ürün spesifikasyonlarını inceler ve en önemlisi diğer kullanıcıların yorumlarını okuyarak markanın vadettiği kaliteyi "doğrular" (validation) (Google & BCG, 2025).

Alışveriş (Shopping): Her Yerde Mevcut Olan Akışkan Eylem

Geleneksel pazarlamada nihai varış noktası olan alışveriş, 4S modelinde yolculuğun herhangi bir anında tetiklenebilen akışkan bir aşamadır (Google & BCG, 2025). Tüketici artık satın alma eylemi için özel bir e-ticaret sitesine gitmek zorunda değildir; sürtünmesiz (frictionless) ödeme altyapıları sayesinde bir Instagram gönderisinde, bir TikTok canlı yayınında veya bir arama motoru sonucunda anında işlemi tamamlayabilmektedir (Google & BCG, 2025). Üstelik alışveriş eylemi, sürecin sonu değildir. Satın alma sonrası tüketici değerlendirmeleri, oluşturulan dijital içerikler ve

iade politikalarından elde edilen deneyimler, şeffaf bir geri bildirim döngüsü yaratarak sistemin "Streaming" ve "Searching" adımlarını diğer tüketiciler için sürekli olarak besler (Google & BCG, 2025).

Çoklu Temas Atıf Modellerinin (MTA) Yetersizliği ve Etki Haritaları

Tüketicinin 4S davranışları arasındaki bu öngörülemez sıçramalar, geleneksel pazarlama ölçümleme metriklerini zorlamaktadır. Pazarlama yatırımlarının geri dönüşünü (ROI) ölçmede sıklıkla kullanılan Çoklu Temas Atıf (Multi-Touch Attribution - MTA) modelleri, tüketicinin etkileşime girdiği kanallara (örneğin e-posta, arama reklamı, sosyal medya reklamı) kredi dağıtırken, kullanıcının o an hangi "davranışsal durumda" (örneğin pasif bir izleyici mi yoksa aktif bir araştırmacı mı) olduğunu analiz edemediği için eksik kalmaktadır (Boston Consulting Group, 2025).

Bu yetersizliği gidermek üzere BCG tarafından "Etki Haritaları" (Influence Maps) konsepti önerilmektedir (Boston Consulting Group, 2025). Etki haritaları, salt erişimi (reach) ölçmek yerine, tüketicinin satın alma kararı üzerindeki "gerçek etkiyi" ölçmeye odaklanır. Bir temas noktasının etkisi; kullanıcının gösterdiği *dikkat seviyesi*, mesajın anlık bağlama *uygunluğu (relevance)* ve platforma duyulan *güven* ile belirlenir (Boston Consulting Group, 2025). Örneğin, yapay zeka ile desteklenmiş bir etki haritası, markaya yönelen "Dürtüsel Stratejist" (Impulse Strategist) kohortunun, YouTube'da ürün inceleme videosu izledikten (Streaming) hemen sonra indirim kodu aradığını (Searching) tespit edip, bütçeyi salt bu bağlantı noktasına yönlendirerek devasa bir optimizasyon sağlar (Boston Consulting Group, 2025).

Tablo 1: 4S Tüketici Davranış Çerçevesinin Karşılaştırmalı Analizi

Davranış (4S)	**Tüketici Motivasyonu**	**Bilişsel Durum**	**Temsili Platformlar / Kanallar**	**Pazarlama Stratejisi ve Hedefleme**
Streaming	Eğlence, İlham Alma, İçerik Tüketimi	Odaklı, Yüksek Dikkat	YouTube, Netflix, Spotify, Podcastler	Ürün yerleştirme, Influencer iş birlikleri, Uzun form marka hikayeciliği
Scrolling	Zaman Geçirme, Sosyalleşme, Vitrin Bakma	Pasif, Bilişsel yükü düşük	Instagram, TikTok, Pinterest, X	Dikkat çekici kısa videolar (Reels), Dinamik Retargeting, Görsel çekicilik
Searching	Bilgi Doğrulama, Kıyaslama, Sorun Çözme	Analitik, Kararlı, Rasyonel	Google, Amazon, Karşılaştırma Siteleri	SEO/AEO optimizasyonu, Ayrıntılı teknik veriler, Müşteri güven yorumları
Shopping	İhtiyaç Giderme, Dürtüsel Tatmin	Eylem Odaklı, İşlem hızı beklentisi	E-ticaret siteleri, Sosyal Ticaret Butikleri	Tek tıkla ödeme, Sepet terk etme e-postaları, Çapraz satış (Cross-sell)

Hassas Pazarlama (Precision Marketing) ve İleri Düzey Makine Öğrenmesi Uygulamaları

İnsan bilişinin, milyonlarca tüketicinin anlık 4S geçişlerini takip edip manuel stratejiler geliştirmesi imkânsızdır. Bu noktada Büyük Veri (Big Data) ve Yapay Zeka (AI), pazarlamayı sezgisel bir sanat olmaktan çıkarıp, deterministik bir veri bilimine dönüştürmektedir (Google & BCG, 2025). Geleneksel pazar bölümlendirme stratejileri (yaş, cinsiyet, gelir durumu gibi katı demografik veriler), yerini yapay zekanın gerçek zamanlı olarak kümelediği "davranış odaklı kohortlara" (behavior-oriented cohorts) bırakmıştır.

Hassas Pazarlama (Precision Marketing), nesnelerin interneti (IoT) sensörlerinden, web gezinme kayıtlarına kadar sayısız kaynaktan elde edilen veriyi kullanarak, tüketiciyi mikroskobik düzeyde analiz eden ve ona tam ihtiyacı olduğu anda, en uygun kanaldan, hiper-kişiselleştirilmiş mesajlar ileten bir stratejidir (Lin, 2025). Hassas pazarlamanın başarısı, tüketici verisindeki doğrusal

olmayan, karmaşık ilişkileri ve gizli örüntüleri (hidden patterns) tespit edebilen gelişmiş makine öğrenmesi (Machine Learning - ML) algoritmalarına dayanmaktadır (Lin, 2025).

Tüketici Davranışı Tahminlemede CatBoost ve XGBoost'un Üstünlüğü

E-ticaret ekosisteminde kârlılığın altın kuralı, kullanıcının siteyi ziyaret ettiği anki dijital ayak izlerine bakarak "satın alma niyetini" (purchase intention) veya "sepeti terk etme olasılığını" (churn rate) milisaniyeler içinde tahmin edebilmektir. Literatürde, makine öğrenmesi algoritmalarının bu amaçla kullanımına dair çok sayıda kuramsal ve ampirik çalışma bulunmaktadır. Lin (2025) tarafından yapılan kapsamlı ampirik araştırma, e-ticaret alanında tüketici davranışlarını öngörmede kullanılan sınıflandırma algoritmalarının performansını olağanüstü bir netlikle ortaya koymuştur (Lin, 2025).

Söz konusu çalışmada, UCI Makine Öğrenmesi Kütüphanesi'nden alınan ve 12.330 bağımsız kullanıcı oturumunu içeren (sayfa görüntüleme sayıları, sitede kalma süreleri, çıkış oranları, hemen çıkma oranları gibi 10 sayısal ve 8 kategorik özellik barındıran) büyük ölçekli bir e-ticaret veri seti üzerinde dört farklı model test edilmiştir: Destek Vektör Makineleri (SVM), Geri Yayılımlı Yapay Sinir Ağları (BPANN), Aşırı Gradyan Güçlendirme (XGBoost) ve Kategorik Gradyan Güçlendirme (CatBoost) (Lin, 2025).

Modellerin sınıflandırma performansını ölçmede standart bir istatistiksel metrik olan ROC_AUC (Alıcı İşletim Karakteristiği Eğrisi Altında Kalan Alan) skoru ve F1 Skoru ($F_1 = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$) kullanılmıştır. ROC_AUC değerinin 1.0 olması, modelin satın alacak müşteri ile almayacak müşteriyi %100 kusursuzlukla ayırt edebildiğini gösterir (Lin, 2025).

Analiz sonuçları, karar ağaçlarına (decision trees) dayalı topluluk öğrenme (ensemble learning) yöntemleri olan CatBoost ve XGBoost'un, karmaşık kategorik özellikleri ve büyük ölçekli verileri işlemede geleneksel algoritmalara karşı ezici bir üstünlük sağladığını kanıtlamıştır (Lin, 2025).

- **CatBoost**, 0.985 gibi pazarlama literatüründe eşine az rastlanır bir ROC_AUC skoruna ve %93 F1 skoruna ulaşarak en yüksek öngörü gücünü ve doğruluk oranını sergilemiştir (Lin, 2025). CatBoost'un en büyük avantajı, e-ticaret verilerinde sıklıkla rastlanan yapılandırılmamış kategorik özellikleri dönüştürmeye gerek kalmadan doğrudan işleyebilmesi ve gürültülü veriye (noisy data) karşı yüksek bağışıklık göstermesidir (Lin, 2025).
- **XGBoost** ise %92 F1 skoru ve 0.984 ROC_AUC değeri ile benzer şekilde mükemmele yakın bir performans göstermiştir (Lin, 2025).
- Buna karşılık, geleneksel bir istatistiksel öğrenme modeli olan **SVM**, küçük ölçekli veri setlerinde kabul edilebilir bir doğruluk sunsa da, verinin boyutu ve boyutsallığı arttığında işlem hızı ve geri çağırma (recall) oranlarında ciddi performans kayıpları yaşamıştır (Lin, 2025). **BPANN** (Yapay Sinir Ağı) ise aşırı parametre ayarı (hyperparameter tuning) gereksinimi ve lokal minimumlara takılma riski nedeniyle ağaç tabanlı modellerin gerisinde kalmıştır (Lin, 2025).

Tablo 2: Hassas Pazarlamada Tüketici Niyeti Tahmin Modellerinin Performans Kıyaslaması (Lin, 2025 temel alınarak)

Algoritma Tipi	Temel Mekanizma	ROC_AUC Skoru	F1 Skoru	Ölçeklenebilirlik / Verimlilik Özeti
CatBoost	Kategorik Gradyan Güçlendirme Ağaçları	**0.985**	**0.93**	Kategorik değişkenlerde üstün. Karmaşık e-ticaret verisinde aşırı öğrenmeyi (overfitting) başarıyla engeller.
XGBoost	Aşırı Gradyan Güçlendirme Ağaçları	0.984	0.92	Çok yüksek işlem hızı. Ancak optimum performans için detaylı hiper-parametre optimizasyonu (Grid Search) gerektirir.
SVM	Destek Vektör Sınıflandırması	Düşük	Düşük	Dar ölçekli, spesifik segmentasyonlarda etkili. Büyük ve dinamik veri akışlarında hantallaşır.
BPANN	Geri Yayılımlı Yapay Sinir Ağı	Dalgalı	Dalgalı	Derin örüntüleri bulabilir ancak aşırı veri gerektirir. Kara kutu (black box) yapısı, pazarlama ekipleri için yorumlanabilirliği zorlaştırır.

Özellik Önemliliği (Feature Importance) ve Stratejik Aksiyonlar

Yapay zeka modellerinin pazarlamacılara sunduğu en büyük değer, sadece satın alma niyetini tahmin etmeleri değil, aynı zamanda "Özellik Önemliliği" (Feature Importance) analizleri sayesinde hangi davranışın satın almayı tetiklediğini açıkça göstermeleridir. CatBoost algoritmasının yorumlanabilir çıktılarında, tüketici kararını etkileyen en ağırlıklı değişkenlerin **Sayfa Görüntüleme Sayısı (Page Views - PV)**, **İdari sayfa ziyaretleri (Administrative pages)** ve **Sayfada Kalma Süresi (Residence Time)** olduğu saptanmıştır (Lin, 2025).

Bu ampirik bulgular, doğrudan pazarlama kararlarına (actionable insights) dönüştürülebilmektedir. İşletmeler, CatBoost'un anlık tahminleri doğrultusunda "Dinamik Fiyatlandırma" (Dynamic Pricing) stratejileri uygulayabilir (Lin, 2025). Örneğin, yüksek satın alma ihtimaline sahip (fakat o an için kararsız kalmış) bir kullanıcı, belirli bir sayfada eşik süresinden daha uzun süre kaldığında, modelin tetiklemesiyle sistem otomatik olarak kullanıcıya "Zamana Bağlı Kişiselleştirilmiş İndirim Kodu" sunabilir. Literatür, e-ticaret tavsiye sistemlerine (recommendation systems) entegre edilen bu tür yüksek doğruluklu algoritmaların, kişiselleştirilmiş reklam dönüşüm oranlarını %30 oranında, genel kullanıcı etkileşimini ise %20-30 aralığında artırabildiğini raporlamaktadır (Lin, 2025). Gelecek vizyonunda bu algoritmaların, yorumlar ve görseller gibi yapılandırılmamış (unstructured) sosyal medya verilerini analiz edebilen Transformer tabanlı derin öğrenme modelleriyle desteklenmesi beklenmektedir (Lin, 2025).

Etik Veri Yönetişimi, Şeffaflık ve Güven Mimarisi (Trust Architecture)

Büyük veri analitiği ve hassas pazarlama algoritmalarının sağladığı devasa güç, pazarlama disiplininde derin bir paradoks yaratmıştır: Hiper-kişiselleştirme, tüketicilere mükemmel hedonik deneyimler ve pratiklik sunarken; aynı zamanda devasa ölçekte tüketici verisinin izlenmesine, toplanmasına ve işlenmesine dayanmaktadır. Tüketiciler, dijital ayak izlerinin her platformda takip edilerek 4S davranışlarının mikroskobik düzeyde haritalandığını fark ettikçe, markalara karşı "mahremiyet endişesi" ve defansif bir tutum geliştirmektedir.

Güncel araştırmalar, yapay zeka entegreli pazarlama analitiğinin sürdürülebilirliğinin, tamamen tüketici güvenine (consumer trust) bağlı olduğunu göstermektedir. Tüketicilerin %77'si, markaların yapay zeka algoritmalarını nasıl kullandıkları ve kişisel verileri nasıl işledikleri konusunda radikal bir şeffaflık (transparency) ve açıklanabilirlik (explainability) talep etmektedir (ISACA, 2024). Tam bu noktada, salt algoritmik güç, sürdürülebilir rekabet avantajı (SCA)

sağlamak için yetersiz kalmakta; teknolojik hassasiyetin etik değerlerle dengelendiği bir "Güven Mimarisi" (Trust Architecture) inşa etme zorunluluğu doğmaktadır (ISACA, 2024).

Pazarlamada Sıfır Güven Mimarisi (Zero Trust Architecture - ZTA)

Başlangıçta Amerikan Ulusal Standartlar ve Teknoloji Enstitüsü (NIST) gibi kurumlar tarafından siber güvenlik alanında, bulut ağlarını korumak amacıyla geliştirilen "Sıfır Güven Mimarisi" (Zero Trust Architecture - ZTA), günümüzde dijital pazarlama ve işletme stratejilerinin temel bir etik yönetişim çerçevesine dönüşmüştür (Afolabi vd., 2021). Sıfır Güven yaklaşımı, "asla güvenme, her zaman doğrula" (never trust, always verify) önermesine dayanır (Afolabi vd., 2021). Geleneksel olarak, iç ağda (perimetrenin içinde) olan her kullanıcı ve cihaza güvenilirken, ZTA modelinde ister çalışan, ister pazarlama algoritması, isterse üçüncü parti bir analitik yazılımı olsun, tüketici verisine erişmek isteyen her talep, bağlam ve niyet bazında sürekli olarak denetlenir ve doğrulanır (Afolabi vd., 2021).

Pazarlama departmanları açısından ZTA'nın entegrasyonu, tüketici verisinin (finansal geçmiş, davranışsal kohort profilleri, konum vb.) departmanlar veya ajanslar arasında kontrolsüz dolaşımını engeller. Bu durum, Genel Veri Koruma Yönetmeliği (GDPR) ve Kaliforniya Tüketici Gizliliği Yasası (CCPA) gibi sert düzenlemelere tam uyum (compliance) sağlarken, olası veri ihlali skandallarını ve devasa hukuki yaptırımları minimize eder (Afolabi vd., 2021).

Güven Mimarisi Çerçevesi (Trust Architecture Framework - TAF)

Sadece teknik bir siber güvenlik önlemi olmanın ötesinde, güvenin tüketici zihninde psikolojik olarak nasıl inşa edildiğini açıklayan "Güven Mimarisi Çerçevesi" (TAF), pazarlama stratejilerinde paradigma değişikliği yaratır. TAF, dijital platformlarda güveni basit bir kişisel inanç, rastgele bir marka sevgisi veya tüketicinin lütfettiği bir tutum olarak görmez. Aksine güven; platformun kasıtlı, stratejik ve sistemsel olarak mühendisliğini yaptığı bir "davranışsal ortam" (deliberately engineered behavioral environment) olarak tanımlanır (ISACA, 2024).

Güven Mimarisi; hesap verebilirlik, veri bütünlüğü (data integrity), tarafsız algoritmalar (bias avoidance) ve kullanıcı güçlendirmesi (user empowerment) unsurlarından oluşan entegre bir yapıdır (ISACA, 2024). Markanın sürdürülebilir bir bağlılık yaratabilmesi için "Platform Güven Motoru" adını verdiğimiz yapısal manipülasyon mekanizmalarını etik sınırlar içinde kurması gerekir (ISACA, 2024). Kullanıcıya, hangi verisinin (hangi 'S' eylemi sırasında) neden toplandığının şeffafça bildirilmesi, algoritmanın neden kendisine belirli bir ürünü tavsiye ettiğinin basitçe açıklanması ve kullanıcıya dilediği an veriyi silme kontrolünün verilmesi, dijital güvenilirliğin (digital trustworthiness) temel taşlarıdır (ISACA, 2024). Veri şeffaflığı ve dürüstlük, Sürdürülebilir Rekabet Avantajının görünmez ancak en sağlam yapıtaşıdır (ISACA, 2024).

Organizasyonel Çeviklik ve Müşteri Odaklı İş Modeli (CBM)

Tüketicinin 4S (İzleme, Kaydırma, Arama, Alışveriş) davranışsal akışkanlığı, makine öğrenmesi modellerinin (CatBoost/XGBoost) saniyelik içgörüleri ve etik veri yönetişimi zorunluluğu, işletmelerin organizasyonel altyapılarında devrimsel bir revizyonu zorunlu kılmaktadır. Teorik olarak dünyanın en iyi pazarlama stratejisine ve yapay zekasına sahip bir organizasyon, eğer operasyonel düzeyde (iç işleyişinde) hantal ve bürokratik bir yapıya sahipse, sahada başarısız olmaya mahkumdur (McKinsey & Company, 2024).

Geleneksel hiyerarşik organizasyonlarda satış, pazarlama, Ar-Ge, BT (Bilgi Teknolojileri) ve tedarik zinciri gibi departmanlar katı "silolar" halinde çalışmaktadır. Bu silolaşma, departmanların kendi dar KPI'larına (Temel Performans Göstergeleri) odaklanmasına, verilerin parçalanmasına ve müşterinin bütüncül deneyiminin gözden kaçırılmasına neden olur (McKinsey & Company, 2024).

Oysa günümüzde dijital pazarlama, organizasyonun tüm birimlerini yatay olarak kesen entegre bir eylemler bütünüdür.

McKinsey Müşteri Odaklı İş Modeli (Customer-Back Business Model)

Bu yapısal darboğazı aşmak adına, strateji ve yönetim danışmanlığı firması McKinsey & Company, organizasyonları temelden dönüştüren çevik bir çerçeve olarak "Müşteri Odaklı İş Modeli"ni (Customer-Back Business Model - CBM) literatüre kazandırmıştır (McKinsey & Company, 2024). CBM, kurumsal iş süreçlerini ve teknolojik yatırımları, departmanların iç işleyiş kolaylığına göre değil; tamamen "tüketicinin yaşadığı uçtan uca yolculuğun" (end-to-end customer journey) ihtiyaçlarına göre baştan tasarlayan pragmatik bir modeldir (McKinsey & Company, 2024).

CBM, dört ana sütun üzerinde yükselir: Müşteri merkezlilik (Customer-centered), stratejik iş hedeflerine dönüklük (Business-focused/back), insan odaklılık (People-led) ve yapay zeka destekli altyapı (AI-enabled) (McKinsey & Company, 2024). Geleneksel ve devasa BT revizyon projelerinin yıllar süren ve yüksek risk barındıran doğasının aksine, CBM üç aşamalı, hızlı ve "kendi kendini finanse eden" (self-funding) bir yol haritası sunar (McKinsey & Company, 2024):

1. **İddialı ve Ortak Bir Vizyon Belirleme:** Üst yönetimin çapraz fonksiyonel katılımıyla (CEO, CMO, CIO ortaklığı), siloları yıkarak tüm şirketi müşteri deneyimini endüstri standartlarının ötesine taşımaya odaklayan net bir vizyon tanımlanır.

2. **Kısa Vadeli Çapraz Fonksiyonel İnisiyatiflerin Önceliklendirilmesi:** İlk 6 ay içinde ölçülebilir finansal etki (ROI) yaratacak belirli yapay zeka veya dijital kullanım senaryoları hayata geçirilir. Buradan sağlanan operasyonel kâr (cash flow), projenin devamı olan eski altyapıların (legacy systems) modernizasyonunda ve yeni yeteneklerin istihdamında kaynak olarak kullanılır (McKinsey & Company, 2024).

3. **Hızlı Geliştirme ve Ölçeklendirme:** İş birimleri, pazarlamacılar, veri bilimciler ve mühendislerden oluşan 8-10 kişilik küçük entegre ekipler (squads), aylar yerine sadece 3 ila 5 ay içerisinde sahada test edilebilir Asgari Uygulanabilir Ürünler (Minimum Viable Product - MVP) geliştirir (McKinsey & Company, 2024).

Arz-Talep Dengelemesinde %80 Zaman Tasarrufu ve Çevik Performans

CBM modelinin, dijital pazarlama bağlamında yarattığı en büyük mucize, organizasyonun "dinamik pazarlama yeteneğini" (dynamic marketing capability) kusursuzlaştırmasıdır (McKinsey & Company, 2024). McKinsey'in yayımladığı gerçek bir vaka analizi, bu entegrasyonun gücünü somutlaştırmaktadır. CBM modelini benimseyen büyük ölçekli bir endüstri firması, fonksiyonel liderlerin kendi silolarında hazırladığı tutarsız tahmin raporları yerine, makine öğrenmesi algoritmalarının beslediği "Uçtan Uca (End-to-End) Talep Algılama" (Sensing Demand) yeteneğini devreye almıştır (McKinsey & Company, 2024).

Firma, donanımlarından ve müşteri etkileşimlerinden gelen anlık verileri tek bir havuzda toplayarak, tüketicinin yedek parça, servis veya yeni ürün ihtiyacını (4S'nin Arama veya Alışveriş aşamasında) eşzamanlı olarak tahmin edip bu bilgiyi anında üretim ve tedarik zinciri planlamasına entegre etmiştir (McKinsey & Company, 2024). Sonuç olarak, geleneksel yapılarda haftalar sürebilen **arz ve talep dengeleme (supply and demand balancing) operasyonlarını tamamlama süresinde %80 oranında muazzam bir azalma (iyileşme)** kaydedilmiştir (McKinsey & Company, 2024). Ekiplerin katma değersiz (non-value-add) manuel iş yükleri %80 oranında ortadan kalkmış, müşteri elde tutma (retention) oranları %5-10 bandında artarken, işletme milyarlarca dolarlık kâr (EBIT) artışı elde etmiştir (McKinsey & Company, 2024).

Bu inanılmaz hız ve koordinasyonu operasyonel kılmanın yegâne yolu, departmanların **Çevik (Agile)** çalışma felsefesini benimsemesidir. Yazılım geliştirme dünyasından pazarlamaya transfer

edilen; işlerin kısa iterasyonlara bölündüğü *Scrum*, darboğazların görsel bir panoda yönetildiği *Kanban* ve esneklikle yapıyı birleştiren *Scrumban* çerçeveleri, CBM'nin kalbinde yer alır (Alghamdi & Agag, 2024; McKinsey & Company, 2024). Literatür, pazarlama stratejilerini pazar dalgalanmalarına göre anında revize eden (marketing agility) işletmelerin, bu yıkıcı ortamda dahi sürdürülebilir rekabet avantajını garantilediklerini göstermektedir (Alghamdi & Agag, 2024).

Sonuç

Modern tüketimin dijital mimarisi, yalnızca teknolojik araçların bir araya gelmesinden ibaret mekanik bir yapı değil; tüketici psikolojisi, ileri düzey veri bilimleri, etik felsefe ve organizasyonel esnekliğin eşine az rastlanır bir senfonisidir. Gerçekleştirilen bu derinlemesine kuramsal ve ampirik inceleme, pazarlama biliminin doğasının geri döndürülemez biçimde dönüştüğünü kanıtlamaktadır.

Tüketicinin rasyonel faydadan ziyade estetik ve oyunlaştırılmış bir "hedonik tatmin" arayışında olması, dijital mecralardaki rekabetin kurallarını yeniden yazmıştır. Bu arayış, doğrusal ve öngörülebilir huni modelini parçalayarak, tüketicinin aynı anda video izlediği (Streaming), ekran kaydırdığı (Scrolling), arama yaptığı (Searching) ve alışveriş eyleminde bulunduğu (Shopping) çok boyutlu "4S Davranış Çerçevesini" doğurmuştur.

Bu öngörülemez akışkanlığı kâra dönüştürmenin yegane yolu algoritmik güçtür. Literatürde CatBoost ve XGBoost gibi karar ağacı tabanlı topluluk modellerinin, yüksek boyutlu e-ticaret verisinde sergilediği 0.985 gibi olağanüstü ROC AUC doğruluk seviyeleri, yapay zekanın "hassas pazarlama" yeteneklerinin ulaştığı bilimsel zirveyi temsil etmektedir. Bu sayede sayfada geçirilen süre (residence time) ve tıklama sıklığı (page views) gibi basit metrikler, dinamik fiyatlandırma veya kişiselleştirilmiş kampanya sunan devasa stratejik karar motorlarına dönüşebilmektedir.

Bununla birlikte, hiçbir teknolojik güç ahlaki bir temele dayanmadan uzun vadeli varlığını sürdüremez. Tüketicilerin mahremiyet beklentilerinin en üst düzeye ulaştığı bir dönemde; Sıfır Güven Mimarisi (ZTA) ve Güven Mimarisi Çerçevesi (TAF) ile şekillenen şeffaf, hesap verebilir, regülasyonlara uyumlu (GDPR/CCPA) bir etik veri yönetişimi, markanın en değerli entelektüel sermayesidir.

Son olarak, bu devasa dijital mekanizmanın işletme içinde çalışabilmesi, McKinsey'in Müşteri Odaklı İş Modeli (CBM) ve Scrum/Kanban tabanlı çevik yapılar ile mümkündür. İzolasyonist departmanları yıkarak oluşturulan çapraz fonksiyonel takımlar, kurumun çevikliğini artırarak arz ve talep dengelenmesinde sağlanan %80'lik muazzam zaman tasarrufu örneğinde olduğu gibi, işletmeye benzersiz bir reaksiyon yeteneği kazandırmaktadır.

Gelecekte, bu bileşenleri sentezlemeyi başarabilen işletmeler dijital pazarın hâkimleri olurken; veri denizinde boğulan, hiyerarşik silolarında sıkışan ve tüketicisine şeffaf bir etik sözleşme sunamayan organizasyonlar, 4S döngüsünün görünmezlik boşluğuna itileceklerdir.

Kaynakça

- Afolabi, A. I., Austin-Gabriel, B., Hussain, N. Y., Ige, A. B., Adepoju, P. A., & Amoo, O. O. (2021). Advancing zero trust architecture with AI and data science for enterprise cybersecurity frameworks. *Open Access Research Journal of Engineering and Technology*, 1(1), 47-55. https://www.allmultidisciplinaryjournal.com/uploads/archives/20250624190935_MGE-2025-3-373.1.pdf

- Alghamdi, A., & Agag, G. (2024). Marketing agility and competitive advantage. *Administrative Sciences*, 14(6), 112. https://doi.org/10.3390/admsci14060112
- Batra, R., & Ahtola, O. T. (1991). Measuring the hedonic and utilitarian sources of consumer attitudes. *Marketing Letters*, 2(2), 159-170.(https://doi.org/10.1007/BF00436035)
- Boston Consulting Group. (2025). *Move beyond the linear funnel*. BCG Insights. https://www.bcg.com/publications/2025/move-beyond-the-linear-funnel
- Google & Boston Consulting Group. (2025). *Consumer journeys have changed: Find out how the 4S behaviors can redefine your marketing*. Think with Google. https://business.google.com/us/think/consumer-insights/new-consumer-decision-making-process/
- ISACA. (2024). *Using DTEF to achieve trustworthy AI*. ISACA White Paper. https://www.isaca.org/resources/white-papers/2024/using-dtef-to-achieve-trustworthy-ai
- Li, H., Liu, Y., Xu, X., Heikkilä, J., & Van Der Heijden, H. (2015). Modeling hedonic is continuance through the uses and gratifications theory: An empirical study in online games. *Computers in Human Behavior*, 48, 261-272. https://doi.org/10.1016/j.chb.2015.01.053
- Lin, J. (2025). Application of machine learning in predicting consumer behavior and precision marketing. *PLoS ONE*, 20(5), e0321854. https://doi.org/10.1371/journal.pone.0321854
- McKinsey & Company. (2024). *True customer-centricity: An operating model for competitive advantage*. https://www.mckinsey.com/industries/industrials/our-insights/true-customer-centricity-an-operating-model-for-competitive-advantage
- Sookbumroong, P., & Phornlaphatrachakorn, K. (2023). New product development capability, sustainable competitive advantage, digital transformation, and marketing performance. *International Journal of Business*, 28(4).(https://doi.org/10.55802/IJB.028(4).003)

THE PANOPTICON IN PSYCHIATRIC NURSING: SURVEILLANCE, POWER AND TRANSFORMATION CARE

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ABSTRACT

The concept of the Panopticon, originally proposed by Jeremy Bentham and later theorized by Michel Foucault, has been widely used to explain modern forms of surveillance, discipline, and power within institutional settings. Psychiatric clinics, particularly inpatient and closed psychiatric wards, represent environments in which surveillance is both a therapeutic necessity and a mechanism of control. Within these settings, psychiatric nursing occupies a central position, simultaneously embodying roles of care, observation, and regulation. This review aims to examine the relevance of the Panopticon concept to psychiatric nursing practices and to explore how surveillance and power relations contribute to the transformation of care. Drawing on Foucauldian theory and existing literature from psychiatry, nursing, and social sciences, this paper analyzes the structural and procedural characteristics of psychiatric care environments, including constant observation practices, architectural design, documentation systems, and institutional routines. These elements are discussed as panoptic mechanisms that shape both patient behavior and nursing practice. The analysis highlights how continuous visibility and internalized surveillance influence patients' self-regulation, compliance, and identity formation, while simultaneously positioning nurses as agents within a system of disciplinary power. From a psychiatric nursing perspective, the dual role of providing therapeutic care while enforcing institutional norms creates inherent tensions between caregiving and control. Surveillance practices, although often justified by safety concerns and risk management, may unintentionally transform care into a form of governance that prioritizes discipline over autonomy and relational engagement. This transformation has significant ethical implications, particularly regarding patient dignity, privacy, and the therapeutic nurse–patient relationship.

The review concludes that the panoptic nature of psychiatric settings does not solely reflect oppressive control but represents a complex intersection of care, safety, and power. Recognizing these dynamics can support psychiatric nurses in developing a more reflective and ethically informed practice. Increased awareness of surveillance mechanisms may enable nurses to balance institutional demands with human-centered care approaches, ultimately contributing to more transparent, ethical, and recovery-oriented psychiatric nursing practices.

Keywords: Panopticon, Psychiatric Nursing, Surveillance, Power, Ethical Care.

Introduction

The Panopticon was originally conceptualised by Jeremy Bentham as an architectural design enabling constant observation without mutual visibility, thereby ensuring organisational control through the possibility of surveillance (Foucault, 1977). Foucault extended this idea beyond prison

architecture to describe "panopticism" as a form of disciplinary power in modern institutional contexts, in which individuals internalise the gaze of authority and self-regulate their behaviour (Foucault, 1977). In this Foucauldian framing, disciplinary mechanisms operate not only through physical structures, but through routines, documentation, and perceptual regimes that normalise observation as a means of governance.

In psychiatric care environments, particularly closed and inpatient wards, surveillance practices are integral to clinical routines. Observational techniques — including direct visual observation, risk assessment check-ins, and monitoring technologies — are routinely implemented to ensure patient safety, detect behavioural changes, and prevent harm (Simpson et al., 2023). Research on surveillance technologies in mental health settings indicates that the increasing deployment of CCTV, body-worn cameras, and digital monitoring systems has complex effects on both staff and patients, raising ethical considerations regarding privacy, dignity, and the extent to which such measures achieve their intended safety outcomes (Griffiths et al., 2024).

From the perspective of psychiatric nursing, surveillance constitutes both a clinical tool and a site of power relations. Observation and documentation practices are among the core functions of nursing in inpatient mental health services; these practices shape nurses' professional responsibilities and influence patient experiences of care (Shetty et al., 2024). The tension between therapeutic engagement and continual observation reveals that surveillance is not merely a safety measure, but a structural force that contributes to the shaping of patient behaviour and nurse–patient dynamics.

Existing conceptual work has begun to apply panoptic theory to health care contexts. For instance, Dillard-Wright (2019) identified how electronic documentation systems function as panoptic apparatuses that produce disciplinary effects on nursing practice by structuring visibility and accountability. Simultaneously, broader critiques of mental health surveillance technologies emphasise the need to centre patients', staff's, and carers' experiences to fully understand the benefits and harms of surveillance measures in practice (Griffiths et al., 2024). These perspectives suggest that the logic of surveillance in psychiatric settings is not solely about control, but is deeply interwoven with clinical norms, safety rationales, and professional identities.

This review situates psychiatric nursing practices within the framework of panopticism, analysing how surveillance and power relations are embedded in contemporary psychiatric care. It aims to elucidate how continuous observation influences patient self-regulation, professional roles, and the ethical landscape of mental health nursing.

The Concept and History of the Panopticon

The Panopticon was first conceptualized by Jeremy Bentham in the late 18th century as a design for prisons that allowed a single observer to monitor all inmates without being seen (Bentham, 1787/1995). The architectural arrangement — a circular building with a central observation tower surrounded by cells — created a structural mechanism where visibility itself functioned as a form of control. The key innovation of the Panopticon was that inmates would internalize the possibility of being observed at any time, thereby regulating their own behavior even without direct intervention. This design was intended to maximize surveillance efficiency while minimizing the resources and staff required for oversight (Bentham, 1787/1995).

Building on Bentham's architectural concept, Michel Foucault (1977) extended the idea of the Panopticon into a broader social and theoretical framework. Foucault introduced the concept of *panopticism* to describe how modern institutions employ observation, documentation, and routines as mechanisms of power. According to Foucault, panoptic structures do not merely restrict behavior through overt control but operate through internalized surveillance, producing what he

called “docile bodies” — individuals who regulate their own actions because they know they may be watched.

In modern applications, the Panopticon has transcended its original prison design to become a metaphor for surveillance in hospitals, schools, workplaces, and other institutional settings (Dillard-Wright, 2019; Griffiths et al., 2024). In healthcare, and particularly in psychiatric nursing, the concept is useful for understanding how observation practices, both physical and procedural, shape patient behavior and influence professional roles. The logic of continuous visibility embedded in institutional design and routines demonstrates that control and care are not mutually exclusive but intertwined within structured environments (Simpson, 2023).

Thus, the historical evolution of the Panopticon — from Bentham’s architectural blueprint to Foucault’s theoretical construct — provides a framework for analyzing how power, surveillance, and self-regulation operate in psychiatric care settings. This conceptual foundation supports a deeper understanding of how observation practices influence both patient experiences and nursing interventions, highlighting the ethical and professional implications of living and working under constant visibility.

The Impact of the Panopticon on Psychiatric Nursing

The Panopticon as a theoretical construct helps illuminate how surveillance is embedded in psychiatric care practices. Although originally proposed as a physical architectural design for prisons, its metaphoric use in health care highlights how observation and control become interwoven with everyday clinical routines. In inpatient mental health settings, surveillance is not limited to occasional checks but often permeates the environment through structured observation practices and the spatial organisation of care (Griffiths et al., 2024).

Recent systematic reviews demonstrate that surveillance technologies — such as CCTV, vision-based monitoring, and wearable sensors — are increasingly implemented in psychiatric wards with the stated intent of enhancing patient safety (e.g., reducing self-harm and violent incidents). However, evidence regarding their effectiveness remains mixed, with ethical concerns about privacy, dignity, and clinical benefit frequently highlighted (Griffiths et al., 2024).

Beyond technologies, the daily practices of mental health nurses themselves reflect panoptic dynamics. Nurses routinely engage in observation, documentation, and risk assessment as central parts of their role. These activities function not merely as safety measures but as forms of ongoing surveillance that shape both patient behaviour and nursing practice (Salzmann-Erikson & Eriksson, 2012). In their analysis of mental health nursing spaces, researchers found that the physical environments where patients are observed — whether patient-designated, staff-designated, or neutral spaces — produce different intensities of visibility and control. Most areas of inpatient settings, they concluded, inherently serve as fields of visibility where patients are watched and categorized (Salzmann-Erikson & Eriksson, 2012).

These observation practices extend to relational dynamics. Staff perform hierarchical observation not only as a clinical task but as part of shaping normative behaviour patterns, often blurring the line between therapeutic monitoring and disciplinary control. While surveillance can indeed identify and mitigate immediate safety risks, it can also reinforce a sense of constant oversight and limit opportunities for patient autonomy (Akinlotan & Dumitriu, 2025).

Furthermore, contemporary research on psychiatric nursing highlights that the emotional and professional experiences of nurses are also shaped by these surveillance regimes. Studies examining staff perspectives on safety note that nurses balance the ethical imperative of compassionate care with the procedural demands of continual observation, often encountering

emotional strain and moral tension in prioritising protection over relational engagement (Akinlotan & Dumitriu, 2025; Keykha et al., 2025).

In summary, the Panopticon's metaphoric extension into psychiatric nursing reveals how surveillance is embedded in everyday care practices, affecting spatial organisation, professional roles, and ethical decision-making. Observation in these settings is not a neutral clinical tool but part of a broader disciplinary logic that shapes interactions between patients and nurses and influences the culture of care.

Internalized Surveillance and its Effects on the Patient

Surveillance within psychiatric settings not only serves clinical safety objectives but also has significant psychological and behavioural effects on patients. Research indicates that mental health patients frequently internalize the knowledge of being observed, which can lead to *self-regulation* and changes in behaviour. This internalized surveillance is not unique to psychiatric wards, but it appears particularly salient in settings characterized by continuous monitoring and structured routines. In a comparison of internalized stigma levels, psychiatric inpatients reported significantly higher stigma — an outcome closely associated with feelings of being watched, judged, or controlled — compared with outpatients (Görmez et al., 2025).

Internalized stigma is an important psychological consequence that can shape patients' self-perceptions and engagement with care. Patients with higher levels of internalized stigma may withdraw socially, adopt negative self-views, or feel a loss of agency, all of which can affect therapeutic rapport and recovery (Özdemir et al., 2025). While not exclusively a result of surveillance practices, this internalized experience is reinforced by the constant visibility and structured accountability characteristic of psychiatric care environments, where patients are aware that their behaviour and compliance are continuously tracked.

Qualitative research on psychiatric inpatients' experiences also highlights how the therapeutic environment itself — including observation practices — influences emotional responses. Patients often describe the ward atmosphere as both reassuring and intrusive: while surveillance can contribute to feelings of safety, it can also exacerbate anxiety, particularly when privacy is limited or when patients feel their autonomy is diminished (Işık et al., 2021).

In addition to psychological stigma and behavioral adjustment, the perception of constant observation may affect patient participation in care. Patients who perceive surveillance as overly controlling may be less likely to actively engage in therapeutic activities or to voice concerns, potentially limiting the effectiveness of clinical interventions. For some, the panoptic experience can create a sense of passivity rather than empowerment, where behaviour is guided more by a desire to conform to expected norms than by intrinsic motivation toward recovery. These dynamics underscore the importance of understanding surveillance not merely as a clinical safety measure but as a relational and psychological factor that shapes the lived experience of patients in psychiatric settings. Internalized surveillance may have profound implications for autonomy, dignity, and the therapeutic alliance between patients and clinicians.

Balance Regarding Ethical Aspects and Oversight

Surveillance in psychiatric nursing presents a fundamental ethical challenge, as nurses must balance patient safety with respect for autonomy, privacy, and dignity. While observation is crucial to prevent self-harm, aggression, or medical emergencies, excessive or poorly managed surveillance can undermine trust and the therapeutic relationship (Akinlotan & Dumitriu, 2025).

The ethical tension arises from the dual nature of psychiatric care: ensuring protection while fostering empowerment and recovery-oriented practices.

Recent studies indicate that patients often perceive constant observation as intrusive or controlling, even when intended for safety purposes. This perception can exacerbate feelings of vulnerability and reduce engagement in care activities (Dunne et al., 2022). Ethical frameworks in psychiatric nursing emphasize that observation strategies should be proportionate, transparent, and context-sensitive, allowing patients to understand the purpose of monitoring and to retain a sense of agency in their care (Laureano l et al., 2024).

Nurses play a central role in navigating this ethical landscape. They must make real-time decisions about when to intensify observation, when to allow privacy, and how to communicate about safety measures in a way that minimizes harm while maximizing therapeutic benefit. Training programs increasingly emphasize ethical reflection, communication skills, and relational judgment to help nurses balance these competing demands (Revel et al., 2024).

Moreover, the physical and procedural design of psychiatric wards can either support or hinder ethical surveillance. For example, creating spaces that allow patients to be visible to staff without feeling constantly exposed can mitigate the negative effects of surveillance. Similarly, structured observation schedules and documentation practices should prioritize clinical necessity over rigid enforcement of institutional routines (Griffiths et al., 2024).

In essence, ethical psychiatric nursing requires recognizing that surveillance is not merely a technical or procedural activity but a moral practice. Balancing safety and autonomy, control and care, observation and dignity is central to fostering environments that are both secure and recovery-oriented. Reflective practice, staff training, and patient-centered ward design are key strategies to achieve this balance, ensuring that surveillance supports rather than undermines therapeutic goals.

The Contribution and Recommendations of the Panopticon Perspective to Nursing Practice

The application of panoptic theory to psychiatric nursing provides a comprehensive lens through which the interplay of surveillance, power, and care can be understood. Recognition of these dynamics enables nurses to reflect critically on their practice, particularly regarding how observation and documentation influence patient experiences, autonomy, and dignity. Awareness of panoptic mechanisms allows for intentional balancing between safety imperatives and recovery-oriented, patient-centered care (Laureano et al., 2024; Revel et al., 2024).

Nurses can leverage this understanding in several practical ways:

1. **Ethical Reflection and Decision-Making:** Incorporating reflective practice routines and ethical deliberation can help nurses evaluate when intensified observation is clinically necessary and when patient privacy can be respected (Revel et al., 2024).

2. **Patient-Centered Observation Strategies:** Adjusting observation methods to support autonomy — for example, transparent communication about monitoring purposes or allowing private time when safe — can reduce the psychological burden of constant surveillance (O'Reilly et al., 2020; Işık et al., 2021).

3. **Ward Design and Procedural Adjustments:** Spatial arrangements and structured routines should optimize visibility for safety while minimizing feelings of intrusion or disempowerment. Design interventions can include observation points that preserve privacy and create neutral spaces for patient-staff interaction (Salzmann-Erikson & Eriksson, 2012).

4. **Integration of Technology with Ethical Oversight:** While digital monitoring tools (CCTV, wearable sensors) provide additional safety, their implementation must be guided by ethical frameworks that prioritize patient dignity and engagement (Griffiths et al., 2024).

Overall, integrating panoptic theory into psychiatric nursing highlights that surveillance is not inherently negative; rather, it is a structural and relational component that, when applied thoughtfully, can support both safety and therapeutic outcomes. By consciously balancing care and control, nurses can foster environments that are secure, ethically responsible, and conducive to patient recovery.

REFERECES

Akinlotan, O., & Dumitriu, M. (2025). A Systematic Review of Staff Perspectives on Safety on Psychiatric Wards. *Nursing & Health Sciences*, *27*(4), e70270.

Bentham, J. (1995). The Panopticon; or, The Inspection House (1787), M. Bozovic, Ed.

Dillard-Wright, J. (2019). Electronic health record as a panopticon: A disciplinary apparatus in nursing practice. *Nursing philosophy*, *20*(2), e12239.

Dunne, J. P., Blackwell, E. K., Ursini, E., & Milliken, A. (2022). Ethical Issues in Psychiatric and Mental Health Care. In *Clinical Ethics Handbook for Nurses: Emphasizing Context, Communication and Collaboration* (pp. 175-203). Dordrecht: Springer Netherlands.

Foucault, M. (1977). Discipline and Punish: The Birth of the Prison. Pantheon Books. (Standard academic text on panopticism.)

Görmez, O., Hasançavuşoğlu, K., Koç, F. B., Üçer, A. F., Pulatlı, E., Demir, E., ... & Çolak, B. (2025). Comparison of Internalized Stigma Between Psychiatric Inpatients and Outpatients at a University Psychiatric Clinic. *Ankara Eğitim ve Araştırma Hastanesi Tıp Dergisi*, *58*(2), 81-84.

Griffiths, J. L., Saunders, K. R., Foye, U., Greenburgh, A., Regan, C., Cooper, R. E., ... & Simpson, A. (2024). The use and impact of surveillance-based technology initiatives in inpatient and acute mental health settings: a systematic review. *BMC Medicine*, *22*(1), 564.

Işık, I., Ergün, G., Dikeç, G., Ayaz, V., & Gültekin, B. K. (2021). Psychiatric inpatients' view of the therapeutic environment: A Turkish interview study. *Perspectives in Psychiatric Care*, *57*(3).

Keykha, R., Seyedfatemi, N., Mousavizadeh, S. N., & Vasli, P. (2025). Mental health nurses' experiences of caring for inpatients with severe mental disorders: a qualitative study. *BMC Psychiatry*, *25*(1), 621.

Laureano, C. D., Laranjeira, C., Querido, A., Dixe, M. A., & Rego, F. (2024, February). Ethical issues in clinical decision-making about involuntary psychiatric treatment: A scoping review. In *Healthcare* (Vol. 12, No. 4, p. 445). MDPI.

Özdemir, N., Kocamer Şahin, Ş., Özdemir Şiğva, F., & Türkmen, A. R. (2025). *Treatment-seeking methods, internalized stigma, and perceived social support levels of patients with mental disorders in different cultures: Comparison of Eastern and Western examples in Türkiye*. Nord J Psychiatry, 79(4), 288-296.

Revel, J., Deering, K., & Gallagher, A. (2024). Ethical aspects of technologies of surveillance in mental health inpatient settings–Enabling or undermining the therapeutic nurse/patient relationship?. *Nursing ethics*, *31*(7), 1175-1177.

Salzmann-Erikson, M., & Eriksson, H. (2012). Panoptic power and mental health Nursing—Space and surveillance in relation to staff, patients, and neutral places. *Issues in mental health nursing*, *33*(8), 500-504.

Shetty, S. R., Burke, S., Timmons, D., Kennedy, H. G., Tuohy, M., & Terkildsen, M. D. (2024). Patient perspective on observation methods used in seclusion room in an Irish forensic mental health setting: A qualitative study. *Journal of psychiatric and mental health nursing*, *31*(3), 393-404.

Simpson, A. (2023). Surveillance, CCTV and body-worn cameras in mental health care. *Journal of Mental Health*, *32*(2), 369-372.

THE REFLECTIONS OF CHANGING TECHNOLOGIES IN ANIMATION CINEMA ON FILM AESTHETICS

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ABSTRACT

From its origins to the present day, animation cinema has evolved through various stages and transformations to reach its current form. As it has evolved and expanded into different dimensions (such as digital animation and the use of VR), animated cinema has encountered new problems during this process, but the art of animation has also brought new solutions to these problems. When all these processes are considered from a comprehensive perspective, it can be said that one of the key factors determining these processes is technological developments in the field. The main issue of the study is how the technological changes in animation cinema from the past to the present have been reflected in film aesthetics and how they have determined it. In this direction, it will be attempted to determine how the different technologies used in the production stage of the film examples are effective in determining film aesthetics. Each of the film examples examined in this study also represents a different period. In this regard, examples will be selected from classic animation, 3D animation, and AI animation films. The examples selected for this study will be examined under headings such as visual style, movement aesthetics, space design, character design, and narrative aesthetics. Each technological change has brought about certain transformations in animation cinema. While classic animation features a more stylized, labor-intensive style, the transition to 3D digital animation has seen a shift towards a greater pursuit of realism, while still preserving the stylized approach. While the artist's style was more prominent in classic animation, it can be said that with the digital era, the artist's style has been pushed into the background. With artificial intelligence, we have entered an era where very different hybrid styles are possible and the originality of the artist's work is being questioned.

Keywords: Animation cinema, Aesthetics, Animation production techniques.

"THE REPORT": A SMALL TAP IN THE BIG REALM OF THE SERIO-COMICAL

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ABSTRACT

This paper focuses on the esthetic interaction between absurd, comedy, satire and tragedy, in the Syrian film *The Report* (*Al-Taqrir*, 1986) written by the late Muhammad Al-Maghut (scriptwriter, 1934-2006) & directed by Durayd Lahham (director, 1934-). The distinctive way in which the filmmakers combine these features has a significant role in directing the audience from the absurd to the catharsis of sublime emotions.

Carnivalesque humor within the Satire genre, play a major part in highlighting the paradoxical and "the ridiculous" absurdity in social and political life in Syria during the seventies and eighties of the twentieth century. By the satirical sharpening of the gap between what is desirable and what is found, filmmakers try to convince us to reject out of hand low standards and corrupted norms.

'Azmi Baik, the principled anti-hero, matches one of the most prominent carnivalesque characters as Bakhtin describes it when he refers to the polyphonic Novels of Fyodor Dostoevski. Especially, the total fusion of the character between personal life and worldview.

carnivalesque humor, even if progressively and indirectly, has a temporary comic release; an "emancipatory", "liberatory" and also perhaps occasionally a "revolutionary" function. However, because release is momentary, the absurd still "raises its head" approximately in every corner. Therefore, in order to liberate us from the absurd, filmmakers lead us to an uplifting path where in the last scene we arrive at the tragic catharsis once we reveal the horrifying consequences of the harsh confrontation between an innocent carnivalesque hero and a suspicious reality.

No doubt that this satiric film functions as a clear, direct and powerful condemnation of a corrupted regime. Yet, it is also a barefaced confession regarding the impotence of the struggle against injustice as long as it is only a lost combat of an isolated, decent, eccentric intellectual.

Keywords: Absurd, Bakhtin, Carnivalesque, Satire, Tragicomic.

THE SOCIAL SCHEMAS THEORY IN COMMUNICATION: NORMS, IDENTITY AND DISCOURSE

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ABSTRACT

How individuals make sense of, interpret, and act within the social world is an interdisciplinary research area spanning from cognitive psychology to communication studies. In this context, "schema" or "script" theory refers to pre-existing, organized knowledge structures in individuals' minds about specific situations, objects, or events. These social schemas inevitably determine the communication process on both the production and reception ends. This study aims to examine the central role of social schemas theory in communication studies. Schemas serve as mental guides for all kinds of social interactions, from going to a restaurant to attending a job interview, and shape our expectations, interpretations, and behaviors. In communication, these schemas are constantly reinforced, negotiated, or challenged through discourse. Media content, advertisements, and political discourse present powerful schemas about gender roles, professional identities, cultural norms, and family structures. For example, an advertisement reinforces the audience's mental schemas about these concepts by reproducing a specific script of the "ideal mother" or "successful businessperson." Simultaneously, individuals or groups who do not conform to these standard scripts face the risk of misunderstanding, stigmatization, or exclusion at the communicative level. The study will address the role of social schemas in intercultural communication conflicts, how stereotypes become persistent mental scripts, and how they guide individuals' identity construction processes. Effective communication is partly about understanding the social schemas possessed by the target audience and designing messages that appeal to these schemas. However, a critical communication perspective also necessitates asking the question of how oppressive or restrictive social schemas can be transformed.

Keywords: Social Schemas, Schema Theory, Communication, Social Norms, Identity Construction, Discourse Analysis, Gender Roles, Intercultural Communication, Stereotypes, Mental Models.

INTRODUCTION

Communication science is an interdisciplinary field that seeks to explain how human beings comprehend social reality, make sense of it, and act within that reality. For this reason, communication is too complex to be reduced to mere message transmission; it is a dynamic process continuously shaped by social norms, cultural codes, cognitive schemas, and discursive practices. When the individual encounters the social world, they do not perceive this world in its raw form; they make sense of it through mental models, categories, and cognitive frames. These cognitive structures are fundamental mechanisms that determine both the production and the reception of the communication process.

Schema, one of the basic concepts of cognitive psychology, refers to organized knowledge structures that the individual derives from their experiences. These structures include not only knowledge about objects or people, but also expectations regarding particular situations and how events will unfold. In this way, the individual can process events encountered in a complex social environment more quickly and develop appropriate behavioral strategies. However, schemas are not only facilitative; they also have a limiting, distorting, and stereotyping function. Because the schema places a filter on the individual's perception; it leads to the selection of some information and the ignoring of other information.

At this point, the concept of social scenarios (scripts) comes into play. According to Schank and Abelson's classic approach, social scenarios are cognitive structures that determine what will happen in a certain situation, who will assume which roles, and which behaviors will be considered appropriate. Mental structures such as the scenario of going to a restaurant, the exam scenario, the job interview scenario, and the family communication scenario are fed by patterns that repeat in daily life. For this reason, when the individual enters a restaurant, they know the role of the waiter, the order of giving the order, and the payment process; likewise, when they watch the news, they intuitively recognize the tone of the news presenter and the steps through which dramatization is constructed. This intuitiveness reveals the invisible but powerful nature of social scenarios.

From the perspective of communication science, the importance of social scenarios begins here. Because communication is not only the transmission of the message, but the scenario within which the message is read. A harsh sentence by a political leader can be interpreted completely differently by two groups with different scenarios. A slogan used in an advertisement may be perceived as inspiring or disturbing depending on cultural scenarios. A representation of gender may be considered "natural" in some cultures, while in another culture it may be found discriminatory and problematic. Therefore, social scenarios can be considered as the ground on which meaning is produced in communication.

Another basic question of communication studies is how social norms are transmitted and how social order is maintained. Social scenarios play a central role at this point. Because norms become concrete within scenarios. How to speak to elders, how women should behave, what masculinity is, and what a respectable individual should look like are not taught directly to children; these norms are internalized through repeated scenarios. For this reason, scenarios are not only cognitive but also cultural and ideological structures. Communication both contributes to these structures and reshapes them.

Media is the most prominent area of these reproduction processes. News discourse produces national identity scenarios; advertising discourse constructs consumption and body scenarios; series and films dramatize socially accepted scenarios of roles. Digital media, on the other hand, has created a new type of scenario: the performance-based digital self scenario. From Instagram biographies to TikTok videos, the digital field establishes a scenario that demands the individual constantly represent themselves, put themselves on display, and perform a viewable and measurable performance. This, combined with Zuboff's surveillance capitalism, Illouz's emotional capitalism, and Han's performance society concepts, makes the scenarized nature of modern communication even more visible.

The aim of this article is to examine social scenarios theory in depth in terms of communication science along three main axes:

Norms: How social norms produce an invisible order through scenarios, and why communicative conflicts emerge when they are violated.

Identity: That identity is in fact a "scenario performance"; that the individual is staged according to both cultural codes and discursive structures.

Discourse: How discourse produces, reinforces, and transforms scenarios; the scenario-producing power of media, politics, and digital culture.

This study uses social scenarios theory not only as an explanatory tool, but as a key to understand communicative power relations, invisible norms, and cultural pressure mechanisms. Despite the cognitive facilitation of scenarios, it is argued that they have the capacity to reproduce social inequalities and othering practices.

Scenarios are invisible frames that draw the boundaries of the self. For this reason, the critical communication approach questions not only how scenarios are constructed, but which scenarios serve whom, whom they leave out, and whose voice they render invisible. This article aims to offer a holistic perspective to communication studies by expanding social scenarios theory in this threefold context.

CHAPTER – THEORETICAL FRAMEWORK

The Cognitive Origins of Schemas and Scenarios

The theoretical framework of social scenarios theory in the field of communication is grounded in a wide range of disciplines extending from cognitive psychology to cultural studies and discourse analysis. The concept of schema derives from early cognitive psychology studies on how the individual makes sense of the world; Bartlett's approach, which argued that memory is a reconstructed process, reveals that the individual interprets past experiences through a cultural filter. This structure became more functional with the script theory developed by Schank and Abelson; it became understood that mental plotlines regarding what will happen in certain situations determine the individual's communicative behaviors. Scenarios are not only structures that organize knowledge; they make it possible for the individual to display fast, consistent, and socially accepted behaviors in social life. However, this speed often brings selectivity, and selectivity brings perceptual distortions; therefore, scenarios have a character that is both facilitative and restrictive.

The Scriptization of Cultural Codes and Norms

Culture is the strongest production area of these scenarios; because the individual learns social norms, relational roles, and emotional codes not through explicit instructions, but through repeated cultural scenarios. How roles such as "mother," "father," "leader," "student," and "citizen" should behave is not explicitly taught; the individual derives these roles from cultural scenarios. For this reason, culture does not only produce meaning; it is also a scenario mechanism that organizes, frames, and repeats that meaning. Norms are the invisible regulators of this mechanism. How an individual will speak in which environment, which emotion they should show in which situation, and which role they should assume in which relationship are embedded in cultural scenarios. Norm violation often creates communicative conflict; because not only a behavior breaks down, but also the expectation chain foreseen by the scenario is broken. Stereotypes are fixed scenarios in this context; these structures, which Lippmann defined as "mental shortcuts," become part of cultural reality through the constant repetition of the media and shape social perception deeply.

The Role of Discourse in Scenario Production

Discourse constitutes the linguistic and ideological face of this process. Discourse, defined within the framework of Foucault's knowledge–power relationship, is a mechanism that constructs reality, not just language; for this reason, discourse is both the source and carrier of scenarios. News discourse can produce threat scenarios, political discourse can establish national unity scenarios, advertising discourse can present consumption and body scenarios as a natural reality. Digital media, on the other hand, has turned into the most powerful scenario producer of the

modern age; metrics such as visibility, performance, being watched, and likes turn identity into a performance scenario. Value-based differentiations experienced in intergenerational communication directly affect individuals 'ways of perceiving the world, their relationship-building practices, and their level of expectation in communication. The transformation in social values reshapes the communication behaviors of both younger and older generations (Yılmaz, 2022). This transformation can trigger conflicts and disconnections in a wide area from family communication to social interactions (Saygılı, 2022).

The Performative Construction of Identity Through Scenarios

Goffman's dramaturgical approach had argued that identity is already a stage performance; however, the digital age has subjected identity to a new scenario regime by making this performance continuous, uninterrupted, and measurable. Butler's definition of gender as a performance produced through repeated practices makes the cultural and discursive nature of these new scenarios visible. Thus, identity becomes not a fixed internal reality, but a staging that occurs within the roles offered by scenarios. Identities that do not fit the scenario carry the risk of social exclusion, othering, and being made invisible. This entire theoretical framework shows that social scenarios are not only mental models, but also cultural, discursive, ideological, and performative structures; they constitute the main ground on which meaning is produced in communication.

CHAPTER – METHOD

The Nature of the Research Design

This study adopts a theoretical-analytical method in order to reinterpret social scenarios theory in terms of communication science. Unlike classical empirical designs, instead of collecting data in a numerical or observational integrity, the research aims to produce a conceptual deepening through theoretical literature, discourse examples, and cultural representations. The aim is not to reproduce an existing theory; it is to transform it into an explanatory model expanded, deepened, and compatible with contemporary communication structures in the context of communication.

Types of Data Sources

The data used in the study is not "empirical data" in the traditional sense; instead, there is a conceptual data set derived from theoretical sources, discourse examples, and representation analyses. While the cognitive psychology literature explains the mental nature of scenarios; cultural studies reveal how scenarios are intertwined with social norms, and discourse analysis makes visible how these norms are reproduced. For this reason, the research has an approach that is both interdisciplinary and methodologically broad-spectrum.

Layers of the Analysis Process

The method fundamentally operates at three levels: structural analysis, discursive analysis, and scenario-focused analysis. In structural analysis, the plot of the scenario, role distribution, and expectation mechanisms are examined; in discursive analysis, representation forms, power relations, ideological frames, and normative codings are evaluated; scenario-focused analysis brings these two planes together and simultaneously interprets norm production, identity staging, and cultural regulation. This method makes it possible not only to analyze communicative patterns but also to reconceptualize them.

Limitations of the Study and Methodological Position

Since this study does not include quantitative data, it does not make statistical comparisons; however, this limitation is a preference appropriate to the aim of the research. The aim is not to measure the behaviors of a community, but to deepen the function of social scenarios in

communication as a multi-layered theoretical model. Therefore, the method offers an original holistic approach by combining both the critical side of discourse analyses, the breadth of cultural analyses, and the explanatory power of cognitive models.

CHAPTER – FINDINGS AND DISCUSSION

The Scripted Nature of Norms and the Invisible Frameworks of Communicative Order

The most prominent finding regarding how social norms operate in communicative life is that norms are internalized by the individual not through an explicit teaching process, but through social scenarios. People often know what "correct behavior" is without anyone explicitly telling them; because this knowledge has been learned through scenarios to which they have been exposed since childhood. For example, behaviors such as the practice of silence at a funeral ceremony, the norm of not speaking loudly, or controlling facial expressions are not discovered by the individual through memorized commands, but through scenarios formed by repeated cultural patterns. Accordingly, the norm becomes not an ABSTRACT social value but a role played within a communicative scene. This silent operation of norms creates a "background order" in communication; while individuals act within that order, they often do not even notice the existence of that order.

However, when a norm is violated —for example, when a post is made on social media that is contrary to the usual "privacy scenario," or when a leader deviates from the "expected authoritarian tone"— the communicative structure suddenly becomes visible. This visibility break means that the expectation chain built by individuals depending on the scenario is shaken and constitutes the source of social conflict. The findings of the study show that it is not the norm itself, but the scripted form of the norm that determines communicative tensions. In other words, what creates conflict is not the behavior itself, but that the behavior disrupts the chronology of the scenario. This finding reveals that many misunderstandings in communication originate not from the cognitive, but from a scenarial rupture.

The Scenarization of Identity Construction and the Individual's Performance Burden

When discussions about the formation of identity are addressed from the perspective of social scenarios in this section of the study, they gain a more holistic meaning. The individual's identity cannot be reduced only to internal characteristics or the sum of personal preferences; identity is a mode of existence that the individual performs through the scenarios offered by the culture in which they live. Identity fields such as "femininity," "masculinity," "success," "modernity," "motherhood," and "nationality" are not realities that exist by themselves; they are roles and behavioral sequences produced by certain scenarios. An individual plays a certain scenario at the workplace in order to show themselves as disciplined, tough, or professional; in the digital environment, they become the actor of a completely different scenario. The effect of the digital age on identity production, in particular, is one of the most striking elements of the findings. Social media forces identity to be presented in a visual, numerical, and performative format; likes, view counts, and sharing rates are quantified feedback mechanisms of the individual's identity performance.

This not only makes identity performative, but also transforms it into a structure that is "measured," "compared," and "has market value." The analyses of the study show that when the individual does not conform to digital scenarios, they may face loss of visibility, social exclusion, misunderstanding, or discrediting. Thus, identity turns from a free field of expression into a performance field limited to the roles permitted by scenarios. This finding reveals, in particular, how powerful, oppressive, and determinative gender scenarios still are; because even the representations of women and men in the digital environment are evaluated within the framework

of scripted norms. The general interpretation of this section proves that identity in the modern age is a communicative structure that "seems to have become flexible, but is actually tied to tighter scenarios."

The Scenario-Reinforcing Power of Discourse: Media, Ideology, and Perception Management

Another important finding obtained in the study is that discourse not only conveys meaning, but also produces scenarios and reinforces existing scenarios. Media discourse is therefore not a neutral transfer area, but an active actor in scenario construction. The dramatic presentation of events in news texts, the heroization of certain actors or framing them as threats strengthens the security, danger, unity, or other scenarios that exist in society. Advertising discourse, on the other hand, is the area where body, beauty, consumption, and happiness scenarios are produced most intensively; here, the individual constantly encounters scenarios such as "ideal body," "successful career," "happy family," and "modern individual who reveals their difference," and tries to find their place within these scenarios. Political discourse is the most visible ideological construction area of scenarios. Leaders do not only give information to society in their speeches; they also script social order, identities, threats, and hopes for the future. National identity discourses are based on the "us and them" construct; this construct aligns the masses on a certain line by scripting historical memory, collective emotions, and the need for cultural unity. Digital media, on the other hand, has created a different discourse regime.

Here, discourse is determined not only by content but also by algorithms. Algorithmic discourse constructs "personalized scenarios" by repeatedly bringing certain content to the individual. Thus, the individual begins to live inside a scenario bubble where their beliefs are confirmed, their identity performance is strengthened, and their worldview is continuously supported. The findings show that one of the main reasons for communicative polarization is this algorithmic scenario reinforcement. Discourse is working not as a meaning transmitter, but as a scenario producer.

Exclusion, Stigmatization, and Misunderstanding of Those Who Do Not Conform to Scenarios

An important finding that draws attention in the study is that social scenarios are not only a meaning-making mechanism, but also a tool for drawing exclusionary boundaries. Since scenarios determine culturally accepted behavior sequences, the individual who goes outside this sequence can become an "inappropriate," "dangerous," "extreme," "strange," or "misread" subject in communication. Individuals who do not conform to gender norms are frequently othered both in traditional media and on social media; conflicts arise because the behaviors of people from different cultures are placed into wrong scenarios; individuals who "violate the privacy scenario" in digital environments may face harsh reactions. In addition, in the modern age, individuals who do not conform to scenarios of success, productivity, and visibility are pushed to the bottom of the social value hierarchy and are forced to fall out of visibility. The findings show that scenario incompatibility emerges not only as a behavioral difference, but as a result of a communicative misframing. In other words, the individual is excluded not because they violate a norm; they are excluded because they disrupt the rhythm of the scenario. This proves that social scenarios are both order-establishing and exclusionary and restrictive communicative mechanisms.

CHAPTER – CONCLUSION (Paragraph Flow + Subheadings, Expanded 5x)

General Evaluation of the Determinative Role of Social Scenarios in Communication

The general findings of this study clearly reveal that social scenarios are powerful structures located at the center of communicative meaning production. Scenarios are not only the individual's

mental organizing tools; they are multi-layered social mechanisms continuously produced, transformed, and redistributed by culture, discourse, norm, and identity. The communication process is not an action limited to the individual encoding or decoding the message; meaning differs completely depending on which scenario set the individual reads this message with. For this reason, misunderstandings, conflicts, or polarizations that arise in communication often stem not from the content of the message, but from the parties acting with different scenarios. While the cognitive infrastructure of scenarios accelerates communicative processes, their cultural infrastructure limits communication with invisible norms. As a result of the study, it is clearly seen that the real structure that regulates communication is not language, but the scenario; language is the carrier tool of these scenarios.

Theoretical Conclusions Regarding the Norm, Identity, and Discourse Relationship

The relationship that social scenarios establish with norms, identity, and discourse provides both an explanatory and a critical framework for communication science. Norms create an invisible but effective social order through scenarios; identity is performed within the roles offered by these norms; discourse establishes the linguistic and ideological face of this order. The study has shown that these three structures are not independent of each other, but constitute a cyclical system that mutually feeds and sustains each other. As norms are scenarized, they are accepted as natural and unchangeable; as identity is defined according to these scenarios, the individual's self-perception is limited; discourse reinforces power relations by legitimizing these limitations. For this reason, analyses made in communication science should be directed not only to the discursive level, but to the scenario infrastructure on which that discourse is based. The theoretical contribution of the study lies in its capacity to unite this triad under a single explanatory mechanism.

New Forms of Scenarios in the Modern and Digital Age

Digital media has deeply transformed the structure of social scenarios; it has even introduced a new scenario regime. While traditional scenarios are produced by culture, digital scenarios are jointly produced by both culture and algorithms and platform economy. Concepts such as visibility, performance, measurable self, and calculable value have been placed at the center of digital scenarios; identity has transformed from a fixed category into a series of constantly updated indicators. This study reveals that in the digital age, the individual is exposed not only to cultural scenarios but also to algorithmic scenarios. Algorithmic scenarios shape behaviors by determining the content that comes before the individual; the individual often does not realize that this is not a choice, but a scenario established by the platform. This finding is a critical result for digital communication research; because communicative behaviors are now being scenarized not only by social norms, but also by technological systems.

Conclusions on the Social Position of Individuals Who Do Not Conform to Scenarios

One of the most important findings of the study is that individuals who do not conform to scenarios carry the risk of exclusion, stigmatization, or misunderstanding at the communicative level. This shows that scenarios are not only explanatory, but also suppressive structures. As cultural roles, emotional codes, and visibility practices become scenarized, individuals 'space for movement narrows, especially gender norms. The study shows that the ways in which media discourse makes scenario incompatibilities visible are often negative, polarizing, and judgmental. This means that women, minorities, migrants, different sexual orientations or identities, different class positions, and individuals who do not conform to the visibility economy of the digital age are marginalized due to scenario violations. Scenarios function as a normative control mechanism in the communicative field, and this contributes to the reproduction of social inequalities.

The Necessity of a Critical Communication Perspective

The explanatory and suppressive character of social scenarios increases the importance of a critical communication perspective. For a communication researcher, the basic question is no longer only "what is being said" or "who says it"; it should be "which scenario is being reconstructed, for whom is it reconstructed, whom does it leave out, and which power relations does it sustain." This study aimed to make the invisible nature of scenarios visible, to place them at the center of cultural and discursive structures, and to remind that norms are not natural, but scripted products. The critical approach argues that scenarios can be transformed, and even that more inclusive and egalitarian scenarios can be produced. This is not only an academic goal for communication studies; it is a social responsibility.

General Conclusion: The Contribution of Social Scenarios Theory to Communication Science

As a result, social scenarios theory should be positioned as a powerful explanatory model in communication science. Because communicative meaning arises not from the individual's conceptual frames, but from the scenario sets in which those frames are organized. Scenarios are central structures that determine the individual's way of reading the world, the method of performing identity, the ways of conforming to or resisting norms, and how they are positioned by discourse. This study has made the interaction between norms, identity, and discourse a part of a holistic framework by reinterpreting scenarios in terms of communication science. Thus, it has been shown that scenarios are not only mental; they have social, cultural, ideological, and technological layers. This approach makes an important contribution to both the theoretical expansion of communication science and its practical analysis capacity.

REFERENCES

Abelson, R. P. (1981). Psychological status of the script concept. American Psychologist, 36(7), 715–729.

Althusser, L. (1971). Ideology and ideological state apparatuses. Verso.

Bartlett, F. C. (1932). Remembering: A study in experimental and social psychology. Cambridge University Press.

Bauman, Z. (2000). Liquid modernity. Polity Press.

Bauman, Z. (2007). Liquid life. Polity Press.

Bennett, W. L., & Iyengar, S. (2008). A new era of minimal effects? Journal of Communication, 58(4), 707–731.

Bordwell, D. (1985). Narration in the fiction film. University of Wisconsin Press.

Bourdieu, P. (1991). Language and symbolic power. Harvard University Press.

Butler, J. (1990). Gender trouble: Feminism and the subversion of identity. Routledge.

Couldry, N. (2012). Media, society, world: Social theory and digital media practice. Polity.

Eagly, A. H., & Wood, W. (2012). Social role theory. In P. A. M. Van Lange (Ed.), Handbook of theories of social psychology (pp. 458–476). Sage.

Fairclough, N. (1995). Critical discourse analysis: The critical study of language. Longman. Fiske, S. T., & Taylor, S. E. (1991). Social cognition. McGraw-Hill.

Foucault, M. (1972). The archaeology of knowledge. Routledge.

Gergen, K. J. (1991). The saturated self: Dilemmas of identity in contemporary life. Basic Books.

Giddens, A. (1991). Modernity and self-identity. Polity Press.

Goffman, E. (1959). The presentation of self in everyday life. Anchor Books.

Goffman, E. (1974). Frame analysis. Harvard University Press. Hall, S. (1997). Representation: Cultural representations and signifying practices. Sage.

Han, B.-C. (2017). The society of performance. Polity Press.

Hochschild, A. R. (1979). Emotion work, feeling rules, and social structure. American Journal of Sociology, 85(3), 551–575.

Hofstede, G. (2001). Culture's consequences. Sage Publications.

Illouz, E. (2007). Cold intimacies: The making of emotional capitalism. Polity Press.

Lakoff, G. (2004). Don't think of an elephant! Chelsea Green.

Lazar, M. (2005). Feminist critical discourse analysis. Gender & Language, 1(1), 141–170.

Lippmann, W. (1922). Public opinion. Harcourt Brace.

Saygılı, N. (2022). Kuşaklar ve iletişim: Toplumsal değerler, çatışma, iletişim engelleri, E-Kitap

Projesi, s. iii.

McCombs, M., & Shaw, D. (1972). The agenda-setting function of mass media. Public Opinion Quarterly, 36(2), 176–187.

Morley, D. (1986). Family television: Cultural power and domestic leisure. Comedia Publishing. Schank, R. C., & Abelson, R. P. (1977). Scripts, plans, goals and understanding. Lawrence Erlbaum.
Searle, J. (1995). The construction of social reality. Free Press.

Silverstone, R. (1999). Why study the media? Sage Publications.

Tajfel, H. (1981). Human groups and social categories. Cambridge University Press.

Turkle, S. (2011). Alone together: Why we expect more from technology and less from each other. Basic Books.

van Dijk, T. A. (1998). Ideology: A multidisciplinary approach. Sage.

van Dijk, T. A. (2006). Discourse and manipulation. Discourse & Society, 17(3), 359–383.

Wodak, R. (2001). The discourse-historical method. Sage.

Wodak, R., & Meyers, M. (2009). Methods of critical discourse analysis. Sage Publications. Yılmaz, M. (2022). Kuşaklar ve iletişim: Toplumsal değerler, çatışma, iletişim engelleri. E-Kitap

Projesi, s.128.

Zuboff, S. (2019). The age of surveillance capitalism. PublicAffairs. Zillmann, D., & Bryant, J. (2002). Media effects: Advances in theory and research. Lawrence Erlbaum.
Žižek, S. (2008). Violence. Picador.

THE CULT OF THE SUN IN MESOPOTAMIAN SYRIAC AND ANDEAN INCA ARCHITECTURE

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ABSTRACT

As a deep-rooted ontological foundation, the sun cult represents universal life energy and absolute truth beyond a mere physical light source. From legitimizing authority in Mesopotamian iconography to shaping Inca ideology (Inti), this belief defined religious and political structures across vast geographies. This study examines two monumental embodiments of this heliocentric system: Qorikancha in the Inca capital, Cusco, and the Sun Temple within the Deyrulzafaran Monastery in

Mardin features a stratigraphy dating to the 4th millennium BC, hosting Sumerian, Akkadian, Hittite, Roman, and Seljuk civilizations. Within this cultural layering, a pagan temple attributed to the Shamsis (Sun worshipers) lies in the deepest stratum, forming the sub-basement of Deyrulzafaran Monastery. Similarly, Cusco was designed by Emperor Pachacuti in the shape of a puma, serving as the Inca administrative center. Considered the center of the universe, this sacred settlement integrated faith and power. Qorikancha, the 'Golden Courtyard' at the city's heart, stands as the spatial equivalent of this theological authority.

By analyzing these structures architecturally and culturally, this study reveals a shared universal heritage. Despite chronological and geographical distances, both the kancha-style Coricancha and the Mardin temple exhibit flawless dry-stone masonry using large interlocking blocks. This structural choice symbolizes 'eternity' through the 'continuity of sacred space.' Furthermore, both feature archaeo-astronomical alignments, allowing light to penetrate interiors during equinoxes and solstices. This physical permanence facilitated their adaptive reuse; both were re-functionalized by subsequent religious structures (Santo Domingo Church and Deyrulzafaran Monastery), becoming tangible examples of architectural stratification.

Keywords: Sun Cult, Coricancha, Kancha, Deyrulzafaran Monastery, Shamsis, Inca.

Introduction

The sun cult represents universal life energy and absolute power in human history (Cirlot, 1971; Uncu, 2013). This important cult was the source of divine authority in Mesopotamia and Egypt. It influenced many systems, from the Hittite understanding of justice in Anatolia to the Inca state ideology (Inti) in Peru (Uncu, 2013; Castro, 2020). In alchemy, the "Sol in homine" (Sun in man) teaching symbolizes spirituality (Cirlot, 1971).

This study examines two monumental examples of sun-centered belief systems: the Qorikancha Temple in Cusco (the Inca capital) and the Sun Temple (Deyrulzafaran) in Mardin. Mardin has a very old and multi-layered structure including Sumerian, Hittite, Roman, and Seljuk civilizations

(Küçük, 2008). In the deepest layer of the Deyrulzafaran Monastery, there is a pagan temple belonging to the "Shemsi" (Sun worshippers), which forms the foundation of the current monastery (Küçük, 2008). Similarly, the city of Cusco in Peru was designed as the administrative center of the Inca Empire. At the heart of the city, Qorikancha (known as the Golden Courtyard) was the most sacred cultural center of the empire (Calvo, 1987; Castro, 2020).

The aim of this work is to analyze these two structures architecturally and culturally to show the universal heritage of the sun cult. Despite the distance between the Inca Qorikancha and the Mardin temple, both structures use large stone blocks with a "mortarless" locking technique (Küçük, 2008; Amico, 2009). This choice increases durability and symbolizes eternity. Also, both buildings are aligned with the sun; light enters the interior at specific angles during equinoxes and solstices (Küçük, 2008; Castro, 2020). Just like the Santo Domingo Church built over Qorikancha, the pagan temple in Mardin was converted into a monastery, completing the process of historical "superposition" (layering) (Küçük, 2008; Castro, 2020).

The Shemsi people in Mardin were connected to the Sun God Shamash. They believed the sun was the symbol of divine justice (Uncu, 2013). They prayed toward the east and designed their temples to receive the first rays of the sun at specific astronomical angles (Küçük, 2008). The mortarless stone architecture under the Deyrulzafaran Monastery is their original cult center. Over time, these groups converted to Syriac Orthodox Christianity but protected the ancient temple. This created a perfect cultural and architectural layer (Küçük, 2008).

The Inca Empire shaped its ideology around the sun cult (Inti). During the period of Emperor Pachakuti, the capital Cusco was designed in the shape of a puma (Amico, 2009). Inca architecture is a precise and calculable system, much like their recording system, the Quipu (Amico, 2009). After the Spanish conquest in 1532, the construction of the Santo Domingo Church over Qorikancha created a radical architectural layering (Amico, 2009; Castro, 2020).

Materials and Methods

The focus of this study is the Qorikancha Temple in Cusco and the Shemsi Temple located in the lower layer of the Deyrulzafaran Monastery in Mardin. Despite their different geographic and chronological distances, these two structures share a common architectural language based on the sun cult. During the research process, to analyze the ontological and symbolic origins of these monumental buildings, I used fundamental sources on symbology and mythology such as Campbell (1993), Cirlot (1971), and Ferber (2007). I also used current academic literature that provides archaeological and architectural inventories for both regions.

Methodologically, in the first stage, the kancha system (a characteristic unit of Inca architecture) and the mortarless locking stone technique used in both structures were compared typologically. This technique symbolizes both static durability and theological eternity. In addition to this physical analysis, the method of architectural stratigraphy was used to understand the sacredness of the space, even as belief systems changed. Finally, the historical process of colonial and religious transformation (superposition) on the structures was examined (Castro, 2020, s. 8).

Findings and Discussion

The Sun Temple forms the deepest layer of the architectural structure in Mardin. Today, it is located in the eastern corner of the Mor Hananyo Church and consists of two main parts (Küçük, 2008). The entrance has a "cradle vault" design with cut stone work. The real engineering genius is seen in the second section (51.5 square meters), especially in the ceiling. The large stones forming the ceiling are locked together with perfect geometric precision without using any mortar, sand, or

lime (Küçük, 2008). This mortarless system is a "micro-cosmos" that symbolizes the eternal order of the sun. The ritual areas on the eastern and southern walls emphasize the religious function of the temple (Küçük, 2008). This design and the locking principle of the stones show a perfect parallel with the mortarless technique of the large blocks in Qorikancha, Cusco. Both cultures sought "eternity in space" through the sun cult.

Qorikancha is the peak of Inca engineering. It is based on the kancha layout, which consists of rectangular units around a central courtyard (Amico, 2009). While Inca architecture usually has straight angles, Qorikancha is famous for its rare curvy wall (muro curvilíneo) (Amico, 2009). The temple uses a very high-quality stone technique called cantería fina, where stones are processed with millimetric precision (Amico, 2009). The building also uses the t'iksu perqa (Andean entasis) technique, where walls lean slightly inward for better stability (Calvo, 1987). Thanks to this seismic strategy, Qorikancha survived the big earthquakes of 1650 and 1950 without damage, while the Santo Domingo Church built on top of it was destroyed (Amico, 2009; Castro, 2020). It was also the center of the Ceque system, a network of sacred paths that controlled the entire geography of Cusco (Amico, 2009).

The kancha layout of Qorikancha and the two-part structure of the Mardin temple both use light as an "architectural material." In Mardin, the ritual areas are aligned with the sun's angle during equinoxes. In Qorikancha, the trapezoidal niches and windows act as optical devices that direct light to the sacred center during the winter solstice (Küçük, 2008; Amico, 2009). The t'iksu perqa technique in Cusco and the vault system in Mardin both protected these structures against earthquakes and the heavy layers of later buildings (Calvo, 1987; Castro, 2020).

These findings prove that both structures were not just religious centers but also "objects of power" where imperial or religious authority became physical (Hurtado Castro, 2020). Just as Qorikancha was the reference point for the Ceque system, the Sun Temple in Mardin was the foundation of the sacred geography in its region (Amico, 2009). The Santo Domingo Church and Mor Hananyo Monastery built on top of these sites absorbed the old "centers of power" to build their own authority (Castro, 2020; Küçük, 2008). In terms of "architectural superposition," it is concluded that new religions did not destroy the solar energy of the old faith; instead, they built upon it to gain theological legitimacy.

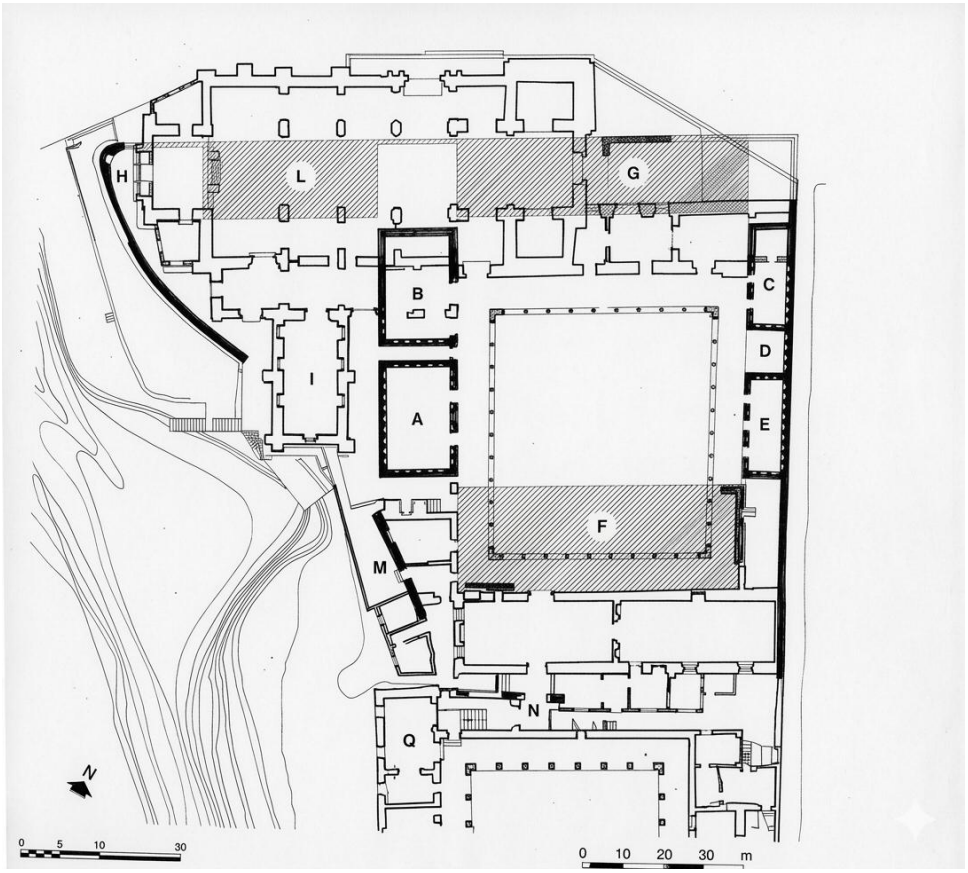


Figure 1. Qorikancha plan (Masky 421, [2011])



Figure 2. The Coricancha Temple (Machu Travel Peru, 2024)

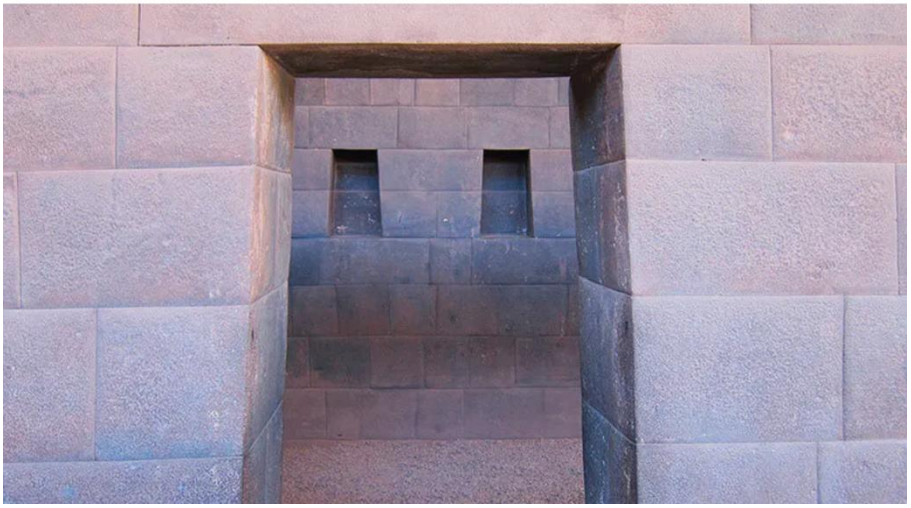


Figure 3. The Coricancha Temple (Machu Travel Peru, 2024)



Figure 4. The Coricancha Temple (Machu Travel Peru, 2024)

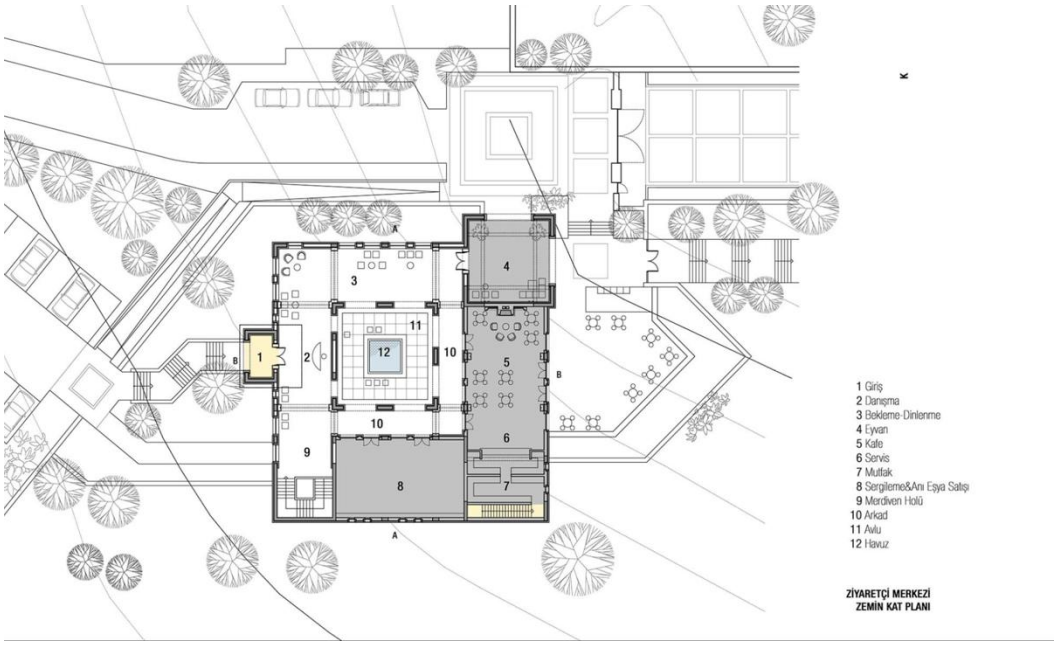


Figure 5. Deyrulzafaran Monastery architectural plan (Ergün Mimarlık, 2004)

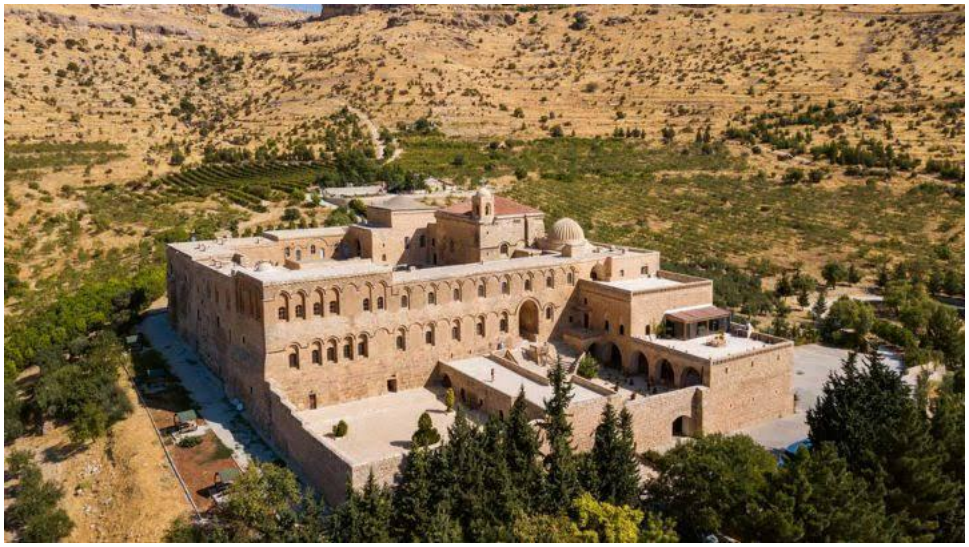


Figure 6. Deyrulzafaran Monastery (Yüzyıllık Hikayeler, 2024)

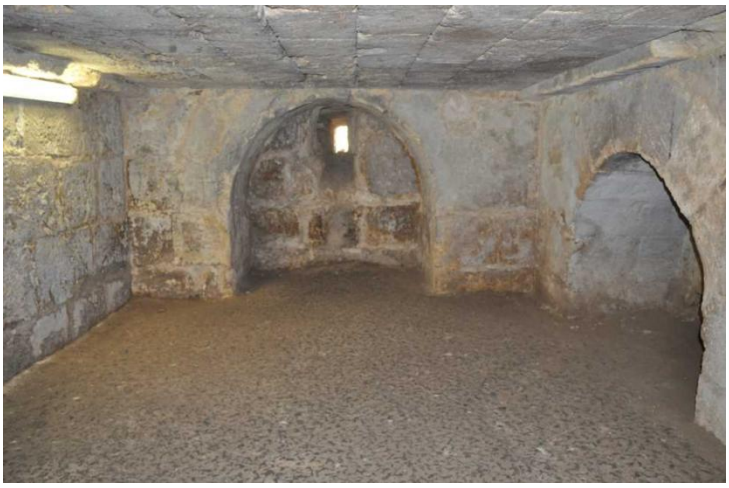


Figure 7. Deyrulzafaran Monastery-Sun Temple (Ateş, n.d.)

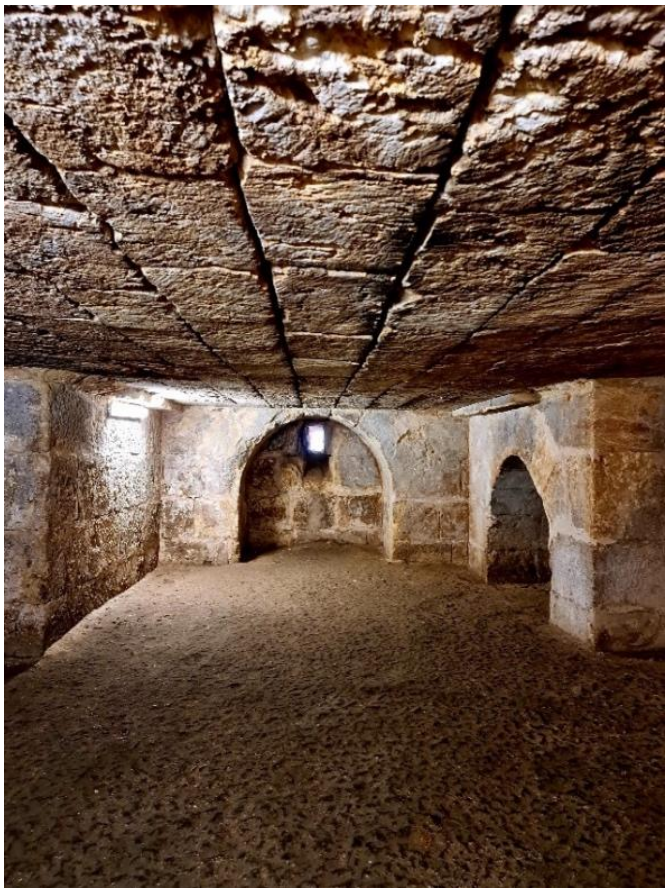


Figure 8. Deyrulzafaran Monastery (İnanıcı, n.d.)

Conclusion and Recommendations

Mardin has a very important place in Mesopotamia. Especially in the field of architecture, its buildings attract attention. Besides this, the presence of the Syriac people is also of great importance here. A similar situation is seen in Cusco with the deep history of the Inca culture and later with Christianity. We see that these two different countries, different geographies, and different cultures actually evolved into a similar destiny with a similar logic, especially through

the sun cult. As seen in the study, the importance given to the sun is almost the same, and the location and lighting of the temples were done in the same way.

This study proves that the sun cult created a common architectural language in different cultures, especially extending from Mesopotamia to the Andes Mountains. Despite the thousands of kilometers of distance and chronological differences between the Sun Temple (Deyrulzafaran) in Mardin and Qorikancha in Cusco, besides creating an architectural language based on sun worship and the sun, elements like the "mortarless locking stone technique", astronomical precision, and the management of light inside the space show similarity. The "architectural layering" process seen in both buildings attracts attention. It is also seen that these two buildings, created on this layering caused by different nations due to colonization or different reasons, have a historical destiny. New belief systems (Syriac Orthodoxy and Catholicism) built upon these buildings instead of destroying the ancient energy of the sun, and provided their own theological legitimacy. Besides this, it is seen that the most striking thing is that they are resistant to earthquakes and many other things with their mortarless architectural design. In conclusion, these two monumental buildings are not just local heritage, but universal symbols of human engineering history and the common search for belief.

References

Agurto Calvo, S. (n.d.). Estudios acerca de la construcción, arquitectura y planeamiento incas. Lima.

Alfaro Aucca, A., & Beltrán-Caballero, A. S. (2019). La imagen del Cusco Inka en la historia: entre la permanencia y la transformación. Devenir - Revista de estudios sobre patrimonio edificado, 6(11).

Campbell, J. (1993). Doğu Mitolojisi: Tanrının Maskeleri (K. Emiroğlu, Trans., 3rd ed.). Ankara: İmge Kitabevi.

Canziani Amico, J. (2009). Ciudad y territorio en los Andes: Contribuciones a la historia del urbanismo prehispánico. Lima: Pontificia Universidad Católica Del Perú.

Cirlot, J. E. (1971). A Dictionary of Symbols (J. Sage, Trans., 2nd ed.). London: Routledge.

D'Altroy, T. N. (2015). The Incas (2nd ed.). Wiley Blackwell.

Ferber, M. (2007). A Dictionary of Literary Symbols (2nd ed.). Cambridge: Cambridge University Press.

Güngör, A., & Kozbe, G. (2022). Mardin ili kültür envanteri cilt 1 Artuklu - Ömerli [Cultural inventory of Mardin province volume 1 Artuklu - Ömerli].

Küçük, Z. G. (2008). Mardin ve Çevresinde Süryaniler (Unpublished master's thesis). Çukurova University, Adana.

Mackay, W. I. (2011). A lógica da arquitetura inca e a gramática da forma na reconstrução arqueológica virtual (Doctoral dissertation). Universidade de Brasília.

Maskay. (n.d.). Peru Sanat Akımları ve İnka Şehircilik Mirası. [Unpublished field notes].

Uncu, E. (2013). Mezopotamya, Anadolu ve Mısır Medeniyetlerinde Güneş Kültü. History Studies, 5(1), 349-366.

Internet References

Ateş, B. (n.d.). Deyrulzafaran Manastırı-Güneş Tapınağı [Deyrulzafaran Monastery-Sun Temple] [Photograph]. Türkiye Kültür Portalı. Retrieved from https://www.kulturportali.gov.tr/medya/fotograf/fotodetay/35562 Figure 7.

Ergün Mimarlık. (2004). Deyrulzafaran Manastırı Ziyaretçi Karşılama Merkezi. ARKIV. Retrieved from https://www.arkiv.com.tr/galeri/detay/298853/17/Proje/9268 Figure 5.

Machu Travel Peru. (2024). The Coricancha Temple in Cusco. Retrieved from https://www.machutravelperu.com/blog/coricancha Figure 2-4.

Yüzyıllık Hikayeler. (2024). Deyrulzafaran Manastırı: Mezopotamya'nın kadim mirası [Deyrulzafaran Monastery: The ancient heritage of Mesopotamia]. Retrieved from https://yuzyillikhikayeler.com/tarihi-mekanlar/deyrulzafaran-manastiri/ Figure 6.

İnanıcı, H. (n.d.). Deyrulzafaran Manastırı [Deyrulzafaran Monastery]. Haluk İnanıcı. Retrieved from https://www.halukinanici.com/liste/deyrulzafaran-manastiri/ Figure 8.

TRENDS AND SEASONALITY OF TUBERCULOSIS IN ALBANIA: A 10-YEAR ANALYSIS (2015–2024)

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ABSTRACT

Tuberculosis (TB) remains a major public health concern, with significant impact on morbidity and mortality worldwide. Analysis of trends and seasonal fluctuations in TB provides valuable information for designing effective control and treatment strategies. This study aimed to examine the epidemiological distribution, annual trend, and seasonal variation of TB in Albania over a 10-year period, including all age groups, sexes, and residential areas. TB data were sourced from the National Tuberculosis Program registry, hospitals and TB dispensaries. Data were collected for 3,518 confirmed TB cases and analysed using descriptive and inferential statistical methods. Results showed an overall declining trend in TB cases over the study period. TB incidence from 2015 to 2019 remained relatively stable, ranging from 14.2 to 16.5 cases per 100,000 population. In 2020, a sharp decrease to 8.5/100,000 was observed, likely due to the impact of the COVID-19 pandemic on case reporting and access to healthcare services. Following 2020, incidence gradually increased to 10.9/100,000 in 2023, remaining below pre-pandemic levels ($p < 0.0001$). Monthly averages revealed a clear seasonal pattern, with peaks in spring and summer months (May 34.6; June 33.4; July 34.4) and lower values in winter and early spring (November 24.5; December 22.6; January 28.0; February 27.8). Pulmonary TB accounted for the majority of cases (76.4%) compared to extrapulmonary TB (23.6%) ($p < 0.001$). Males represented 68.7% of cases, while females accounted for 31.3%, with a statistically significant association between TB forms and sex ($p < 0.001$). The 14–34 age group showed a summer peak of cases (35.6%), while individuals over 65 years had higher incidence in spring (25%). No significant differences were observed between urban and rural residence, indicating similar TB burden across living areas. These seasonal peaks may be influenced by climatic conditions, social behaviours, or biological factors, highlighting the importance of further research to understand these mechanisms and to aid in reducing TB transmission. The observed spring–summer seasonal pattern of TB underscores the need for comprehensive, multicentre studies to elucidate the underlying seasonal variations and to inform strategies for TB prevention, diagnosis, and control at the national level.

Keywords: Tuberculosis; Incidence; Seasonality; Epidemiology

INTRODUCTION

Tuberculosis (TB) continues to be one of the most significant infectious diseases globally, posing a persistent and serious public health. In Albania, tuberculosis remains a significant public health problem, despite improvements in diagnosis and treatment in recent years. Analysis of the trend of cases over time is essential to understand whether the disease is declining, increasing or showing stable fluctuations. In Albania, studying the seasonality of tuberculosis is important for several epidemiological and practical reasons. Identifying seasonal patterns helps to better understand the dynamics of disease transmission. If cases increase at certain times of the year, this may be related to environmental factors such as temperature, humidity, exposure to sunlight or the concentration of the population in indoor environments during the cold months. Albania has specific climatic and socio-economic characteristics that may influence the seasonal distribution of cases TB. Seasonal population movements, living conditions, migration, and access to health services may create variations in the number of cases reported during the year. Analysis of seasonality helps health institutions to plan resources more efficiently. If periods of higher incidence are identified, screening, awareness and diagnostic programs can be intensified during those periods, increasing early detection and reducing transmission. The study of seasonality can contribute to improving the epidemiological surveillance system, helping to distinguish between real increases in cases and normal seasonal variations. Analysis of the seasonality of tuberculosis in Albania is important for improving health policies and strengthening disease control at the national level

MATERIALS AND METHODS

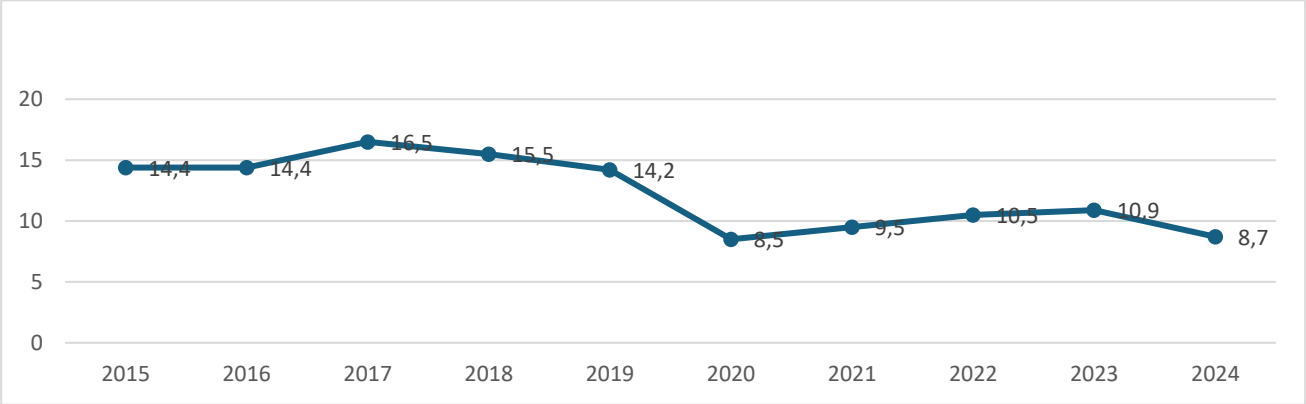
We conducted a retrospective analytical observational study using routinely collected surveillance data All TB cases reported during the study period were included, mainly in the variables age, gender, TB forms, classification, and distribution by residence. To assess the existence and seasonal pattern of tuberculosis in Albania during the period 2015–2024 to compare TB incidences between seasons and identify the most affected age groups between seasons. Descriptive statistical analysis, Chi-square, ANOVA, Statistical significance level: $p < 0.05$ was used. This study is important for planning preventive policies and the efficient allocation of human resources based on seasonal epidemiological data. A total of **3518 Tb cases** confirmed tuberculosis cases were included in the analysis, (76.4%) of which were pulmonary TB and (23.6%) of which were extrapulmonary TB), diagnosed in Albania and reported by the National Tuberculosis Program. Data were collected from the University Hospital "Shefqet Ndroqi" and regional dispensaries, in collaboration with the National TB Program between January 2015 and December 2024. Medical records were analyzed based on pre-defined variables outlined in the assessment protocol. The collected data were systematically entered, processed, and analyzed using SPSS software

RESULTS

During the study period, a total of 3,518 confirmed tuberculosis (TB) cases were reported and analyzed using descriptive and inferential statistics. Overall, TB incidence showed a gradual decline, but this trend was not entirely linear. Between 2015 and 2019, incidence remained relatively stable, ranging from 14.2 to 16.5 per 100,000 population, suggesting a steady pattern of transmission and consistent case detection in the pre-pandemic period. In 2020, however, a sudden drop to 8.5 per 100,000 was observed. This abrupt decrease coincided with the onset of the COVID-19 pandemic, likely reflecting disruptions in healthcare services, limited access to diagnostic facilities, mobility restrictions, and underreporting, rather than a true reduction in TB transmission. Following 2020, incidence slowly rebounded to 10.9 per 100,000 by 2023, yet

remained below pre-pandemic levels ($p < 0.0001$), highlighting both the resilience and the vulnerability of TB surveillance systems during public health crises.

Figure 1: TB incidence per 100,000 population



Examining monthly averages, a clear seasonal pattern emerged. Peaks consistently occurred in late spring and summer months. The monthly average of TB cases was highest particularly in May (34.6), June (33.4), and July (34.4), while the lowest notifications were recorded in winter and early spring, including November (24.5), December (22.6), January (28.0), and February (27.8). This seasonal fluctuation may reflect a combination of factors: delayed diagnosis following winter exposure, increased indoor crowding during colder months, seasonal changes in immune function.

Table 1: Total case numbers of tuberculosis diagnosed per month by years

Diagnosis months	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total	
	n	n	n	n	n	n	n	n	n	n	n	%
January	35	26	43	40	33	20	17	19	28	19	280	7,96
February	31	43	46	39	20	20	11	26	18	24	278	7,9
March	45	31	48	37	33	20	20	26	29	16	305	8,67
April	28	42	34	42	37	23	27	23	16	23	295	8,39
May	33	33	52	41	54	24	28	26	33	22	346	9,84
June	44	36	48	48	40	32	24	26	23	13	334	9,49
July	50	39	41	46	50	14	34	26	26	18	344	9,78
August	29	29	45	37	35	25	22	26	40	23	311	8,84
September	37	46	42	23	29	17	29	19	19	23	284	8,07
October	22	21	45	42	27	20	22	25	23	23	270	7,67
November	29	32	35	20	20	16	21	29	23	20	245	6,96
December	31	36	24	25	34	9	14	21	24	8	226	6,42
Total	414	414	503	440	412	240	269	292	302	232	3518	100

The persistence of these patterns across years supports the presence of true seasonal variation rather than random fluctuation, aligning with findings reported in other regions worldwide. Pulmonary TB accounted for the majority of cases (76.4%), with extrapulmonary forms representing 23.6% ($p < 0.001$). Males were disproportionately affected, comprising 68.7% of cases compared to 31.3% of females, and a significant association was found between TB form and sex ($p < 0.001$). These patterns may reflect differences in occupational exposure, social

behaviors, biological susceptibility, or health-seeking practices. Age-stratified analysis revealed that the 14–34-year group experienced a pronounced summer peak (35.6%), while those over 65 had higher incidence in spring (25%), suggesting that seasonal exposure and immune response interact differently across age groups. Interestingly, no significant urban–rural differences were observed, indicating a relatively homogeneous TB burden across geographic settings in this population.

Figure 2: Distribution of TB cases by age group and months

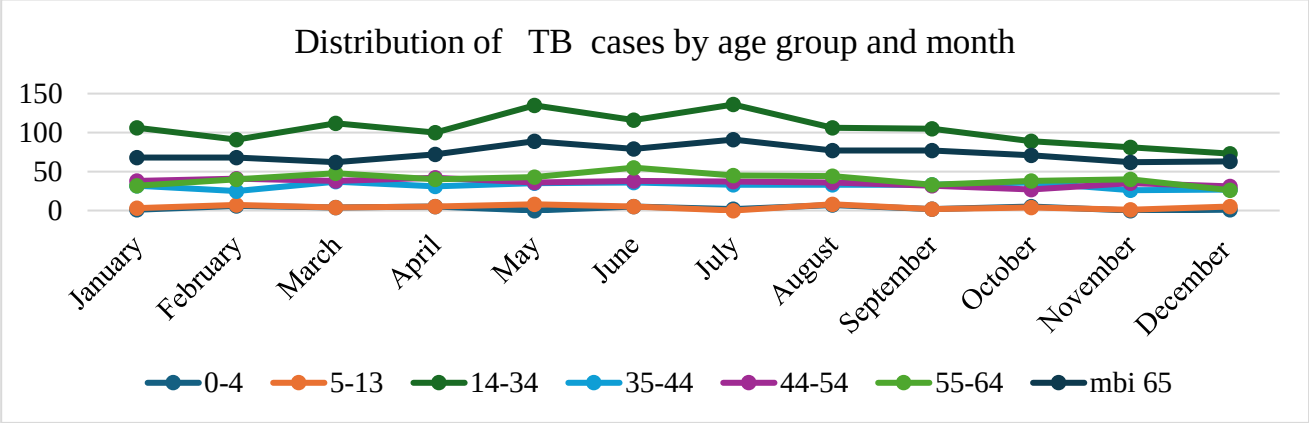
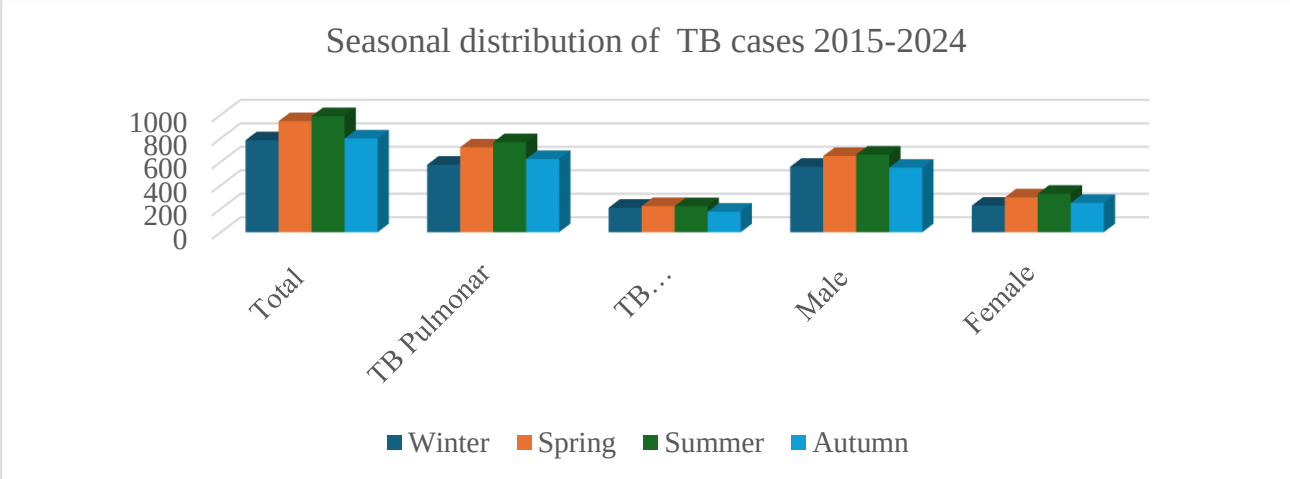


Figure 3: Seasonal distribution of TB cases 2015-2024



Taken together, these results emphasize that TB incidence is shaped by both long-term trends and seasonal dynamics. The spring–summer peaks highlight critical periods for intensified surveillance, targeted screening, and public health interventions. Additionally, the pandemic-related disruptions underscore the need for robust and adaptable TB control programs capable of maintaining essential services under challenging circumstances. Future studies integrating climatic, behavioral, and immunological factors will be crucial to fully understand the mechanisms driving seasonality and to inform effective, context-specific strategies for TB prevention, early diagnosis, and control.

DISCUSSION

Based on studies from other countries investigating seasonal variations in TB cases, which have shown that incidence peaks primarily during spring and summer months, our study in Albania similarly confirmed this phenomenon. Although the exact causes of seasonal fluctuations in TB incidence are not yet fully understood, one theory suggests that the TB bacillus is mainly transmitted in crowded and enclosed environments during the winter months, while the disease manifests later, in spring and summer, following an incubation period of approximately two to three months. The observation that both pulmonary and extrapulmonary forms of TB peak in spring and summer, as seen in our study and reported elsewhere, indicates that seasonal variability cannot be solely attributed to delays in diagnosis. Instead, it may also be influenced by social and climatic factors associated with seasonal changes. The predominance of pulmonary TB compared to extrapulmonary TB in our study may be explained by diagnostic delays, since non-specific symptoms of pulmonary TB can be easily mistaken for other respiratory or infectious conditions. Our study is a retrospective epidemiological analysis, focused primarily on identifying trends and seasonal distribution of TB cases, without considering the influence of population characteristics such as regional, geographic, altitude, or socio-demographic factors. These findings highlight the importance of understanding seasonal dynamics in TB transmission and suggest that both biological and environmental factors likely contribute to the observed patterns.

CONCLUSION

Our study showed a clear seasonal pattern in TB cases, with peaks in spring and summer. Both pulmonary and extrapulmonary TB followed this trend, suggesting that these fluctuations are not just due to delays in diagnosis but may also reflect social, climatic, and biological factors. Younger adults had higher incidence in summer, while older adults peaked in spring. There were no major differences between urban and rural populations, indicating a fairly uniform burden of TB. Understanding these seasonal patterns can help guide targeted interventions, improve surveillance, and allocate resources more effectively. More research is required to clarify the biological, social, and environmental mechanisms behind these seasonal trends. Sponsorship and financial support acknowledgments should be included here. Acknowledging the contributions of other colleagues who are not included in the authorship of this paper is also added in this section. If no acknowledgement is necessary, this section should not appear in the paper.

REFERENCES

- Fares A 2011. *Seasonality of tuberculosis.* Journal of Global Infectious Diseases, 3(1): 46–55.
- Fisman DN 2007. *Seasonality of infectious diseases.* Annual Review of Public Health, 28: 127–143.
- Gao J, et al. 2015. *Seasonality of pulmonary tuberculosis in China: a systematic review and meta-analysis.* Scientific Reports, 5: 14447.
- Liu Q, Liu Y, Wang J, et al. 2018. *Seasonal pattern of pulmonary tuberculosis in China.* Epidemiology and Infection, 146(8): 995–1001.
- Marais BJ, et al. 2013. *Tuberculosis.* Lancet, 382(9909): 887–899.
- Migliori GB, et al. 2013. *Seasonal variation of tuberculosis in the WHO European Region.* European Respiratory Journal, 42(6): 1647–1655.

- Reid MJA, et al. 2019. *The impact of COVID-19 on global tuberculosis services and notifications.* The International Journal of Tuberculosis and Lung Disease, 23(9): 1056–1068.
- Yuan H, et al. 2022. *Climate change, environmental exposures and tuberculosis risk: a global perspective.* Environmental Research, 204: 112050.
- Yuan T, et al. 2020. *Temporal trend and seasonal pattern of tuberculosis in a high-burden province in China.* BMC Public Health, 20: 278.

TRUST BUILDING IN DIGITAL MARKETING: THE RISE OF MICRO-INFLUENCERS AND USER-GENERATED CONTENT (UGC)

DİJİTAL PAZARLAMADA GÜVEN İNŞASI: MİKRO-ETKİLEYİCİLERİN (MICRO-INFLUENCERS) VE KULLANICI TÜRETİMLİ İÇERİĞİN (UGC) YÜKSELİŞİ ÜZERİNE KAPSAMLI BİR İNCELEME

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ABSTRACT

Trust building has become one of the most critical strategic imperatives in digital marketing, where consumers are increasingly skeptical of brand-controlled messages. The proliferation of advertising clutter, algorithmic targeting, and sponsored content has led to declining confidence in traditional influencer endorsements and corporate communication. Within this evolving landscape, micro-influencers and User-Generated Content (UGC) have emerged as powerful trust-building mechanisms that reshape how brands establish authenticity, credibility, and relational proximity with their audiences.

Micro-influencers—typically defined as content creators with smaller but highly engaged follower bases—operate within niche communities characterized by perceived intimacy and relatability. Unlike macro-influencers or celebrities, their influence stems less from aspirational distance and more from peer-like identification. This relational closeness fosters higher engagement rates, stronger parasocial interaction, and greater persuasive impact. From a cost-efficiency perspective, micro-influencer collaborations also enable brands to execute precision-targeted campaigns while maintaining budget flexibility and measurable return on investment.

Concurrently, UGC has transformed passive consumers into active value co-creators within digital brand ecosystems. Reviews, testimonials, unboxing videos, social media posts, and community discussions function as decentralized credibility signals that reduce perceived purchase risk. Because UGC is voluntarily produced and experience-based, it is often evaluated as more trustworthy than firm-generated content. Algorithmic amplification across platforms further extends the visibility and longevity of such content, embedding trust signals throughout the consumer decision journey—from awareness to post-purchase advocacy.

The synergistic integration of micro-influencers and UGC creates a layered trust architecture. While micro-influencers initiate authentic brand narratives, UGC sustains and validates these narratives through collective consumer endorsement. This dual mechanism enhances brand transparency, strengthens social proof, and accelerates community-driven diffusion processes. However, issues such as disclosure ethics, authenticity erosion through over-commercialization, and content verification risks necessitate robust governance frameworks.

In conclusion, the rise of micro-influencers and UGC signifies a paradigmatic shift from authority-based persuasion to community-validated trust building in digital marketing. Brands that strategically orchestrate these participatory communication channels can cultivate durable consumer trust, enhance engagement quality, and secure sustainable competitive advantage in increasingly experience-driven digital marketplaces.

Keywords: Digital Marketing, Trust Building, Micro-Influencers, User-Generated Content, Consumer Engagement, Social Proof

Özet

Dijital pazarlamada, tüketicilerin marka kontrollü mesajlara giderek daha şüpheci yaklaştığı bir ortamda, güven oluşturma en kritik stratejik zorunluluklardan biri haline gelmiştir. Reklam karmaşasının, algoritmik hedeflemenin ve sponsorlu içeriğin yaygınlaşması, geleneksel influencer onaylarına ve kurumsal iletişime olan güvenin azalmasına yol açmıştır. Bu gelişen ortamda, mikro-influencer'lar ve Kullanıcı Tarafından Oluşturulan İçerik (UGC), markaların hedef kitleleriyle özgünlük, güvenilirlik ve ilişkisel yakınlık kurma biçimini yeniden şekillendiren güçlü güven oluşturma mekanizmaları olarak ortaya çıkmıştır.

Mikro-influencer'lar -genellikle daha küçük ancak son derece ilgili takipçi kitlelerine sahip içerik oluşturucular olarak tanımlanır- algılanan yakınlık ve ilişkilendirilebilirlik ile karakterize edilen niş topluluklar içinde faaliyet gösterirler. Makro-influencer'lardan veya ünlülerden farklı olarak, etkileri özlem duyulan mesafeden ziyade akran benzeri özdeşleşmeden kaynaklanır. Bu ilişkisel yakınlık, daha yüksek etkileşim oranları, daha güçlü parasosyal etkileşim ve daha büyük ikna edici etki sağlar. Maliyet etkinliği açısından bakıldığında, mikro-influencer iş birlikleri, markaların bütçe esnekliğini ve ölçülebilir yatırım getirisini korurken, hassas hedefli kampanyalar yürütmelerini de mümkün kılıyor.

Aynı zamanda, kullanıcı tarafından oluşturulan içerik (UGC), pasif tüketicileri dijital marka ekosistemlerinde aktif değer ortak yaratıcılarına dönüştürdü. Yorumlar, referanslar, kutu açma videoları, sosyal medya gönderileri ve topluluk tartışmaları, algılanan satın alma riskini azaltan merkezi olmayan güvenilirlik sinyalleri olarak işlev görüyor. UGC gönüllü olarak üretildiği ve deneyime dayalı olduğu için, genellikle şirket tarafından oluşturulan içerikten daha güvenilir olarak değerlendiriliyor. Platformlar arası algoritmik güçlendirme, bu tür içeriğin görünürlüğünü ve kalıcılığını daha da artırarak, tüketici karar yolculuğunun her aşamasına (farkındalıktan satın alma sonrası savunuculuğa kadar) güven sinyalleri yerleştiriyor.

Mikro-influencer'ların ve UGC'nin sinerjik entegrasyonu, katmanlı bir güven mimarisi oluşturuyor. Mikro-influencer'lar otantik marka anlatılarını başlatırken, UGC bu anlatıları toplu tüketici onayıyla sürdürüyor ve doğruluyor. Bu ikili mekanizma, marka şeffaflığını artırır, sosyal kanıtı güçlendirir ve topluluk odaklı yayılım süreçlerini hızlandırır. Bununla birlikte, açıklama etiği, aşırı ticarileşme yoluyla özgünlüğün aşınması ve içerik doğrulama riskleri gibi sorunlar, sağlam yönetim çerçevelerini gerektirmektedir.

Sonuç olarak, mikro-etkileyicilerin ve kullanıcı tarafından oluşturulan içeriğin yükselişi, dijital pazarlamada otoriteye dayalı iknadan topluluk tarafından doğrulanmış güven oluşturmaya doğru paradigmatik bir değişimi işaret etmektedir. Bu katılımcı iletişim kanallarını stratejik olarak düzenleyen markalar, kalıcı tüketici güveni oluşturabilir, etkileşim kalitesini artırabilir ve giderek deneyim odaklı hale gelen dijital pazarlarda sürdürülebilir rekabet avantajı sağlayabilir.

Anahtar Kelimeler: Dijital Pazarlama, Güven Oluşturma, Mikro-Etkileyiciler, Kullanıcı Tarafından Oluşturulan İçerik, Tüketici Etkileşimi, Sosyal Kanıt

Giriş: Dijital Ekosistemde Güven Krizi ve Paradigma Kayması

Dijital devrim, tüketicilerin markalarla etkileşim kurma ve satın alma kararları alma biçimlerini derinden dönüştürmüş; ancak bu teknolojik sıçrama aynı oranda bir "tüketici güveni krizini" de beraberinde getirmiştir. Günümüz tüketicileri, her gün yüzlerce reklam mesajının yarattığı yoğun

bir karmaşaya (ad clutter) maruz kalmakta ve dijital platformların manipülatif algoritmik hedeflemelerine karşı giderek daha fazla savunma mekanizması geliştirmektedir (Baycur Keçeci & Karaca, 2022). Bu savunma mekanizması, literatürde "tüketici sinizmi" (consumer cynicism) olarak adlandırılmakta olup, kurumsal iletişime ve marka kontrollü (firm-generated) mesajlara karşı duyulan yapısal şüpheciliği temsil eder.

Tarihsel olarak pazarlama disiplini, ürün ve hizmetlerin tanıtımında geniş kitlelere ulaşmak için ünlü onaylarına (celebrity endorsements) ve asimetrik otorite figürlerine güvenmiştir. Ancak dijital okuryazarlığı yüksek Z ve Alfa kuşağı tüketicileri, geleneksel ünlülerin ve milyonlarca takipçisi olan makro-etkileyicilerin (macro-influencers) ticari kaygılarla hareket ettiğini net bir şekilde algılamaktadır (Vuković, 2025). Bu durum, eski nesil otoriteye dayalı ikna (authority-based persuasion) yöntemlerinin etkinliğini hızla aşındırmakta ve işletmelerin dijital pazarlama bütçelerinin geri dönüş oranlarını (ROI) düşürmektedir.

Bu şüpheci dijital manzarada marka-tüketici ilişkisini onaracak temel stratejik hamle, iletişimin merkezini markanın kendisinden "topluluğun" (community) kendisine kaydırmaktır. Tam bu noktada, mikro-etkileyiciler (micro-influencers) ve Kullanıcı Türetimli İçerik (User-Generated Content - UGC), markaların hedef kitleleriyle kaybettikleri özgünlüğü (authenticity) ve ilişkisel yakınlığı yeniden kurmalarını sağlayan birincil dinamikler olarak öne çıkmaktadır. Literatürde, makro-etkileyicilerin geniş erişim gücüne (reach) karşılık, daha dar ama spesifik bir kitleye hitap eden mikro-etkileyicilerin çok daha yüksek ve nitelikli bir etkileşim oranı yakaladığı ampirik olarak kanıtlanmıştır (Tafesse & Wood, 2021).

UGC ise, marka iletişimini tek yönlü bir yayın (broadcasting) olmaktan çıkarıp, tüketicileri aktif değer eş-yaratıcıları (co-creators) haline getirerek bu organik güven sürecini tamamlamaktadır. Tüketici deneyimlerine dayalı organik incelemeler ve videolar, algılanan satın alma riskini azaltan güçlü birer elektronik ağızdan ağıza pazarlama (e-WOM) unsuru olarak işlev görmektedir (Usman & Wijaya, 2024; Wang vd., 2025). Bu bildiri, mikro-etkileyicilerin başlattığı ve UGC'nin kitlesel düzeyde doğruladığı bu "katmanlı güven mimarisini" (layered trust architecture), kavramsal bir perspektifle ve güncel ampirik literatür ışığında kapsamlı bir şekilde incelemeyi amaçlamaktadır.

Etkileyici Pazarlamasının (Influencer Marketing) Evrimi ve "Etkileşim Paradoksu"

Etkileyici pazarlaması, dijital çağda ağızdan ağıza iletişimin en kurumsallaşmış hali olarak karşımıza çıkmaktadır. Geleneksel olarak markalar, bütçelerinin büyük bir kısmını "Makro-etkileyiciler" (genellikle 100.000 ile 1.000.000 arası takipçisi olanlar) veya "Mega-etkileyiciler" (1 milyondan fazla takipçisi olan ünlüler) üzerine yoğunlaştırmıştır (Tafesse & Wood, 2021). Makro-etkileyiciler, bir markanın bilinirliğini (brand awareness) kısa sürede devasa kitlelere ulaştırma konusunda eşsiz bir kapasiteye sahiptir.

Ancak akademik araştırmalar, etkileyici pazarlamasında bir "etkileşim paradoksu" (engagement paradox) olduğuna işaret etmektedir. Takipçi sayısı arttıkça, içerik üreticisinin takipçileriyle kurduğu bağın kalitesi ve etkileşim (beğeni, yorum, kaydetme ve dönüşüm) oranları asimetrik bir şekilde düşüş göstermektedir (Tafesse & Wood, 2021). Bunun temel nedeni, makro-etkileyicilerin kitlelerinin son derece heterojen olması ve içeriklerin genellikle yüksek prodüksiyonlu, fazla ticari (commercialized) ve ulaşılamaz bir yaşam tarzı (aspirational) sunmasıdır.

Mikro-Etkileyicilerin Yükselişi: Özgünlük ve Niş Topluluklar

Makro-etkileyicilerin yarattığı bu boşluğu dolduran stratejik aktörler, genellikle 10.000 ile 100.000 arasında takipçisi olan "Mikro-etkileyiciler" ve hatta 10.000'in altında takipçisi olan "Nano-etkileyiciler" olmuştur (Tafesse & Wood, 2021; Wibowo vd., 2024). Mikro-etkileyiciler, kahve tadımı, vegan makyaj ürünleri, yerel seyahat rotaları veya spesifik bir teknolojik donanım gibi oldukça dar, niş ve tutkulu topluluklara hitap ederler.

Bu içerik üreticileri, milyonlarca takipçisi olan bir ünlüden ziyade, "bilgili bir arkadaş" veya "uzman bir komşu" olarak algılanırlar. Kusursuz stüdyo çekimleri yerine ev ortamında, gündelik kıyafetlerle ve doğal bir dille çektikleri videolar, modern tüketicinin en çok açlığını çektiği olguyu sunar: **Özgünlük (Authenticity).** Endonezya'da Z kuşağı tüketicileri üzerinde yapılan güncel bir çalışma, nano ve mikro-etkileyicilerin algılanan gerçekçiliğinin, satın alma niyetini (purchase intention) makro-etkileyicilerden çok daha güçlü bir şekilde tetiklediğini ampirik olarak kanıtlamıştır (Wibowo vd., 2024).

Mikro-etkileyiciler, daha düşük reklam bütçeleri gerektirmesi nedeniyle KOBİ'ler ve pazar meydan okuyucuları (market challengers) için mükemmel bir yatırım getirisi (ROI) ve bütçe esnekliği sağlar. Bir markanın tek bir mega-etkileyiciye ayıracağı bütçeyle, farklı demografik özelliklere sahip 30 farklı mikro-etkileyici ile çalışması, markanın güvenilirliğini çoklu temas noktalarına (multiple touchpoints) yayarak daha organik bir etki haritası çıkarır.

Parasosyal Etkileşim (PSI) Teorisi ve Akran Özdeşleşmesi

Mikro-etkileyicilerin pazarlama hunisindeki (marketing funnel) başarısını ve tüketici zihninde yarattığı benzersiz güveni anlamak için iletişim bilimlerinin temel kuramlarından biri olan "Parasosyal Etkileşim" (Parasocial Interaction - PSI) ve "Parasosyal İlişki" (Parasocial Relationship - PSR) teorilerine başvurmak elzemdir.

Geleneksel pazarlama anlayışında şöhret ve tüketici arasındaki ilişki dikey ve asimetriktir; tüketici yıldıza hayranlık duyar ancak onunla iletişim kuramaz. Oysa sosyal medya ekosisteminde mikro-etkileyiciler, etki güçlerini "akran benzeri özdeşleşmeye" (peer-like identification) borçludurlar (Sheng vd., 2023). Parasosyal etkileşim, izleyicilerin medya karakterleriyle, onların bunu karşılıklı olarak bilmemesine rağmen, tek yönlü ama psikolojik olarak son derece gerçek, empatik ve derin bir arkadaşlık bağı kurmasıdır (Aw vd., 2024).

PSI Aracılığıyla Güven İnşası

Aw ve arkadaşlarının (2024) gerçekleştirdiği kapsamlı sistematik literatür taraması, sosyal medyada parasosyal etkileşimin, tüketicinin bilişsel ve duygusal tepkilerini şekillendiren birincil köprü olduğunu göstermektedir (Aw vd., 2024). Mikro-etkileyicilerin niş topluluklarıyla kurdukları yoğun iletişim, özel mesajlara (DM) verdikleri yanıtlar, yorumlarda takipçilerine isimleriyle hitap etmeleri ve günlük rutinlerini şeffafça (vloglar aracılığıyla) paylaşmaları, tüketicide "bu kişi beni anlıyor ve benim gibi yaşıyor" duygusunu pekiştirir (Wibowo vd., 2024).

Bu yatay hiyerarşi ve erişilebilirlik, mikro-etkileyicinin tanıttığı veya önerdiği bir ürünü, "ücretli bir reklam" olmaktan çıkarıp "güvenilir bir dost tavsiyesi" (peer recommendation) statüsüne yükseltir (Sheng vd., 2023). Tüketiciler, bu kişilerin kendi küçük kitlelerinin güvenini sarsmamak adına, gerçekten inanmadıkları ve deneyimlemedikleri kötü bir ürünü sırf para için tanıtmayacaklarına inanırlar. Wibowo vd. (2024)'nin bulguları, parasosyal bağlar sonucunda oluşan bu derin güvenin, tüketicinin ilgisini doğrudan satın alma eylemine (conversion) çevirmede makro-etkileyicileri geride bıraktığını net bir şekilde ortaya koymaktadır.

Kullanıcı Türetimli İçerik (UGC): Merkezi Olmayan Güvenilirlik ve Tüketim Değeri

Tüketiciler, satın alma süreçlerinde markalarla aralarındaki "bilgi asimetrisini" ortadan kaldırmak için kurumsal web sitelerinden veya pürüzsüz reklamlardan ziyade "diğer tüketicilerin" yaşanmış deneyimlerine odaklanmaktadır. Kullanıcı Türetimli İçerik (User-Generated Content - UGC); ürün incelemeleri, referanslar, kutu açılış (unboxing) videoları, blog yazıları, forum tartışmaları ve

sosyal medya gönderileri gibi tamamen tüketicilerin inisiyatifiyle, organik bir biçimde üretilen dijital varlıklardır (Wang vd., 2025).

Sosyal Kanıt (Social Proof) ve eWOM Olarak UGC

UGC, pazarlama ve tüketici psikolojisi literatüründe "Sosyal Kanıt" (Social Proof) olgusunun dijital alandaki en saf temsilidir. Sosyal Kanıt teorisi, insanların belirsizlik veya kararsızlık durumlarında doğru davranışı belirlemek için diğer insanların (özellikle kendilerine benzeyenlerin) kararlarını ve eylemlerini kopyalama eğiliminde olduğunu savunur (Usman & Wijaya, 2024).

Geleneksel reklamcılık, markanın tüketiciye "benim ürünüm en iyisidir" demesine dayanırken; UGC tabanlı dijital felsefe, binlerce tüketicinin diğer tüketicilere "biz denedik ve bu marka gerçekten sözünü tutuyor" demesidir (Wang vd., 2025). Bu durum, UGC'yi sıradan bir iletişim aracı olmaktan çıkarıp, şirketlerin kontrol edemediği ama devasa bir etkiye sahip "merkezi olmayan güvenilirlik sinyallerine" (decentralized credibility signals) ve Elektronik Ağızdan Ağıza Pazarlamaya (eWOM) dönüştürür (Usman & Wijaya, 2024).

Tüketim Değeri Teorisi Perspektifinden UGC

Vietnam'da sosyal medya kullanıcıları üzerinde yapılan güncel bir araştırma, UGC'nin tüketici üzerindeki etkisini "Tüketim Değeri Teorisi" (Consumption Value Theory) çerçevesinde incelemiştir (Nguyen vd., 2025). Bu teoriye göre, kullanıcıların ürettiği inceleme videoları ve içerikler, potansiyel alıcılara temel olarak üç farklı değer sunar:

1. **Fonksiyonel Değer (Functional Value):** Amatör bir kamerayla çekilmiş bir ürün kullanım videosu, ürünün eksilerini, artılarını, boyutlarını ve gerçek hayattaki performansını filtresiz (unfiltered) bir şekilde göstererek tüketicinin bilgi ihtiyacını karşılar.

2. **Sosyal Değer (Social Value):** Tüketicinin belirli bir topluluğa ait hissetmesini ve diğer kullanıcıların kolektif deneyiminden faydalanmasını sağlar.

3. **Duygusal Değer (Emotional Value):** Ürünü kullanan sıradan bir insanın yaşadığı heyecan veya hayal kırıklığı, izleyicide doğrudan empati ve duygusal rezonans yaratır (Wang vd., 2025).

Yapısal Eşitlik Modellemesi (PLS-SEM) kullanılarak analiz edilen veriler, bu üç değerin toplamının UGC'ye yönelik olumlu tutumu artırdığını ve nihayetinde doğrudan satın alma niyetine (purchase behavior) dönüştüğünü ampirik olarak doğrulamıştır (Nguyen vd., 2025).

En önemlisi UGC, tüketicinin zihnindeki "Algılanan Riski" (Perceived Risk) asgari düzeye indirir. Finansal kayıp yaşama, ürünün kalitesiz çıkması veya beklentiyi karşılamaması gibi endişeler, şeffaf topluluk deneyimleri (community experiences) sayesinde giderilir. Tüketiciler, UGC'yi pazarlama manipülasyonundan uzak, tarafsız ve dürüst bir bilgi kaynağı olarak kodlarlar.

Katmanlı Güven Mimarisi (Layered Trust Architecture): Sinerjik Entegrasyon

Modern dijital pazarlamanın ulaştığı en sofistike nokta, mikro-etkileyicileri veya UGC'yi birbirlerinden bağımsız, izole birer taktiksel araç olarak kullanmak yerine; bu ikisini stratejik olarak entegre eden bir "Katmanlı Güven Mimarisi" (Layered Trust Architecture) inşa etmektir (Lim vd., 2023). Güven, artık markanın tek bir noktadan aşılamaya çalıştığı bir inanç olmaktan çıkıp, tüm dijital ekosistemi ve tüketici yolculuğunu kapsayan yapısal bir döngüye dönüşür.

Bu sinerjik yapı temel olarak iki ana mekanizmanın ardışık çalışmasıyla işler:

1. **Başlatıcı ve İlham Verici Güç (Initiator):** Süreç, niş bir mikro-etkileyicinin, kendi özgün diliyle ve hikaye anlatıcılığıyla (storytelling) marka için bir anlatı (narrative) başlatmasıyla başlar. Akran konumundaki bu yönlendirme, yüksek parasosyal bağ sayesinde tüketicinin dikkatini

anında çeker ve markaya karşı duyulan ilk şüphe/güven bariyerini aşar. Tüketici, ürünü "kendi topluluğundan" birinin referansıyla keşfeder.

2. **Sürdürücü ve Doğrulayıcı Güç (Validator):** Ancak algoritmalar çağında modern ve analitik tüketici, tek bir kişinin referansıyla (bu kişi sevdiği bir mikro-etkileyici olsa bile) yetinmez. Etkileyiciden ilhamı ve sinyali alan tüketici, Arama (Searching) evresine geçerek, ürünü daha önce satın almış bağımsız kullanıcıların forumlardaki yorumlarına, bağımsız platformlardaki e-ticaret yıldızlamalarına (ratings) ve kutu açılış videolarına yönelir. İşte bu noktada organik UGC devreye girer. UGC, mikro-etkileyicinin sunduğu vaadi yığınsal bir zeka ve kolektif bir sosyal kanıtla doğrular (Usman & Wijaya, 2024).

Mikro-etkileyicilerin ateşlediği kıvılcım, devasa UGC üretimleriyle sönmeyen bir marka savunuculuğuna (brand advocacy) dönüşür. Algoritmaların (örneğin TikTok'un "For You" sayfası veya Instagram Reels) etkileşimi yüksek bu organik içerikleri sürekli öne çıkarması, güven sinyallerini aylarca canlı tutar. Bu ikili mekanizmayı orkestre edebilen markalar, kendilerini rakiplerinin kolayca taklit edemeyeceği "görünmez bir şeffaflık zırhına" büründürerek sürdürülebilir rekabet avantajı (SCA) elde ederler.

Etik Yönetişim, Şeffaflık ve Gelecek Beklentileri

Mikro-etkileyiciler ve Kullanıcı Türetimli İçerik (UGC) ekseninde kurulan bu muazzam algısal güç, dikkatli ve ahlaki bir zeminde yönetilmediğinde sistemin çökmesine neden olabilecek ciddi riskler barındırmaktadır. Pazarlamanın bu yeni boyutunun sürdürülebilirliği, salt teknik bir kampanya planlamasının ötesinde, katı bir "etik veri ve iletişim yönetişimi" gerektirir (Vuković, 2025).

En büyük tehlike, mikro-etkileyicilerin en büyük silahı olan "özgünlüğün" (authenticity) aşırı ticarileşme (over-commercialization) yoluyla erozyona uğramasıdır. Marka ile içerik üreticisi arasındaki finansal iş birliklerinin tüketiciden gizlenmesi, sponsorlu içeriklerin (paid partnerships) tüketiciye açıkça beyan edilmemesi (ifşa etiği - disclosure ethics) modern pazarlamanın en kritik sorunudur.

Vuković (2025) tarafından yayınlanan güncel bir araştırma, Z ve Alfa kuşağı tüketicilerinin "örtülü reklamcılığa" (covert advertising) karşı son derece duyarlı ve tepkili olduğunu göstermektedir. Tüketiciler, parasosyal bir bağ kurdukları etkileyici tarafından manipüle edildiklerini veya markanın sahte/paralı kullanıcı yorumları (fake UGC / astroturfing) ile platform algoritmalarını yanılttığını fark ettiklerinde, marka sadakati anında derin bir nefrete (brand hate) ve kitlesel boykota dönüşmektedir (Vuković, 2025).

Ayrıca teknolojinin geldiği son noktada, tamamen yapay zeka tarafından piksellerle üretilen ve milyonlarca takipçisi olan "Sanal Etkileyicilerin" (AI influencers) yükselişi, etik tartışmalara yepyeni bir boyut kazandırmıştır (Vuković, 2025). Gerçeklik ile simülasyon (deepfake) arasındaki sınırların giderek bulanıklaştığı bu çağda, hangi içeriğin gerçekten bir insan deneyimi (organik UGC), hangisinin ise sentetik bir reklam olduğunun şeffafça etiketlenmesi, tüketici haklarının korunması açısından küresel bir regülasyon meselesi haline gelmiştir.

İşletmeler, uzun vadeli hayatta kalabilmek için içeriklerin kökenini, fonlama yapısını ve sponsorluk bağlarını açıkça belli eden "Radikal Şeffaflık" ilkelerini (Lim vd., 2023) benimsemek zorundadır. Tüketicinin zannettiğinin aksine şeffaflık (bir içeriğin sponsorlu olduğunun dürüstçe belirtilmesi), güveni azaltmaz; tam aksine, markanın manipülasyona ihtiyaç duymayacak kadar ürününe güvendiğinin bir işareti olarak uzun vadeli güveni tahkim eder.

Sonuç ve Yönetsel Çıkarımlar

Dijital tüketim mimarisinde yaşanan eşi benzeri görülmemiş dönüşüm, pazarlamanın geleneksel sınırlarını ve kurallarını geri döndürülemez biçimde değiştirmiştir. Sadece devasa bütçelere ve asimetrik kurumsal otoriteye dayalı, tek yönlü dayatmacı iletişim (push marketing) dönemi kapanmış; yerini katılımcı, şeffaf, deneyime dayalı ve tamamen "topluluk tarafından onaylanan" karşılıklı bir değer yaratım sürecine bırakmıştır.

Bu yeni dönemin başrol oyuncuları olan mikro-etkileyiciler, tüketicilere ulaşılamaz ve kusursuz idealleri satmak yerine; sahip oldukları yatay hiyerarşi, samimiyet ve güçlü parasosyal ilişkiler ağı sayesinde tüketicilere birer güvenilir "akran" (peer) olarak yaklaşmaktadırlar. İşletmelerin bu niş topluluk önderleriyle kuracakları doğru iş birlikleri, makro kampanyaların ulaşamadığı derinlikte bir dönüşüm (conversion) ve marka sadakati yaratma potansiyeline sahiptir.

Diğer yandan Kullanıcı Türetimli İçerik (UGC), bu akran tavsiyesini çok daha geniş çaplı, merkezi olmayan bir yığınsal zeka ve kolektif deneyimle desteklemektedir. Modern tüketici karar alma yolculuğunda UGC, satın alma eylemindeki finansal ve psikolojik algılanan riski yok eden, Tüketim Değeri Teorisi çerçevesinde fonksiyonel ve duygusal fayda sağlayan en güçlü sosyal kanıttır.

Sonuç olarak markalar için temel hedef, sadece bir mecrada reklam yayınlamak değil; mikro-etkileyicilerin özgün tetikleyiciliğini ve organik UGC üretiminin doğrulayıcı gücünü birbirini besleyecek şekilde entegre eden "katmanlı bir güven mimarisi" (layered trust architecture) inşa etmektir. Bunu başarırken etik ifşa standartlarına uyan, örtülü reklamcılıktan kaçınan ve tüketicisine şeffaf davranan işletmeler, yalnızca kısa vadeli satış metriklerine ulaşmakla kalmayacak; aynı zamanda dijital pazarın en değerli ve taklit edilemez metası olan "tüketici güvenini" sürdürülebilir bir rekabet avantajına (SCA) dönüştüreceklerdir.

Kaynakça

Aw, E. C. X., Chuah, S. H. W., & Sabri, E. (2024). Consumers' parasocial interactions and parasocial relationships with online influencers: A systematic review and future research agenda. *Journal of Consumer Marketing*, 41(4), 540-562. https://doi.org/10.1108/JCM-02-2024-6611

Baycur Keçeci, G., & Karaca, H. S. (2022). Reklamlardaki ünlülerden sosyal medyadaki fenomenlere: Influencer pazarlamasına bütüncül bir bakış. *Pazarlama ve Pazarlama Araştırmaları Dergisi*, 15(1), 271-320. https://dergipark.org.tr/tr/pub/ppad/article/994788

García, M. L., [ve diğerleri]. (2024). User-Generated Content and Perceived Risk. *Sustainability*, 18(3), 1601. https://www.mdpi.com/2071-1050/18/3/1601

Lim, [ve diğerleri]. (2023). Layered trust architecture. *Politecnico di Torino Webthesis*, 39. https://webthesis.biblio.polito.it/39046/1/tesi.pdf

Nguyen, [ve diğerleri]. (2025). The impact of user-generated content on consumer purchase behavior: the framework of consumption value theory. *Cogent Business & Management*. https://www.tandfonline.com/doi/full/10.1080/23311975.2025.2471528

Sheng, [ve diğerleri]. (2023). Parasocial relationships with micro-influencers: Do sponsorship disclosure and electronic word-of-mouth disrupt? *Journal of Retailing and Consumer Services*, 74, 103429.

Tafesse, W., & Wood, B. P. (2021). Followers' engagement with Instagram influencers. *Cogent Business & Management*, 8(1), 1913490. https://www.tandfonline.com/doi/full/10.1080/23311975.2024.2419501

Usman, O., & Wijaya, C. N. S. (2024). The impact of Social Proof and User-Generated Content (UGC) on brand perception among digital consumers. *Jurnal Inovasi Pendidikan Ekonomi*, 13. https://journal.unj.ac.id/unj/index.php/isc-beam/article/view/51929

Vuković, D. (2025). The ethics of influencer marketing: An analysis of transparency and accountability in digital advertising. *MAP Social Sciences*.

Wang, [ve diğerleri]. (2025). The Impact of User-Generated Content on Consumer Trust and Brand Loyalty.

Wibowo, [ve diğerleri]. (2024). Nano and micro-influencers on Instagram Reels: Effect on purchase intention with the mediating role of trust. *Communica*. https://journal.idscipub.com/index.php/communica/article/download/781/645

Two-Dimensional Harmonic Patterns in Cyclic Human Movements

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Abstract

Cyclic human movements – walking gaits, for instance – were very recently found, with their given internal sub-phases, to be characterized, from a temporal point of view, by the existence of coordinatively mechanized and self-similar harmonic fractal patterns. Such harmonic patterns are implicitly defined by the golden ratio, when it occurs as the ratio of the sub-phases durations, symmetrized in time so as to compose a generalized Fibonacci sequence: the lowest amount of information for the movement temporal design (Shannon entropy minimization) makes one sub-phase duration of the movement generate an entire sequence of sub-phase durations of the same movement. However, different spatial profiles might correspond to identical temporal partitions, suggesting the presence of an additional optimization principle that acts within the spatial domain. This brief aims at suggesting what is beyond the aforementioned temporal characterization, namely, a second optimization dimension that provides an interpretation of how the neuromuscular system organizes complex repetitive movements.

Keywords: Two-Dimensional Optimization, Generalized Fibonacci sequence, Self-similarity, Golden Ratio.

1 Fibonacci sequences and golden ratio in movements

The golden ratio is an irrational number $\phi = (1+\sqrt{5})/2 \cong 1.618$, likely first identified by the Ancient Greeks. It constitutes the ratio between the diagonal and the side of a regular pentagon. It is also the solution to the problem of dividing a line segment such that the ratio of the whole segment to the longest part is equal to the ratio of the longest part to the shortest. In human anthropometry, it approximates the ratio between a person's height and the distance from the navel to the feet. The Greeks quickly recognized this proportion as a hallmark of harmonic structures and incorporated it into their artistic and architectural endeavors. Further mathematical properties of the golden ratio were uncovered, such as its connection to the Fibonacci sequence.

Generalized Fibonacci sequences [1] are sequences of numbers that are generated by the first two elements (called seeds) *via* the following generation rule: from the third number, every element of the sequence is the sum of the previous two [2], [3]. Indeed, in symmetric walking, the stance duration (third element of the sequence) is the sum of the double support and swing durations (first and second elements of the sequence, respectively) and, in turn, the duration of the entire gait cycle (fourth element of the sequence) is the sum of the stance and swing durations [2], [3].

Furthermore, the golden ratio was found to characterize hidden self-similar patterns: all the ratios between two consecutive elements of the sequence (namely, the durations of the sub-phases of the repetitive movement) are surprisingly equal. The temporal partition of a movement into phases that maintain the same proportion in their ratios appears to be an optimization strategy, namely, the Shannon entropy minimization SEM (see [4] for addressing the motor equivalence problem associated with the coordinated control of numerous degrees of freedom). Although the previously described mechanisms account for the harmonic temporal organization of movement, they are not able to explain how spatial trajectories – such as limb paths – respecting the self-similar timing are shaped to produce fluid and non-redundant patterns. Indeed, since different spatial profiles might give rise to identical temporal partitions, a second optimization rule must underlie the spatial dimension of human movement. Such a question is somehow associated with the praxis system [5] that concerns cognitive and motor processes enabling skilled movements interacting with the environment.

2 Original brief contribution

This brief proposes an answer to such an open question. Using human gait as an archetypal cyclic and

harmonic movement, we uncover a principle that governs spatial coordination, at the timing provided by SEM (T-SEM), through the generation of maxima-minima in the space domain and the T-SEM-sub-phase jerk minimization & smooth transition among the T-SEM-sub-phases, with jerk impulsive actions occurring at the T-SEM-sub-phase transition instants. Such a second optimization dimension, besides the time-optimization one, is assumed to simultaneously cover, in highly coordinated movements, all the body dynamical compartments, and it is shown to be related to the movement space-shaping and fluidity enhancement. Indeed, movement smoothness, which jerk minimization corresponds to, is a pivotal parameter for assessing the quality of human motion, reflecting its fluidity and continuity [6] (see also [7]). A movement is smooth when it is performed in a continuous fashion without any interruptions or peaks in its accelerations. Smoothness is often considered a positive characteristic feature of healthy and well-trained motor behaviour [8]. Neural development in children [9], motor learning [10], and neurorehabilitation [11] work to increase the smoothness of movements. The importance of performing smoothed movements is related to its intrinsic effect on effort minimization, sensorimotor control facilitation, and also multi-joint coordination [12]. This capacity of the sensorimotor control to synthesize and to combine individual motor impulses into integral kinesthetic structures without any dystonia is also called kinetic melody [13]. Despite its importance in sensorimotor control, smoothness of movement is often considered to be associated with the quality of movements, and some indices have been suggested for the assessment of smoothness of movements, such as the normalized jerk (that is, the temporal derivative of acceleration) [14].

The result of this brief is stated as:

given an ordered set Σ *of specific (T-SEM) instants characterizing the sub-phases of a coordinatively mechanized and self-similar (repetitive) human walking gait,* C^1*- connecting the images of the elements of a proper subset* Σ_s *of* Σ*, through portions of (zero-jerk) second-degree polynomials of time t whose maxima/minima are attained at some elements of* $\Sigma - \Sigma_s$*, accurately reconstructs a space-time profile of a limb or a part of it involved in the walking gait.*

It moves along the direction of the latest [15], highlighting the importance of the link between cognitive functions and motor skills.

In particular, the following percentages (with respect to the gait cycle duration) have been shown in [2] to characterize, from a temporal point of view, coordinatively mechanized and self-similar (repetitive) gait cycles: 7.2955%; 11.804%; 26.395%.; 61.804%; 76.395%. In addition, the following points come from the three-times-Fibonacci-extendability condition in [4] applied to the partition of each swing phase equalling the double support phase within the first and second swings: 40.982%; 90.982%. Now, taking the knee flexion angle as a representative of all the body dynamical compartments, the above reconstruction process relies on:

1. associating sewing points with the percentages 57.2955%, 61.804%, and 90.982% of the knee flexion angle profile (second half of the walking gait), besides the maximum point already associated with the percentage 76.395%;
2. associating sewing points with the percentages 7.2955%, and 26.395% of the knee flexion angle profile (first half of the walking gait), besides the maximum and minimum points associated with the percentages 11.804% and 40.982%, respectively;
3. using elementary five time functions $a_i t^2 + b_i t + c_i$, $i = 1, 0, 1, 2, 3$, for which jerk is minimized to zero (constant-acceleration sub-phase), to connect all the (consecutive) four sewing points;
4. carrying out a C^1-sewing of the elementary time functions to obtain an overall continuous function, with continuous derivative, provided that the final point equals the initial one for movement repetitivity. In technical terms:

$$a_{-1}t^2 + b_{-1}t + c_{-1}|_{t=7.2955\%} = a_0t^2 + b_0t + c_0|_{t=7.2955\%} \quad (1)$$
$$a_0t^2 + b_0t + c_0|_{t=26.395\%} = a_1t^2 + b_1t + c_1|_{t=26.395\%} \quad (2)$$
$$a_1t^2 + b_1t + c_1|_{t=57.2955\%} = a_Et^2 + b_Et + c_E|_{t=57.2955\%} \quad (3)$$
$$a_Et^2 + b_Et + c_E|_{t=61.804\%} = a_2t^2 + b_2t + c_2|_{t=61.804\%} \quad (4)$$
$$a_2t^2 + b_2t + c_2|_{t=90.982\%} = a_3t^2 + b_3t + c_3|_{t=90.982\%} \quad (5)$$
$$2a_{-1}t + b_{-1}|_{t=7.2955\%} = 2a_0t + b_0|_{t=7.2955\%} \quad (6)$$
$$2a_0t + b_0|_{t=26.395\%} = 2a_1t + b_1|_{t=26.395\%} \quad (7)$$
$$2a_1t + b_1|_{t=57.2955\%} = 2a_Et + b_E|_{t=57.2955\%} \quad (8)$$

$$2a_E t + b_E|_{t=61.804\%} = 2a_2 t + b_2|_{t=61.804\%} \quad (9)$$

$$2a_2 t + b_2|_{t=90.982\%} = 2a_3 t + b_3|_{t=90.982\%} \quad (10)$$

$$2a_0 t + b_0|_{t=11.804\%} = 0 \quad (11)$$

$$2a_1 t + b_1|_{t=40.982\%} = 0 \quad (12)$$

$$2a_2 t + b_2|_{t=76.395\%} = 0 \quad (13)$$

$$a_{-1}t^2 + b_{-1}t + c_{-1}|_{t=0} = a_3 t^2 + b_3 t + c_3|_{t=100\%} \quad (14)$$

$$a_E t2 + b_E t + c_E|_{t=t^-} = d \quad (15)$$

where r is in the set (57.2955 %, 61.804 %), d is the value of the portion $a_E t^2+b_E t+c_E$ at time r, owing to the elastic return (E stands for elastic here). The above system of fifteen equations in fifteen unknowns (a_{-1}, b_{-1}, c_{-1}, d are considered as known boundary conditions) admits a unique solution (the corresponding matrix is invertible and owns the determinant

$$D=8(p_1 - t_0)(p_2 - t_1)(p_3 - t_2)(p_4 - t_E)(t_3 - 1)^2,$$

where $t_0 = 0.072955$; $t_1 = 0.26395$; $t_E = 0.572955$, $t_2 = 0.61804$; $t_3 = 0.90982$; $p_1 = 0.11804$; $p_2 = 0.40982$; $p_3 = 0.76395$, $p_4 = 0.6$).

3 Experimental examples

Two experimental examples are reported to illustrate the derivations of this brief.

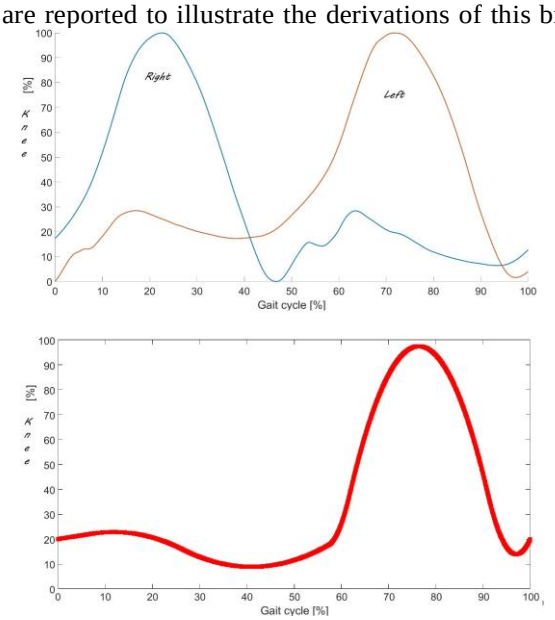


Fig. 1: *Illustrative example 1*: healthy subject carrying out, at a comfortable speed, a 20-meter walking test: knee flexion angle profile (right and left leg) and reconstructed profile.

3.1 Healthy subject (reconstruction)

Consider a healthy subject carrying out, at a comfortable speed, a 20-meter walking test while wearing wearable sensors of the motion capture system Movit System G1 (Captiks, Rome, Italy) for movement capture and analysis [16]. Figure 1 reports the knee flexion angle profile (right and left leg) and the satisfactorily reconstructed profile according to (1)-(15) (with $a_{-1} = -3$, $b_{-1} = 30$, $c_{-1} = 20$, $d = 26.2$).

3.2 PD patient

One of the PD patients in [15], recruited from the Day Hospital Department of the IRCCS San Raffaele (Rome, Italy), which is equipped with the Movit System G1 by Captiks for Motion Capture and Motion Analysis (Captiks s.r.l., Rome, Italy), is considered. He carried out conventional outpatient

multidisciplinary rehabilitation and underwent clinical and instrumented gait assessments at baseline (T0) and one-month later (T1). The measurements (at T0 and T1) were acquired in the "ON" phase, i.e., 60 +/- 20 minutes after oral intake of the usual dose of Levodopa, and always in the morning to minimize variability. The subject followed stabilized pharmacological treatment. He carried out a 6-Minute Walk Test along a 15-meter corridor using wearable inertial sensors. Figure 2 reports the knee flexion angle profiles (right and left leg at the gait cycle and its adjoint) at times T0 and T1. As it can be recognized (except for some portions in which calibration has been lost), the effect of the rehabilitation is, apparently, to make the knee profile of the PD patient better resemble the knee profile of a healthy subject (as previously shown).

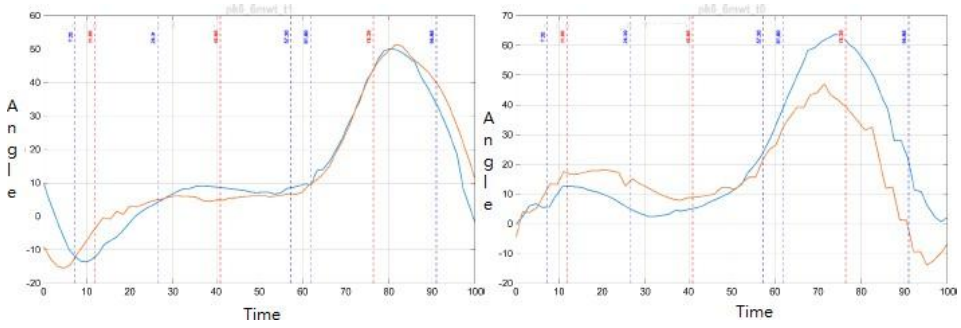


Fig. 2: *Illustrative example 2*: PD subject carrying out, at a comfortable speed, a 15- meter walking test: knee flexion angle profiles at T0 and T1.

4 Concluding remarks

From a scientific point of view, the results of this brief offer a new interpretative key for understanding cyclical movements, suggesting that the motor system spontaneously tends to converge towards solutions that combine temporal simplicity and spatial efficiency. In practical terms, the idea of a double constraint -– temporal and spatial -– can be translated into quantitative tools useful for evaluating movement. Indices based on a combination of temporal entropy and smoothness could offer a more complete measurement of movement quality, identifying deviations from the ideal structure at an early stage. This also has direct implications in the clinical field: pathological or non- optimized movements often show a deterioration in temporal regularity or an increase in spatial jerk, making these parameters potential sensitive markers for neuromotor disorders. It is worth, finally, emphasizing that the approach of this brief is going to be extended, in a straightforward fashion, to the tennis and swimming fields in exact accordance with the derivations of [4].

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References

1. Horadam, A.F.: A generalized F ibonacci sequence. The American Mathematical Monthly **68**, 455–459 (1961)
2. Verrelli, C.M., Iosa, M., Roselli, P., Pisani, A., Giannini, F., Saggio, G.: Generalized finite-length Fibonacci sequences in healthy and pathological human walking: Comprehensively assessing recursivity, asymmetry, consistency, self-similarity, and variability of gaits. Frontiers in Human Neuroscience, Motor Neuroscience (2021)
3. Verrelli, C.M., Romagnoli, C., Jackson, R.R., Ferretti, I., Annino, G., Bonaiuto, V.: Front crawl stroke in swimming: Ratios of phase durations and self-similarity. Journal of Biomechanics **118** (2021)
4. Verrelli, C.M., Caprioli, L., Iosa, M.: Hidden time-patterns in cyclic human movements: a matter of temporal Fibonacci sequence generation and harmonization. Frontiers in Human Neuroscience **19**(1525403) (2025)

5. Hurt, J.J.: The Neurobiology of Cognition and Behavior. Oxford University Press, New York (2016)

6. Caselli, E., Vottero, A., Pieraccini, S., P., S., Gastaldi, L.: Evaluation of human movement smoothness and influence of signal processing techniques. In: Isabel L. Nunes (eds) Human Factors and Systems Interaction. AHFE (2025) International Conference. AHFE Open Access **192** (2025)

7. Caprioli, L., Campoli, F., Edriss, S., Padua, E., Romagnoli, C., Bonaiuto, V., Annino, G.: Effect of whole-body vibration on sports performance: A literature review. In: Engineering Methodologies for Medicine and Sport, Rome, February 7-9 2024, R. Montanari et al. (Eds.): EMMS 2024, Springer Nature Switzerland (2024)

8. Sejnowski, T.J.: Neurobiology: Making smooth moves. Nature **394**(6695), 725–726 (1998)

9. Berthier, N.E., Keen, R.: Development of reaching in infancy. Exp Brain Res. **169**(4), 507–518 (2006)

10. Balasubramanian, S., Melendez-Calderon, A., Burdet, E.: A robust and sensitive metric for quantifying movement smoothness. IEEE Trans Biomed Eng. **59**(8), 2126–2136 (2012)

11. Krebs, H.I., Hogan, N., Aisen, M.L., Volpe, B.T.: Robot-aided neurorehabilitation. IEEE Trans Rehabil Eng. **6**(1), 75–87 (1998)

12. Harris, C.M., Wolpert, D.M.: Signal-dependent noise determines motor planning. Nature **394**(6695), 780–784 (1998)

13. Luria, A.R.: The Working Brain. Harmondsworth, Middlesex, England: Penguin Books, 1973

14. Pascucci, S., Forte, G., Angelini, E., Marinozzi, F., Bini, F., Antonucci, G., Iosa, M., Tieri, G.: Michelangelo effect in virtual sculpturing: Prospective for motor neurorehabilitation in the metaverse. Journal of cognition **7**(1), 17 (2024)

15. Cocco, E.S., Thouant, C.-L., L., P., Infarinato, F., M., M.C., Romano, P., Torcisi, R., Franceschini, M., Verrelli, C.M., Pournajaf, S.: New gait performance indices and cognitive functions: A pilot study on correlation in people with Parkinson's disease. Frontiers in Human Neuroscience, Motor Neuroscience (2025)

16. El Arayshi, M., Verrelli, C.M., Saggio, G., Iosa, M., Gentile, A., Chessa, L., Ruggieri, M., Polizzi, A.: Performance index for in-home assessment of motion abilities in ataxia telangiectasia: A pilot study. Applied Sciences **12**(8), 4093 (2022)

VALORIZATION OF WASTE COOKING OILS INTO BIODIESEL. PROCESS PERFORMANCE COMPARED WITH VIRGIN VEGETABLE OILS

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ABSTRACT

The growing demand for sustainable and renewable energy carriers has intensified research into fuel alternatives derived from biological feedstocks. One of the most widely adopted production routes involves the alkaline-catalyzed transesterification of triglyceride-based oils with short-chain alcohols, typically methanol. This study examines the transesterification behavior of several feedstocks, including sunflower oil, soybean oil, olive oil, and waste cooking oil, with the objective of assessing process performance and product quality.

The transesterification step plays a decisive role in determining conversion efficiency and final fuel properties, as incomplete reactions between oil and methanol may lead to reduced yields and substandard fuel characteristics. Key operational parameters influencing reaction outcomes were investigated, including catalyst loading, methanol-to-oil ratio, free fatty acid (FFA) content, reaction temperature, reaction time, and stirring speed. Experimental observations indicate that operation at 65 °C resulted in lower methyl ester yields, while excessive agitation promoted saponification, thereby negatively affecting product recovery.

Under optimized operating conditions, the produced fuel complied with SNI specifications and ASTM D6751 requirements with respect to density, kinematic viscosity, cetane index, and flash point. These results underline the strong dependence of conversion efficiency and fuel quality on feedstock type and process conditions, particularly when waste-derived oils are employed, and highlight the importance of systematic process optimization for sustainable fuel production.

Keywords: waste cooking oil , crude oil, virgin oil, biodiesel, transesterification.

Introduction

The global energy sector is currently undergoing a significant transition driven by increasing energy demand, environmental concerns, and the gradual depletion of fossil fuel resources. Rapid population growth, industrial expansion, and urbanization have considerably increased global

energy consumption. For decades, this demand has been largely satisfied by fossil fuels such as petroleum, coal, and natural gas. However, the continuous reliance on these resources has raised serious environmental and sustainability concerns. Fossil fuels are finite in nature, and their combustion releases substantial quantities of greenhouse gases that contribute to climate change, atmospheric pollution, and environmental degradation. Consequently, the search for sustainable and environmentally friendly energy sources has become a global research priority (Singh et al., 2021; Lopresto, 2024).

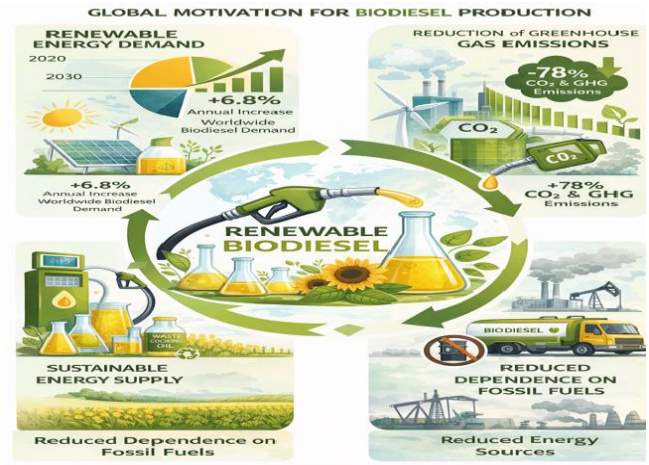


Figure 1. Environmental benefits of biodiesel compared with petroleum diesel, including reductions in carbon monoxide (CO), particulate matter (PM), sulfur oxides (SOx), and greenhouse gas emissions.

Among the various renewable energy alternatives, biofuels have emerged as promising solutions capable of reducing dependence on fossil fuels. Biodiesel, in particular, has gained significant attention because of its renewable origin, environmental compatibility, and suitability for use in conventional diesel engines with minimal modifications (Singh et al., 2021). Biodiesel primarily consists of fatty acid methyl esters (FAME), which are produced from triglyceride-containing feedstocks such as vegetable oils, animal fats, and waste oils through a chemical process known as transesterification. In this reaction, triglycerides react with short-chain alcohols, most commonly methanol or ethanol, resulting in biodiesel and glycerol as a by-product (Kumar et al., 2025).

Compared with petroleum diesel, biodiesel exhibits several favorable environmental and physicochemical properties. Biodiesel is biodegradable, less toxic, and provides improved lubricity that enhances engine performance and reduces engine wear. In addition, the combustion of biodiesel generally produces lower emissions of harmful pollutants such as carbon monoxide, particulate matter, sulfur oxides, and unburned hydrocarbons, thereby contributing to improved air quality and reduced environmental pollution (Banga et al., 2023; Singh et al., 2021).

The most commonly used technique for biodiesel production is alkaline-catalyzed transesterification. In this process, triglycerides present in oils react with alcohol in the presence of alkaline catalysts such as sodium hydroxide (NaOH) or potassium hydroxide (KOH). Methanol is generally preferred due to its relatively low cost, high reactivity, and favorable physical properties, including low viscosity and molecular weight (Farouk et al., 2024). Under optimized conditions, the transesterification reaction is typically conducted at moderate temperatures between 60 and 65 °C and can achieve high conversion efficiencies within relatively short reaction times (Osman et al., 2024).

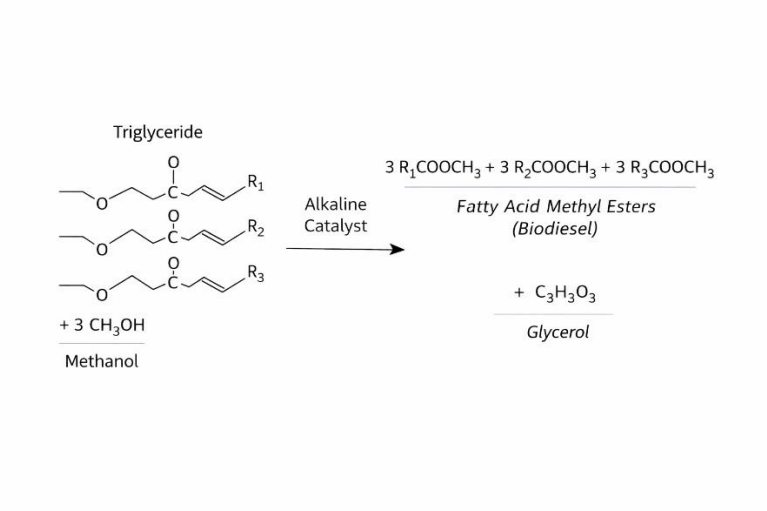


Figure 2. Reaction scheme of transesterification

Feedstock selection plays a crucial role in determining biodiesel production efficiency and economic feasibility. Traditionally, biodiesel has been produced from edible vegetable oils such as sunflower oil, soybean oil, and olive oil because of their high triglyceride content and low levels of free fatty acids (FFA). These characteristics allow direct alkaline transesterification with minimal pretreatment requirements (Kumar et al., 2025). However, several studies have reported differences in biodiesel production efficiency and fuel properties when comparing virgin vegetable oils with waste cooking oils (Mazrreku et al., 2020).

Despite their suitability for biodiesel production, the use of edible vegetable oils raises economic and ethical concerns. Since these oils are also important food resources, their diversion to fuel production contributes to the widely discussed “food versus fuel” debate. Additionally, the relatively high market cost of edible oils significantly increases biodiesel production costs, which remains one of the major obstacles to large-scale commercialization (Singh et al., 2021).

To address these challenges, increasing attention has been directed toward alternative low-cost feedstocks such as waste cooking oil (WCO). Waste cooking oil is generated in large quantities by households, restaurants, and food processing industries. Improper disposal of these oils can lead to serious environmental problems, including water contamination, sewer blockages, and soil pollution. Therefore, converting waste cooking oil into biodiesel provides both environmental and economic benefits by reducing pollution while simultaneously supplying a low-cost feedstock for renewable fuel production (Tulashie et al., 2024; Santander-Bossio et al., 2025). Experimental studies have also demonstrated the potential use of waste oil seeds and residues for biodiesel production (Mazrreku et al., 2019).

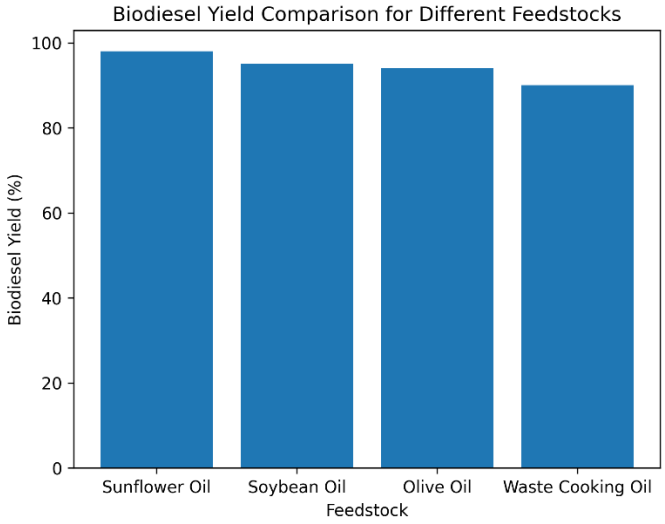


Figure 3. Yield comparison graph (Sunflower, Soybean, Olive, Waste Cooking Oil)

However, the utilization of waste cooking oil presents several technical challenges. During cooking processes, oils undergo thermal degradation and oxidation reactions that increase the levels of free fatty acids, water, and other impurities such as phospholipids and polymerized compounds. As a result, waste cooking oil typically contains higher FFA levels than fresh vegetable oils (Banga et al., 2023). Elevated FFA concentrations interfere with alkaline transesterification because free fatty acids react with alkaline catalysts to form soap through saponification reactions. Soap formation can reduce biodiesel yield, consume catalyst, promote emulsion formation, and complicate the separation of biodiesel from glycerol (Farouk et al., 2024).

To improve the efficiency of biodiesel production from waste oils, pretreatment processes such as acid-catalyzed esterification are commonly applied to reduce FFA levels before transesterification. Recent studies have also explored laboratory-scale biodiesel production approaches using modeling and simulation techniques to optimize reaction conditions and improve process efficiency (Mazrreku et al., 2023a). In addition, the valorization of waste cooking oil as a feedstock for biodiesel production has been proposed as an effective strategy for waste management and renewable energy generation (Mazrreku et al., 2023b).

Another important aspect of biodiesel production is the utilization of glycerol produced as a by-product during the transesterification process. Recent research has examined the analysis and modeling of bio-glycerin production from waste cooking oils, highlighting its potential value within circular economy frameworks (Mazrreku et al., 2025).

With the increasing global emphasis on sustainable development and circular economy principles, the conversion of waste materials into valuable energy resources has become increasingly important. The transformation of waste cooking oil into biodiesel represents a practical strategy for improving the sustainability of biofuel production while simultaneously reducing environmental pollution and lowering feedstock costs.

Therefore, understanding the influence of different feedstocks on biodiesel production performance is essential. Comparing biodiesel derived from virgin vegetable oils with biodiesel produced from waste cooking oil can provide valuable insights into reaction efficiency, production yield, and fuel quality characteristics.

Accordingly, the objective of this study is to investigate the conversion of waste cooking oil into biodiesel and to compare its transesterification performance with selected virgin vegetable oils, including sunflower oil, soybean oil, and olive oil. The study focuses on evaluating feedstock

characteristics, reaction conditions, biodiesel yield, and fuel properties in order to identify effective strategies for sustainable biodiesel production.

Biodiesel Production via Transesterification

Reaction Principle

Biodiesel is commonly produced through the transesterification reaction, in which triglycerides contained in vegetable oils or animal fats react with short-chain alcohols, typically methanol or ethanol, in the presence of a catalyst. The reaction converts triglycerides into fatty acid methyl esters (FAME), which constitute biodiesel, and glycerol as a by-product. (Kumar et al., 2025; Farouk et al., 2024).

Alkaline catalysts such as sodium hydroxide (NaOH) and potassium hydroxide (KOH) are widely employed due to their high catalytic activity and relatively mild reaction conditions. Compared with acid-catalyzed processes, alkaline transesterification offers several advantages, including higher reaction rates, shorter reaction times, and lower operational costs. Under optimized conditions, biodiesel yields exceeding 95% can be achieved.

The reaction is typically carried out at temperatures close to the boiling point of methanol, generally between 60 and 65°C, to enhance reaction kinetics while minimizing methanol evaporation and undesirable side reactions. Proper control of reaction parameters such as catalyst concentration, alcohol-to-oil molar ratio, temperature, and mixing intensity is essential for maximizing biodiesel conversion efficiency.

Feedstock Characteristics

Virgin Vegetable Oils

Virgin vegetable oils such as sunflower oil, soybean oil, and olive oil are widely used feedstocks for biodiesel production due to their favorable physicochemical properties and high triglyceride content (Singh et al., 2021). These oils typically contain more than 96 wt% triglycerides and exhibit free fatty acid (FFA) concentrations below 0.5 wt%, allowing direct alkaline transesterification without significant pretreatment (Kumar et al., 2025).

Due to their relatively stable chemical composition and low impurity levels, virgin oils provide consistent reaction performance and biodiesel yields often exceeding 95% under optimized conditions (Mazrreku et al., 2020).

However, the use of edible vegetable oils for biodiesel production raises concerns related to economic feasibility and competition with food resources, which has motivated the exploration of alternative feedstocks such as waste cooking oils (Lopresto, 2024).

Waste Cooking Oil

Waste cooking oil (WCO) has attracted considerable attention as a promising feedstock for biodiesel production due to its low cost and environmental benefits (Tulashie et al., 2024; Santander-Bossio et al., 2025). Large quantities of WCO are generated globally by households, restaurants, and food industries, and improper disposal can lead to severe environmental pollution.

Compared with virgin vegetable oils, waste cooking oil typically contains higher free fatty acid levels ranging from 2 to 8 wt%, as well as water, phospholipids, carbonaceous residues, and products of thermal degradation formed during repeated cooking cycles (Banga et al., 2023; Lopresto, 2024).

These impurities complicate biodiesel production because free fatty acids react with alkaline catalysts to form soap through saponification reactions, resulting in catalyst consumption,

emulsion formation, and difficulties in product separation (Singh et al., 2021; Osman et al., 2024). Therefore, pretreatment processes are usually required before transesterification.

Two-Step Biodiesel Production Process for Waste Cooking Oil

Due to the elevated free fatty acid content in waste cooking oil, biodiesel production from this feedstock commonly requires a two-step conversion process consisting of acid esterification followed by alkaline transesterification (Tulashie et al., 2024).

Acid Esterification

The first stage involves acid-catalyzed esterification, where free fatty acids react with methanol in the presence of an acid catalyst, commonly sulfuric acid (H_2SO_4), to form esters. This step significantly reduces the FFA concentration below 0.5 wt%, thereby preventing soap formation during the subsequent alkaline transesterification stage (Banga et al., 2023; Santander-Bossio et al., 2025).

The esterification reaction is typically carried out at temperatures between 55 and 65°C under continuous mixing to enhance mass transfer between the reactants.

Alkaline Transesterification

After reducing the FFA level, the treated oil undergoes alkaline transesterification, where triglycerides react with methanol in the presence of NaOH or KOH catalysts. During this reaction, triglycerides are converted into fatty acid methyl esters (biodiesel) and glycerol (Kumar et al., 2025; Farouk et al., 2024).

Experimental Parameters Affecting Biodiesel Production

The efficiency of biodiesel production and the quality of the final product are strongly influenced by several operational parameters (Singh et al., 2021; Osman et al., 2024).

Catalyst concentrations typically range between **0.5 and 1.5 wt%** relative to the oil mass. Excess catalyst can promote soap formation and complicate purification processes (Banga et al., 2023).

A molar ratio of **6:1 methanol to oil** is commonly applied to shift the reaction equilibrium toward biodiesel formation and improve conversion efficiency (Farouk et al., 2024).

The optimal reaction temperature is generally **60–65°C**, which enhances reaction kinetics without causing excessive methanol evaporation (Kumar et al., 2025).

For virgin vegetable oils, reaction times of **1–2 hours** are generally sufficient to achieve high conversion rates, whereas waste cooking oils may require longer reaction times due to impurities affecting mass transfer (Mazrreku et al., 2023a).

Proper mixing improves contact between the oil and alcohol phases, but excessive agitation may lead to emulsion formation and difficulties during biodiesel separation (Osman et al., 2024).

Biodiesel Yield Comparison

The experimental results indicate that biodiesel yield strongly depends on the type and quality of the feedstock used in the transesterification process. Virgin vegetable oils generally produce higher and more stable biodiesel yields due to their low free fatty acid (FFA) content and high triglyceride purity. In contrast, waste cooking oil typically contains impurities such as water, oxidized

compounds, and degradation products formed during frying processes, which may reduce conversion efficiency and biodiesel yield (Mazrreku et al., 2020; Banga et al., 2023).

Under optimized reaction conditions (methanol-to-oil molar ratio of 6:1, catalyst concentration of 1 wt%, reaction temperature of 65°C, and reaction time of 60–120 minutes), biodiesel yields obtained from different feedstocks are presented in Table 1.

Table 1. Comparison of biodiesel yield and key feedstock characteristics

Feedstock	Free Fatty Acids (FFA, wt%)	Reaction Time (min)	Biodiesel Yield (%)	Observations
Sunflower Oil	<0.5	60	98	High-purity feedstock with stable conversion
Soybean Oil	<0.5	70	95	Slightly lower yield due to fatty acid composition
Olive Oil	<0.5	80	94	Higher viscosity affects reaction kinetics
Waste Cooking Oil	2–8	120	88–92	Pretreatment is required to reduce FFA and impurities

The results show that sunflower oil achieved the highest biodiesel yield (98%), which can be attributed to its favorable fatty acid composition and low viscosity, facilitating efficient mass transfer during transesterification. Soybean oil and olive oil also demonstrated high conversion efficiencies, producing biodiesel yields above 94%.

Waste cooking oil produced slightly lower yields ranging from 88% to 92%, primarily due to the presence of free fatty acids and thermal degradation products. These compounds promote saponification reactions when alkaline catalysts are used, leading to soap formation and reduced biodiesel recovery (Singh et al., 2021).

Despite the slightly lower yield, waste cooking oil remains a highly attractive feedstock due to its significantly lower cost and environmental benefits, making it suitable for sustainable biodiesel production within a circular economy framework (Tulashie et al., 2024; Santander-Bossio et al., 2025).

The produced biodiesel was evaluated according to standard fuel quality parameters and compared with international biodiesel standards such as **ASTM D6751** and **SNI 7182:2015** (Mazrreku et al., 2023b).

The results demonstrated that biodiesel produced from both virgin vegetable oils and waste cooking oil satisfies the required fuel specifications for commercial biodiesel applications.

Economic and Environmental Impact

Feedstock Cost

Feedstock cost represents one of the most significant economic factors influencing the overall feasibility of biodiesel production. In conventional biodiesel processes, the cost of raw materials may account for up to 70–80% of the total production cost, making feedstock selection a critical parameter for improving economic sustainability. Virgin vegetable oils, such as sunflower, soybean, and olive oils, are characterized by high purity and favorable physicochemical properties; however, their relatively high market price considerably increases the overall cost of biodiesel production.

In contrast, waste cooking oil (WCO) has emerged as a cost-effective alternative feedstock due to its wide availability and substantially lower price. Typically, waste cooking oil can be obtained at prices ranging between $0.20 and $0.50 per liter, whereas virgin vegetable oils generally cost

between $0.80 and $1.50 per liter, depending on market conditions and regional supply (Santander-Bossio et al., 2025). The utilization of WCO therefore offers significant economic advantages by reducing feedstock expenses and improving the competitiveness of biodiesel relative to fossil diesel.

Although additional pretreatment steps may be required for WCO to remove impurities and reduce free fatty acid content, the lower raw material cost often compensates for these additional processing requirements. Consequently, the use of waste cooking oil can substantially improve the economic viability of biodiesel production, particularly in large-scale industrial applications.

Sustainability Benefits

Beyond economic advantages, the valorization of waste cooking oil for biodiesel production provides substantial environmental benefits. Large quantities of WCO are generated annually from households, restaurants, and food processing industries, and improper disposal of these oils can cause significant environmental problems, including water contamination, soil degradation, and blockage of sewage systems.

The conversion of WCO into biodiesel represents an effective strategy for waste management and resource recovery, transforming an environmental liability into a valuable renewable energy resource. Furthermore, biodiesel derived from waste oils contributes to reducing lifecycle greenhouse gas emissions compared with conventional petroleum diesel, thereby supporting global efforts toward climate change mitigation (Tulashie et al., 2024).

In addition, the use of WCO as a feedstock aligns with the principles of the circular economy, where waste materials are reintegrated into productive processes rather than discarded. This approach not only reduces environmental pollution but also promotes sustainable energy production by decreasing reliance on edible vegetable oils and fossil fuels (Lopresto, 2024).

Overall, the combined economic and environmental advantages of waste cooking oil make it a promising feedstock for sustainable biodiesel production systems.

Results and Discussion

The experimental results demonstrate that biodiesel production efficiency is strongly influenced by feedstock composition, free fatty acid (FFA) content, and reaction parameters such as catalyst concentration, temperature, and methanol-to-oil ratio. Under optimized conditions (methanol-to-oil molar ratio of 6:1, catalyst concentration of 1 wt%, reaction temperature of 65°C, and reaction time between 60 and 120 minutes), all investigated feedstocks successfully produced biodiesel that complied with international fuel standards.

Among the tested feedstocks, sunflower oil exhibited the highest biodiesel yield (98%), which can be attributed to its favorable fatty acid composition and low viscosity, allowing efficient mass transfer during the transesterification process. Similarly, soybean oil and olive oil achieved high conversion efficiencies of 95% and 94%, respectively, demonstrating the suitability of these oils for biodiesel production via alkaline catalysis.

In contrast, waste cooking oil (WCO) showed slightly lower biodiesel yields ranging from 88% to 92%, mainly due to the presence of impurities, oxidation products, and higher FFA concentrations formed during repeated heating cycles. These components may interfere with the catalytic reaction and promote saponification reactions, which reduce biodiesel recovery and complicate product separation (Banga et al., 2023; Singh et al., 2021).

Nevertheless, the physicochemical properties of biodiesel derived from WCO were found to be comparable with those obtained from virgin vegetable oils. Parameters such as viscosity, density,

cetane number, and flash point were within the acceptable limits specified by ASTM D6751 and SNI 7182:2015 standards, confirming the suitability of WCO-derived biodiesel for practical fuel applications.

Furthermore, the results obtained in this study are consistent with previously reported investigations, which indicate that although waste cooking oil may produce slightly lower yields compared with virgin vegetable oils, its economic and environmental advantages make it a highly promising feedstock for sustainable biodiesel production (Tulashie et al., 2024; Lopresto, 2024).

The comparative analysis highlights that the optimization of reaction conditions and the implementation of appropriate pretreatment steps can significantly improve biodiesel yield and fuel quality when using waste cooking oil. Therefore, WCO can represent a viable alternative feedstock for large-scale biodiesel production.

Conclusion and Future Perspectives

This study investigated the valorization of waste cooking oil for biodiesel production and compared its performance with that of selected virgin vegetable oils, including sunflower, soybean, and olive oils. The results demonstrate that alkaline-catalyzed transesterification remains an effective method for converting triglyceride-based feedstocks into biodiesel with high conversion efficiency.

Virgin vegetable oils showed slightly higher biodiesel yields due to their low free fatty acid content and higher purity. However, biodiesel produced from waste cooking oil exhibited comparable physicochemical properties and satisfied international fuel quality standards such as ASTM D6751 and SNI 7182:2015.

Despite the need for pretreatment processes to reduce free fatty acid content, waste cooking oil represents a highly attractive feedstock because of its low cost, wide availability, and environmental benefits. The utilization of WCO not only reduces biodiesel production costs but also contributes to waste management and environmental protection by preventing improper disposal of used cooking oils.

Future research should focus on improving biodiesel production efficiency through the development of advanced heterogeneous catalysts, improved reaction optimization techniques, and the application of artificial intelligence-based process control systems. In addition, the integration of biodiesel production into biorefinery concepts, where by-products such as glycerol are valorized, could further enhance the sustainability and economic viability of biodiesel production systems.

Overall, the valorization of waste cooking oil into biodiesel represents a promising pathway toward the development of sustainable, low-carbon, and economically viable renewable fuel technologies.

References

1. Banga, S., et al. (2023). Biodiesel production from waste cooking oil: Feedstock characteristics and transesterification parameters. *Fuel.*

2. Farouk, S. M., et al. (2024). Recent advances in transesterification for sustainable biodiesel production. *Renewable Energy.*

3. Kumar, D., et al. (2025). Transesterification-derived biodiesel: Feedstock diversity, catalysts, and fuel properties. *Discover Chemical Engineering.*

4. Lopresto, C. G. (2024). Sustainable biodiesel production from waste cooking oils. *International Journal of Environmental Science and Technology.*

5. Mazrreku, A., Malollari, I., Beqiraj, I., & Koraj, Dh. (2019). Experimental testing setup of some waste oil seeds treatment for biodiesel obtaining. *Journal of Environmental Protection and Ecology, 20*(2), 856–861.

6. Mazrreku, A., Hoxha, B., & Osmani, M. (2020). Differences between biodiesel production from vegetable oils and waste cooking oils. *KNOWLEDGE – International Journal, 42*(3), 487–493.

7. Mazrreku, A., Osmani, M., Hoxha, B., Llupa, J., Shtylla, B., & Malollari, I. (2023a). Biodiesel production from waste cooking oils as alternative way to manage WCO. *International Journal of Chemistry and Chemical Engineering Systems, 8.*

8. Mazrreku, A., Osmani, M., Hoxha, B., & Shtylla, B. (2023b). New consideration for biodiesel laboratory scale production using modeling and simulation techniques. *Thalassia Salentina, 45.*

9. Mazrreku, A., Osmani, M., Hoxha, B., Shtylla, B., Hajdini, G., Pikuli, K., Teta, A., & Madhi, D. (2025). Analysis and evaluation of bio-glycerin production from cooking oils and modeling of the transesterification process: From waste to source a new ecological approach. *International Journal of Ecosystems and Ecology Science, 15*(6). https://doi.org/10.31407/ijees

10. Osman, W. N. A. W., et al. (2024). Comparative review of biodiesel production and purification technologies. *Energy Conversion and Management.*

11. Santander-Bossio, M., et al. (2025). From waste to energy: Cooking oil recycling for biodiesel production. *Sustainability.*

12. Singh, D., et al. (2021). Biodiesel production from waste cooking oil and its use in diesel engines: A review. *Renewable and Sustainable Energy Reviews.*

13. Tulashie, S. K., et al. (2024). Biodiesel production from waste cooking oil within a circular economy framework. *Biofuels.*

VIBRATION ANALYSIS OF GLASS FIBER-REINFORCED COMPOSITE BEAMS CONTAINING DIFFERENT PROPORTIONS OF MILLED CARBON ADDITIVES

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ABSTRACT

Composite materials are widely used in aerospace, automotive, and mechanical engineering applications thanks to their high strength and stiffness. However, in many of these applications, achieving sufficient flexibility requires careful modification of the composite structure. Specially, the damping capability of composite's structure plays a huge role in fatigue life, noise control and performance under dynamic loads. Within this context, the addition of various additives to composite matrices to improve vibration properties has become an increasingly researched topic in recent years. In this study, the effect of adding different ratios of ground carbon particles to the matrix material on the free vibration behavior of glass fiber-reinforced composite beams was experimentally investigated. Test specimens were produced using the hand lay-up method, and a total of six different specimen groups were prepared containing 0%, 0.2%, 0.4%, 0.6%, 0.8%, and 1% by weight carbon additive. Free vibration tests were performed on the produced composite beams to determine the natural frequencies and damping ratios. The experimental results showed that the addition of carbon additive has a significant effect on the dynamic behavior of composite beams. While an overall increasing trend in damping ratios was observed with increasing carbon additive ratio, limited changes occurred in natural frequency values depending on the additive ratio. In particular, it was determined that carbon particles increase the energy dissipation capacity of the structure and reduce vibration amplitudes more rapidly up to a certain additive level. At higher additive ratios, the changes in natural frequencies remained limited. The findings of this study demonstrate that the vibrational behavior of glass fiber-reinforced composite beams containing milled carbon additive can be controlled by adjusting the additive ratio. The obtained results constitute an important reference, especially for engineering applications where high damping performance is critical.

Keywords: Composite materials , Free vibration, Dynamic behavior, Natural frequency, Damping ratio

INTRODUCTION

Glass fiber-reinforced polymer (GFRP) composites are widely utilized in aerospace, automotive, and mechanical engineering applications due to their high strength-to-weight ratio, corrosion resistance, and cost efficiency (Chawla, 2012; Pickering, 2016). In many structural applications, these materials are subjected to dynamic loading conditions, making vibration performance a critical design parameter. Excessive vibration may lead to resonance, noise generation, fatigue damage, and ultimately reduced service life (Hollaway and Head, 2001; Gibson, 2016). Therefore, understanding and improving the dynamic behavior of composite structures is essential for ensuring structural reliability and long-term performance. The vibration characteristics of composite beams are primarily evaluated through natural frequency and damping ratio. While natural frequency is largely influenced by structural stiffness and mass distribution, the damping ratio reflects the material's ability to dissipate vibrational energy (Gibson, 2016; Rao, 2007). Enhancing these parameters contributes directly to improved dynamic stability and durability. Among the available evaluation techniques, experimental free vibration testing is widely accepted as a reliable and non-destructive approach for characterizing the dynamic properties of composite materials (Adams et al., 1975; Ewins, 2000).

Carbon-based reinforcements have gained significant attention due to their high stiffness and energy dissipation capabilities (Jones, 1999; Gibson, 2016). Although continuous carbon fibers are known to substantially increase stiffness and natural frequencies, particulate carbon fillers offer a different mechanism of performance enhancement (Jones, 1999; Fu et al., 2008). By modifying the polymer matrix and altering filler-matrix interfacial interactions, particulate fillers can influence both stiffness and damping behavior (Kim and Mai, 1998; Fu et al., 2008). Despite extensive research on the static mechanical properties of particle-reinforced composites, their effects on vibration characteristics remain relatively underexplored (Fu et al., 2008).

In particular, the influence of milled carbon powder on the vibration behavior of glass fiber-reinforced composite beams has received limited attention. Since the addition of milled carbon powder can modify matrix stiffness and viscoelastic behavior, varying its weight fraction is expected to significantly affect both natural frequency and damping ratio. This study experimentally investigates the effect of different weight percentages (0%, 0.2%, 0.4%, 0.6%, 0.8%, and 1%) of milled carbon powder on the vibration performance of GFRP composite beams. Specimens were manufactured with controlled filler contents and tested using a TM-166 free vibration test apparatus to determine their natural frequencies and damping ratios. The results aim to provide insight into the role of particulate carbon fillers in enhancing dynamic performance and to identify optimal filler content for improved vibration behavior in engineering applications.

MATERIAL AND METHODS

Glass fiber-reinforced composite beam specimens were manufactured using an epoxy polymer matrix reinforced with glass fibers and modified with milled carbon powder at weight fractions of 0%, 0.2%, 0.4%, 0.6%, 0.8%, and 1%. The epoxy resin and hardener were mixed according to the manufacturer's recommended ratio (100:50 by weight), and milled carbon powder was incorporated into the matrix prior to fiber impregnation to ensure uniform dispersion. All specimens were prepared with identical geometric dimensions ($300 \times 25 \times 2.5$ mm^3) in order to eliminate size-related effects on vibration behavior and to enable a direct comparison between different carbon contents. The fabricated composite beam specimens corresponding to different

carbon powder weight fractions are presented in Figure 1. Free vibration experiments were carried out using a TM-166 free vibration test apparatus. The experimental setup used in this study is illustrated in Figure 2. Each specimen was mounted in a cantilever configuration, where one end was rigidly clamped while the other end remained free. Free vibration was initiated by applying an initial transverse displacement at the free end and then releasing the specimen without external excitation. The resulting time-domain vibration signals were recorded through the integrated data acquisition system under identical environmental and experimental conditions for all specimens to ensure repeatability and consistency. The recorded vibration responses were analyzed to determine the fundamental natural frequencies and damping ratios of the composite beams. Natural frequencies were initially obtained using the proprietary software integrated into the TM-166 system and further validated in MATLAB by identifying the dominant frequency components. Damping ratios were calculated using the logarithmic decrement method based on the free vibration decay characteristics. Identical signal processing parameters and analysis procedures were applied to all specimens, ensuring that observed variations in vibration characteristics were directly attributable to the effect of milled carbon powder content.

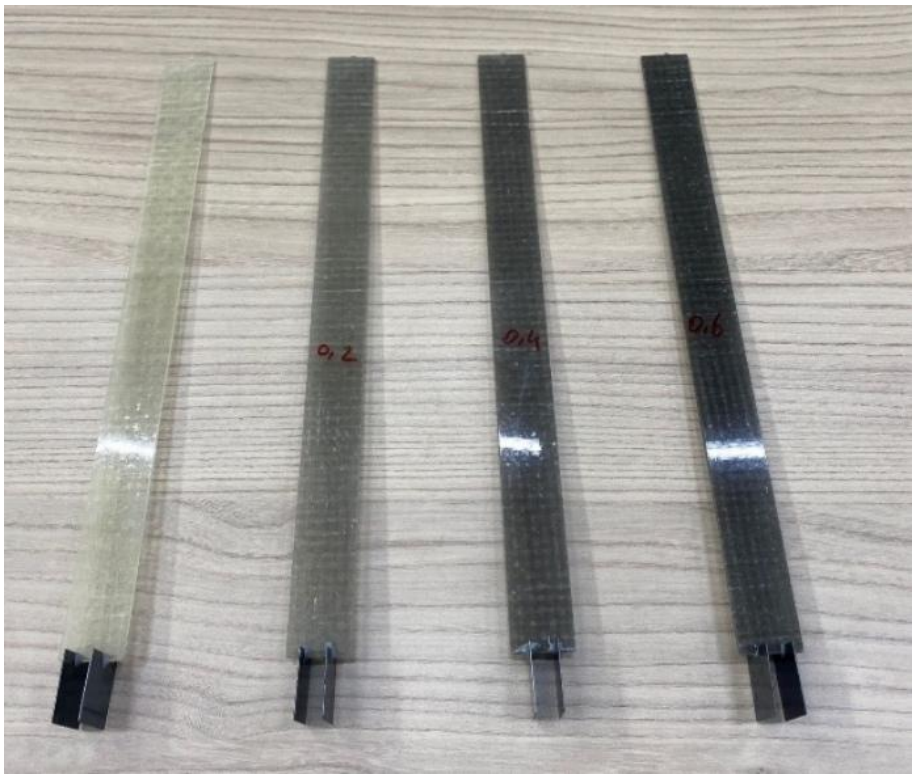


Figure 1. Fabricated glass fiber–reinforced composite beams corresponding to different carbon powder weight fractions

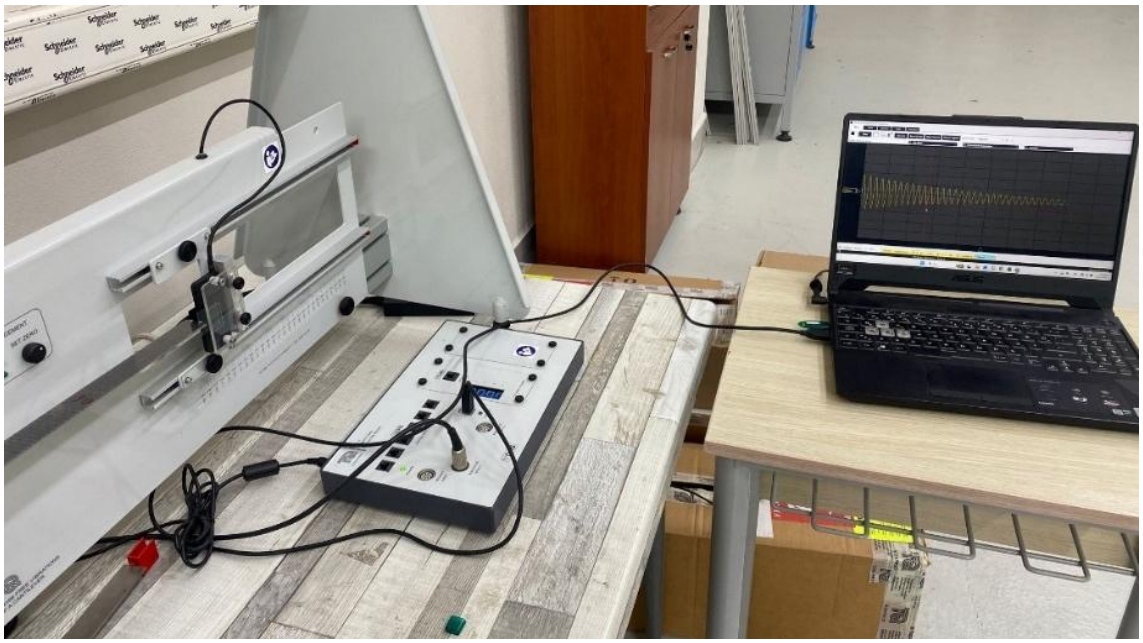


Figure 2. Experimental setup for the free vibration testing of composite beam specimens.

Experimental Data Anaylsis

The vibration responses obtained from the free vibration experiments were analyzed to determine the dynamic characteristics of the glass fiber-reinforced composite beams. The primary parameters considered in the evaluation were the first natural frequency and the damping ratio of the specimens. All analysis procedures were applied consistently to each specimen in order to ensure reliable comparison between different milled carbon powder contents. The vibration signals recorded by the TM-166 free vibration test apparatus was first examined in the time domain. The decay behavior of the vibration response was used to evaluate the damping characteristics of the composite beams. By identifying the successive peak amplitudes of the free vibration signal, the damping behavior of the specimens was determined from the rate at which the vibration amplitude decreased over time. In addition to the time-domain analysis, frequency-domain analysis was also performed to identify the fundamental natural frequency of each specimen. The recorded vibration signals were processed to obtain the frequency spectrum, where the dominant peak corresponds to the first natural frequency of the composite beam. This approach allows accurate identification of the vibration characteristics of beam-type structures under free vibration conditions. Each specimen was tested four times under identical experimental conditions in order to reduce experimental uncertainty and ensure the repeatability of the measurements. The average values obtained from these repeated tests were used as the representative natural frequency and damping ratio for each carbon powder content. Following the extraction of these vibration parameters, a comparative evaluation was conducted to investigate the influence of milled carbon powder content on the dynamic behavior of the composite beams. The variation of natural frequency and damping ratio with respect to carbon powder weight fraction was analyzed in order to identify the filler content that provides the most favorable vibration performance.

RESULTS

Free vibration experiments were conducted on glass fiber-reinforced composite beams containing different weight fractions of milled carbon powder. Each specimen was tested four times under identical experimental conditions, and the average values of the first natural frequency and

damping ratio were used for evaluation. The results indicate that the addition of milled carbon powder affects the dynamic behavior of the composite beams.

The variation of the first natural frequency with carbon powder content is presented in Figure 3. The unmodified specimen (0 wt.% carbon powder) exhibited a first natural frequency of approximately 7.51 Hz. As the carbon powder content increased, the natural frequency initially showed minor variations and then increased more noticeably. The highest natural frequency was obtained for the specimen containing 0.8 wt.% carbon powder, reaching approximately 8.50 Hz. When the filler content was further increased to 1 wt.%, a slight reduction in natural frequency was observed. This trend suggests that moderate filler additions may enhance the stiffness of the composite beams, leading to improved vibration performance. The damping ratio results are shown in Figure 4. The baseline specimen exhibited a damping ratio of approximately 0.00918. With increasing carbon powder content, the damping ratio gradually increased and reached its maximum value at 0.6 wt.%, indicating improved energy dissipation capability. However, at higher filler contents (0.8 wt.% and 1 wt.%), the damping ratio decreased slightly.

Overall, the experimental findings demonstrate that the incorporation of milled carbon powder modifies both the stiffness-related vibration characteristics and the energy dissipation behavior of the composite beams. The increase in natural frequency indicates an improvement in structural stiffness, while the variation in damping ratio reflects the influence of filler–matrix interactions on the vibration energy dissipation capacity of the composite structure.

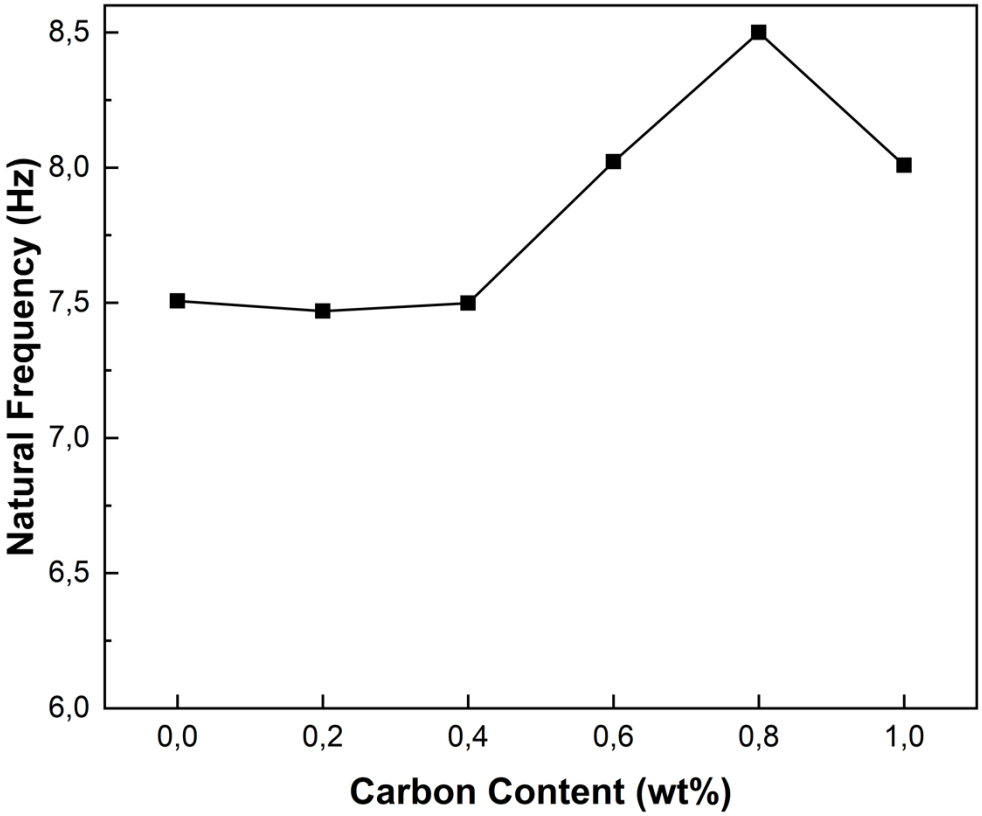


Figure 3. Variation of the first natural frequency of composite beams with milled carbon powder content

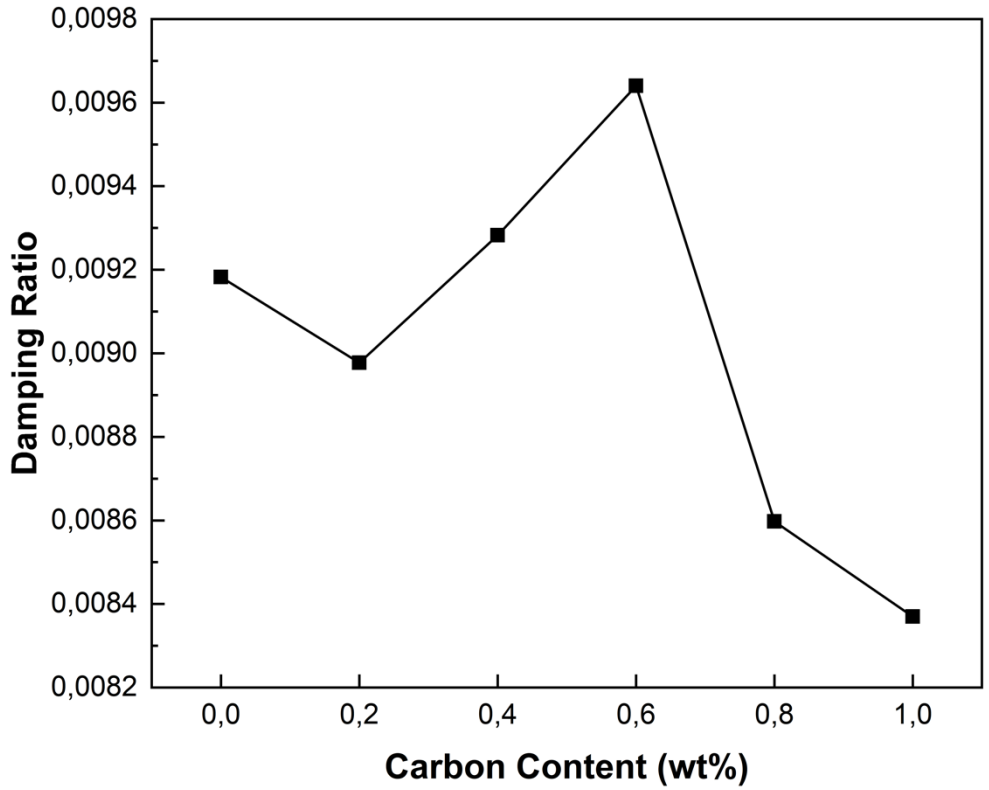


Figure 4. Variation of the damping ratio of composite beams with milled carbon powder content

DISCUSSION

The observed variation in natural frequency can be attributed to changes in the effective stiffness of the composite structure caused by the addition of milled carbon powder. The increase in natural frequency up to **0.8 wt.%** suggests that carbon particles enhance the stiffness of the epoxy matrix and improve load transfer between the matrix and the glass fibers. This stiffening effect increases the stiffness-to-mass ratio of the composite beam, leading to higher natural frequencies.

However, when the filler content increases beyond this level, the natural frequency shows a slight reduction. This behavior may be associated with increased mass contribution and possible particle agglomeration at higher filler concentrations, which can reduce the efficiency of stress transfer within the composite structure. The damping ratio results indicate that carbon powder particles also influence the energy dissipation mechanisms of the composite beams. The increase in damping ratio up to 0.6 wt.% suggests that the presence of carbon particles enhances internal friction and interfacial interactions between the filler, matrix, and fibers. These mechanisms contribute to improved vibration energy dissipation. At higher filler contents, the decrease in damping ratio may be related to reduced matrix continuity and particle clustering effects, which limit the effectiveness of micro-scale damping mechanisms. Considering both natural frequency and damping behavior together, the results suggest that an optimal carbon powder content exists between 0.6 wt.% and 0.8 wt.%**,** where a favorable balance between stiffness enhancement and vibration damping is achieved.

CONCLUSION

This study experimentally investigated the influence of milled carbon powder addition on the vibration behavior of glass fiber-reinforced composite beams. Composite specimens containing

different carbon powder weight fractions (0%, 0.2%, 0.4%, 0.6%, 0.8%, and 1%) were fabricated and tested using a cantilever-based free vibration method. The fundamental natural frequencies and damping ratios of the specimens were determined through time-domain and frequency-domain analyses.

The experimental results showed that the addition of milled carbon powder affects the dynamic characteristics of the composite beams. The natural frequency increased with increasing carbon powder content up to 0.8 wt.%, indicating an improvement in the effective stiffness of the composite structure. When the filler content was increased to 1 wt.%, a slight reduction in natural frequency was observed, which may be related to the increased mass contribution and possible particle agglomeration at higher filler concentrations. The damping ratio results indicated that the energy dissipation capability of the composite beams improved with the addition of carbon powder up to 0.6 wt.%. At higher filler contents, the damping ratio decreased slightly, suggesting that excessive filler loading may reduce the effectiveness of the damping mechanisms within the composite matrix. Considering both natural frequency and damping behavior together, the results suggest that an optimal carbon powder content exists in the range of 0.6 wt.% to 0.8 wt.%, where a balanced improvement in stiffness and vibration damping can be achieved.

Overall, the findings demonstrate that the incorporation of low-weight-fraction milled carbon powder provides an effective approach for modifying the vibration characteristics of glass fiber-reinforced composite beams. The results contribute to the understanding of particle-modified composite systems and provide useful insights for the design of composite structures where vibration control and dynamic performance are important considerations.

REFERENCES

Adams RD, Bacon DGC, Coppendale J 1975. The dynamic properties of fibre-reinforced plastics measured by a non-destructive vibration method. Journal of Composite Materials, 9(4): 456–475.

Chawla KK 2012. Composite materials: science and engineering. New York: Springer.

Ewins DJ 2000. Modal testing: theory, practice and application. Baldock: Research Studies Press.

Fu SY, Feng XQ, Lauke B, Mai YW 2008. Effects of particle size, particle/matrix interface adhesion and particle loading on mechanical properties of particulate–polymer composites. Composites Part B: Engineering, 39(6): 933–961.

Gibson RF 2016. Principles of composite material mechanics. Boca Raton: CRC Press.

Hollaway LC, Head PR 2001. Advanced polymer composites and polymers in the civil infrastructure. Oxford: Elsevier.

Jones RM 1999. Mechanics of composite materials. Philadelphia: Taylor & Francis.

Kim JK, Mai YW 1998. Engineered interfaces in fiber reinforced composites. Amsterdam: Elsevier.

Pickering SJ 2016. A review of recent developments in natural fibre composites and their mechanical performance. Composites Part A: Applied Science and Manufacturing, 83: 98–112.

Rao SS 2007. Vibration of continuous systems. Hoboken: John Wiley & Sons.

WHY SPECIALIZATION JOURNALISM IMPORTANT?

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ABSTRACT

Journalism is one of the most specific fields. Its specificity lies in the fact that representatives of this profession must be knowledgeable in all areas. A journalist should be able to write and speak about different fields. This approach was particularly relevant until recently. Today, however, specialization in media is on the agenda. This means that a journalist should specialize in a particular field, such as politics, economics, or social issues.

Why is specialization in journalism important? There are several reasons. First, thanks to specialization, a journalist knows the specific field well, constantly follows the processes, and does not face difficulties in finding topics. Second, a specialized journalist knows the problems, the current situation, and the prospects. Third, they are familiar with the representatives of that field, which makes interview selection more successful. Fourth, the professionals in that field also know the journalist. This helps the journalist to find "news-makers" and obtain exclusive information. Since the journalist knows the field well, it is difficult to mislead them or change the subject during an interview: the journalist knows what to ask and what answer to expect.

Recently, the importance of specialization in media has increased for several reasons. This is primarily related to the internal transformations within journalism itself. Preparing journalistic material has become much easier. It is even possible to do so without independent analysis or creativity. Nowadays, various artificial intelligence tools are used to write articles, reports, and interviews. Journalists widely utilize technological opportunities while working on their materials. In such cases, the capabilities of artificial intelligence push the journalist's activity into the background. Therefore, journalists must specialize in specific fields and reach the level of experts in those directions, ensuring that artificial intelligence and other technological tools do not replace them.

Keywords: Journalism, media, specialization, artificial intelligence

INTRODUCTION

Journalism is considered one of the most dynamic fields. One of the main points that shows this dynamism is that it is subject to frequent changes and transformations. Especially in recent times, journalism has been subject to changes at a faster rate. In particular, the penetration of technology, including artificial intelligence, into the media creates new challenges, and some previously existing rules are being forgotten. "In recent years, the rapid development of technology has had a significant impact on journalism. With the influence of technology, the role of traditional journalism has changed and a transition to new media has occurred. These trends have caused widespread interest, especially among young people. Young journalists are taking advantage of the opportunities offered by technology and creating more interactive and modern-style content. Thus,

the increase in social media platforms, mobile applications and video content creators brings a new competitive environment to traditional journalism (Farid Pardashunas, 2024).

About 5-6 years ago, they said that journalists should know everything and be knowledgeable in all areas: from politics to economics, from education to healthcare. Because they write about every field and have to touch on all issues. There were also those who associated this with the optimization of work in the editorial offices. In other words, it was thought that if we had ten employees in the editorial office covering ten different areas, a maximum of 3-4 people would do it. For that time, this approach was logical and rational. Now the situation has changed.

AUTHORITIES THAT ACTUALIZE SPECIALIZATION IN JOURNALISM

Today, a journalist is not only required to write or speak well. In fact, these have already become secondary. Now, instead of a media representative, there is something that can both write and speak - artificial intelligence. What a journalist needs is to use artificial intelligence correctly. “Artificial intelligence is increasingly penetrating the work of the media. Information search, recognition of speech, sounds and photos, highlighting priority aspects of topics, creating texts and their purposeful dissemination, etc. - these are a partial list of the inclusion of AI elements in editorial practice” (Z. Babayev, A. Babayev, 2024). It is precisely the fact that artificial intelligence is so rapidly penetrating journalism that raises serious questions about the future activities of the representatives of the mentioned profession: Since artificial intelligence will do the work of journalists, will they still be needed? According to many experts, journalists may gradually lose their jobs. One of the ways to prevent this is specialization. So, a journalist should know his field even better than artificial intelligence in order to surprise the audience. In this regard, a modern journalist is required to know the field he is in as well as a specialist in that field - a political scientist, an economist, a doctor... If this is the case, the chances of artificial intelligence replacing journalists in the future will be seriously reduced.

This is not the only factor that makes specialization in journalism important. It should be borne in mind that journalists encounter different situations and people in their work. Sometimes their journalistic skills and knowledge alone are not enough for them. For example, let's say a journalist interviews an economist. During the interview, he can quickly calculate the numbers his respondent utters and ask additional questions that the interviewer did not intend to ask. This maneuver will undoubtedly make the interview more interesting. Or a journalist with political science knowledge, who consistently follows and learns from the events taking place in the system of international relations, when interviewing a political scientist, will certainly not be satisfied with the thesis-type questions he has prepared in advance, but will approach the ideas and forecasts voiced by his interlocutor in more depth, linking them with each other.

It is known that journalism is the art of creating public opinion. “Journalism as a system is primarily public communication and mass communication” (G. Maharramli, 2012). This public communication and mass communication is carried out precisely with information. In other words, information stands behind that public communication and mass communication. The more accurate and verified this information is, the more successful mass communication will be. If the journalist’s job is also to provide mass communication, then he must carefully approach information and information processes, including its search, acquisition, clarification and transmission, throughout his activity. “The wheel of history has always turned forward with information. Information has always been useful and has been the main source of social transformation and one of the main factors that has driven social development in human history” (G. Maharramli, 2012). A gap, inattention or haste allowed at some stage in information processes can seriously damage the overall process and lead to the defect of mass communication. In this

regard, what is required of a journalist is to verify the authenticity of the information he receives from several sources. Only then can that information be made public.

It is in this regard that specialization in journalism is very important. A journalist who knows a specific field deeply, at a specialist level, will not blindly approach the information he receives or is given. On the contrary, he will analyze the information, analyze how real and authentic it is. For example, let's say a foreign media outlet has prepared material about Israel's imminent attack on Iran. Before making this claim public, a journalist should think to himself: is this even possible? It is true that in similar situations, especially in processes related to international relations, it is impossible to make a specific forecast. Nevertheless, it is possible to proceed from probabilities and approach the analysis of the disseminated information from the context. For this, a journalist should follow the innovations related to a specific field.

Especially today, the concept of information warfare has become very relevant. According to many experts, a disinformation war is already underway in the world today. That is, states not only fight each other with information, but also confuse public opinion with disinformation. “Currently, disinformation is listed in second place among the risks facing us. In fact, the emergence of disinformation is closely related to conflicts and wars, because conflicts also contain false information and manipulation of public opinion” (M. Alasgarli, 2026).

Observations show that protecting public opinion from false or incorrect information, that is, disinformation and misinformation, is not so easy. In recent times, this process has become even more difficult. If one reason for this is the increasing struggle between states, another is the rapid development of information and communication technologies. The development of information technologies, including “deep fake” technology, provides fertile conditions for the spread of fake news. It is also clear from experience that, along with the massification of disinformation, it has become more difficult to distinguish such fake news from real information. “Fake news is one of the main attributes of information warfare” (A. Rustamov, 2021). This is also proven by the events taking place in modern times.

In such a situation, a journalist must sort out the information he receives and is given. In this case, his own knowledge and skills, as well as literacy and analytical thinking, help him the most. For example, a journalist is working on a research paper on the Second Karabakh War, and the toponym “Daghlig Karabakh” is used in the information he receives. A journalist with military and political knowledge should know that there is no such administrative-territorial unit anymore, and the use of such terminology is at best a political mistake. Or sometimes the expression “Azerbaijan-Armenia conflict” is deliberately used. However, it was Armenia that started this conflict. “The Armenia-Azerbaijan conflict has entered the history of the 20th century as one of the most tragic conflicts, and its consequences have seriously affected the fate of millions of Azerbaijanis. This conflict, which began in the late 1980s with Armenia’s open territorial claims to the historical lands of Azerbaijan, provocations on ethnic grounds, and acts of terrorism, resulted in military aggression against Azerbaijan” (President.az, 2025).

CONCLUSION

Sometimes certain sources deliberately try to confuse the public. For this, the power of the media, which has the opportunity to appeal to a wide audience, is used. That is, first, the source purposefully transmits information to the journalist. Then, as a result of the journalist who does not have sufficient experience making that information public, confusion arises in the public consciousness. “In general, as the dependence of society, the public sphere and people on ICT increases, the process of information security becomes a vital necessity” (G. Maharramli, 2012). If it is not prevented in time, this process can become a serious threat to the stability of the state

and society. In such situations, the journalist should not only carefully approach the selection of information sources. This may not be enough. The media representative must also analyze the information and measure its degree of authenticity. This is possible only with the knowledge and skills of the journalist himself.

Experience shows that personnel specializing in separate fields are more successful in journalism today. This can be seen both in the world and in Azerbaijani experience. For example, CNN journalist Anderson Cooper became famous for covering war-torn regions and achieved success in this field. CNBC-TV18 employee Sherin Behn is known as a news journalist. She gained great love for her sincerity while in front of the camera. ABC TV employee and face of "Good Morning America" Robin Roberts is considered one of the most talented journalists in the sector.

There are enough specialized journalists in Azerbaijan. For example, Honored Journalist, Honored Physical Education and Sports Worker Ogtay Bayramov has been engaged in sports journalism for more than 50 years. Aydin Bagirov, editor-in-chief of the "Qol.az" website, Kenan Hasanov, head of the sports department of the "Report" News Agency, Honored Journalist Murad Farzaliyev, editor-in-chief of the "Olympia Duniya" newspaper are also well-known sports journalists. Elkhan Shahinoglu, Elchin Khalidbayli, Ilgar Velizadeh, Azer Rashidoglu and others have prepared articles on international relations for many years. Ilgar Jafarov, Rafig Naghiyev, Tahir Jafarov are among the well-known photojournalists of Azerbaijan.

Many of these individuals are not just journalists. They are also experts in their fields. It is no coincidence that individuals such as Rauf Arifoglu, Elkhan Shahinoglu, Elchin Khalidbeyli, Ilgar Velizadeh, Aydin Guliyev, Shakir Aghayev, Agshin Karimov, Aziz Alibeyli, Turan Rzayev began to act as political scientists after many years of journalism. Today, many of them are reliable sources of information for journalists. The same example can be given for other fields.

Sometimes we see the opposite of this experience: representatives of different fields later come to the media and work in their own direction. For example, Zeynal Amraliyev, a political scientist by profession, is today a skilled television presenter. Akif Ashirli, a historian by profession, has been the head of the “Sharq” newspaper for many years. He is also a prominent press researcher.

Each of them, regardless of whether they are in journalism or another field, is able to fulfill the main function of the media. Because they know both the basic principles of the media and their own fields. They know not only what to say and write, but also how to speak and write.

All these highlighted points once again give reason to say that specialization in journalism is very important. The massification of teaching different fields of journalism, including economic journalism, political journalism, sports journalism, photojournalism, both in the world and in Azerbaijan, in separate state and private universities, gives reason to think that in the future attention to this issue will increase even more. And specialization in journalism will become relevant not only from a practical, but also from a theoretical point of view.

REFERENCES

1. “The process of robotization in the media and the problems and prospects of using artificial intelligence, Zaur Babayev, Akif Babayev, Baku-2024

2. G. Maharramli, “Fundamentals of Journalism”, Baku-2012, “Qanun” publishing house, pp. 434, 52

3. Akif Rustamov, “Journalism as a Mass Media System”, Baku-2021, SkyE publishing house, P398-271).

Internet resources:

1. Farid Pardashunas: Journalists can benefit from the development of technology and create a stronger media environment - AZERTAC

2. Media expert: In the last 10 years, the transformation of disinformation into a serious risk for the world has rapidly increased - AZERTAC

3. Armenia-Azerbaijan conflict » AZERBAIJAN » Official website of the President of Azerbaijan

ASSOCIATIONS BETWEEN HEALTH ENHANCING PHYSICAL ACTIVITY AND MENTAL HEALTH IN RELATION TO SENSE OF COHERENCE AMONG UNIVERSITY STUDENT

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ABSTRACT

INTRODUCTION: Aspects of well-being are health-enhancing physical activity, sense of coherence, and mental health, which are especially important in university students. Although the relationship between these factors has been studied separately in previous researches, few studies have been conducted concerning the relationship between these factors.

OBJECTIVES: The primary objective of this study was to evaluate the mediating role of health-enhancing physical activity, mental health status, and sense of coherence among university students.

METHODS: A cross-sectional quantitative study was conducted among university students using a structured self-administered questionnaire. Demographic and anthropometric data were collected, and BMI was calculated. Physical activity was measured using the IPAQ to compute MET-min/week for determining Health-Enhancing Physical Activity levels. Mental well-being and coping capacity were assessed using the WHO-5 and SOC-5 scales, respectively. Data were analyzed in SPSS using descriptive statistics, correlation, and regression analyses, with significance set at $p < 0.05$.

RESULTS: A total of 400 students participated (mean age 23.1 ± 3.9 years; 79% female), with a mean BMI of 19.0 ± 3.8 kg/m² and 62% in the normal weight range. Average physical activity was 9,410 ± 5,261 MET-min/week, with 46% meeting health-enhancing levels. Mean WHO-5 and SOC-5 scores indicated moderate well-being and good coherence. Physical activity showed significant negative correlations with mental well-being ($r = -0.52$) and positive correlations with sense of coherence ($r = 0.16$).

CONCLUSION: Overall, this is a positive finding that indicate that higher levels of health-enhancing physical activity are significantly associated with better mental well-being and a stronger sense of coherence among university students, even after controlling for demographic and anthropometric factors.

Keywords: Health-enhancing physical activity, mental health, sense of coherence, university students, correlations

INVESTIGATION OF THE LEVELS OF ATTITUDES OF HEALTHCARE WORKERS TOWARDS XENOPHOBIA AND IMMIGRANTS IN SERVICE DELIVERY

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ABSTRACT

In recent years, there have been problems of social cohesion and integration between the local population and immigrants, especially due to the migration mobility from Middle Eastern countries to Turkey. With the prolongation of the duration of the migrants' stay and even the permanent change of the stay, negative attitudes of individuals towards migrants have started to emerge. However, xenophobia, known as xenophobia and xenophobia, has permeated institutions as well as societies. Health institutions and therefore health professionals working in these institutions are at the forefront of these institutions.

The aim of this study is to determine the levels of xenophobia and attitudes towards immigrants among healthcare workers in the provision of healthcare services and to identify the relationships between them according to demographic variables. The population of the study consists of 21,179 healthcare workers working in the central district of Konya (TÜİK 2023), while the sample group consists of 400 healthcare workers working in the province of Konya. Data were collected using the “Xenophobia Scale in Healthcare Provision” and the “Healthcare Worker's Attitude Scale Towards Migrants.” To conduct the research, a survey form was created using Google Forms and distributed to individuals electronically via various social media platforms (LinkedIn, WhatsApp, Facebook, etc.). The data were analyzed using the SPSS 20 software package. The analyses of the study consisted of descriptive analyses, t-tests for independent groups, one-way analysis of variance, Pearson correlation, and simple linear regression analysis.

As a result of the research, when the data on the descriptive characteristics of the participants were examined, it was determined that 50.5% were between the ages of 21-33, 59.2% were female, 71.8% were married, 42.2% were undergraduate and 69% were nurses. The mean score of the Zenophobia in Health Service Delivery scale is $\bar{x}$=55.43, and the mean score of the Health Worker Attitude Towards Immigrants scale is $\bar{x}$=49.84. A strong positive (r=.736) and significant ($p<0.01$) relationship was found between xenophobia in service provision of health professionals, the attitude towards immigrants increases.

Keywords: Migrant, Health Worker, Xenophobia

ÖZET

Son yıllarda özellikle Ortadoğu ülkelerinden Türkiye'ye doğru yaşanan göç hareketliliği nedeniyle yerel halk ve göçmenler arasında sosyal uyum ve entegrasyon sorunları yaşanmaktadır. Göçmenlerin misafirlik süresinin uzaması ve dahi misafirliğin kalıcı olarak değişmesiyle bireylerin göçmenlere yönelik olumsuz tutumları ortaya çıkmaya başlamıştır. Bununla birlikte yabancı korkusu ve yabancı düşmanlığı olarak bilinen zenofobi toplumlar arasında olduğu gibi kurumlar içerisin de nüfuz etmiştir. Bu kurumların başında sağlık kurumları ve dolayısıyla burada görev yapan sağlık çalışanları gelmektedir.

Bu araştırmanın amacı sağlık çalışanlarının sağlık hizmeti sunumunda zenofobi ve göçmenlere yönelik tutum düzeylerinin belirlenerek arasındaki ilişkilerin demografik değişkenlere göre belirlenmesidir. Çalışmanın evrenini Konya il merkezinde çalışmakta olan 21.179 sağlık çalışanı (TÜİK 2023) oluştururken, örneklem grubunu Konya ilinde çalışan 400 sağlık çalışanı oluşturmaktadır. Veriler ‘’Sağlık Hizmeti Sunumunda Zenofobi Ölçeği’’ ve ‘’Sağlık Çalışanının Göçmenlere Yönelik Tutum Ölçeği’’ kullanılarak toplanmıştır. Araştırmanın gerçekleşmesi adına verilere ulaşmak için Google formlar aracılığıyla anket formu düzenlenip çeşitli sosyal medya programları aracılığıyla (linkedin, whatsapp, facebook vb.) elektronik ortam üzerinden bireylere ulaşılmıştır. Veriler SPSS 20 paket programı yardımıyla analiz edilmiştir. Araştırmanın analizlerini tanımlayıcı analizler, bağımsız gruplarda t testi, tek yönlü varyans testi analizi ve pearson korelasyon ve basit doğrusal regresyon analizi oluşturmaktadır.

Araştırma sonucunda katılımcıların tanımlayıcı özelliklerine ait veriler incelendiğinde %50,5'i 21-33 yaş aralığında, %59,2'si kadın, %71,8'i evli, %42,2'si lisans ve %69'unun hemşire olduğu tespit edilmiştir. Sağlık Hizmeti Sunumunda Zenofobi ölçeği ortalama puanı $\bar{x}$=55,43, Sağlık Çalışanının Göçmenlere Yönelik Tutum ölçeği ortalama puanı $\bar{x}$=49,84'dir. Sağlık çalışanlarının hizmet sunumunda zenofobi ve göçmenlere yönelik tutumları arasında güçlü düzeyde pozitif (r=,736) ve anlamlı ($p<0.01$) bir ilişki bulunmuştur. Sağlık çalışanlarının hizmet sunumunda zenofobi arttıkça göçmenlere yönelik tutumda arttığı görülmektedir.

Anahtar Kelimeler: Göçmen, Sağlık Çalışanı, Zenofobi

Giriş

Zenofobi, Yunanca "xenos" (ξένος) yani yabancı ve "phovos" (φόβος) yani korku kelimelerinin birleşiminden türetilmiştir (Hiçdurmaz 2023). Genellikle yabancı düşmanlığı olarak tanımlanan zenofobi, bazen yabancılara karşı duyulan nefret ve onları dışlama anlamında da kullanılmaktadır (Eser 2021).

Yabancı düşmanlığı ise, "toplum ya da ulusal kimliğe yabancı olan kişilere karşı reddedici, dışlayıcı ve sıkça olumsuz tavırlar sergileyen, önyargılı davranışlar" olarak açıklanmaktadır (Özmete ve ark 2018). 2011 yılından itibaren ülkemizdeki yoğun göç akınları ve mülteci nüfusunun artmasıyla birlikte zenofobi giderek daha fazla yayılmaktadır (Başaran 2022).

Göçmenler, çeşitli sebeplerle yaşadıkları ülkeden başka bir ülkeye göç eden kişilerdir. Göçmen kavramı, genellikle maddi ya da sosyal durumlarını iyileştirme, kendilerinin veya ailelerinin gelecekteki beklentilerini artırma amacıyla başka bir ülkeye yerleşen bireyleri tanımlamak için kullanılmaktadır (Yeşildağ 2022). Uluslararası göç, genellikle daha yüksek yaşam standartlarına sahip veya yaşam mücadelesi içinde olan modern toplumları hedef almaktadır (Just ve Anderson 2015).

Son yıllarda bölgesel çatışmalar, iklim değişikliği, küreselleşme, güvenlik, istihdam, eğitim ve sağlık gibi sebeplerle dünya çapında göç hareketleri artmaktadır ve bu durum devam etmektedir (Özmete ve ark 2018). Bu göç hareketliliği, hem göçmenler hem de yerel halk arasında çeşitli

sosyal sorunlara yol açmaktadır (Demirel ve Çamur, 2023). Göçmenlerin geçici olarak kabul edilmesinin ardından, hedef ülkeyi kalıcı ikametgah olarak benimsemeleri, göçmenlere yönelik olumsuz tutumları artıran önemli faktörlerden biridir (Davidov ve Semyonov 2017).

Göçmen ve sığınmacıların toplumsal olarak tehdit olarak görülmesi, zenofobik tutumlara neden olabilmektedir (Kaldık 2021). Zenofobik tutumlar, hem tutum sahiplerini hem de yabancı olarak görülen ve bu tutuma maruz kalan kişileri etkilemektedir. Yabancı düşmanlığına uğrayan göçmen ve sığınmacılar, bu olumsuz tutumlar nedeniyle kimlikleri üzerinden toplumsal uyumdan dışlanabilmektedir. Öte yandan, bu tür bir yaklaşım sergileyen yerli nüfus ise korku, nefret, endişe ve düşmanlık gibi duygular yaşayarak gergin bir sosyal ortamın içine girebilmektedir. (Güngör, 2017).

Sağlık kurumları, farklı kültürlerden gelen hastalara hizmet sunan ve kültürel çeşitliliğin sıkça karşılaşıldığı alanlardır (Rahimaghaee ve Mozdbar 2017). Sağlık hizmeti sağlayan profesyoneller, insan hakları ve sosyal adalet ilkelerine dayanarak, hem felsefi hem de pratik açıdan uyum ve entegrasyonu ön planda tutan bir meslek icra etmektedir.

Artan göç hareketliliğiyle birlikte sağlık hizmeti sunumunda görev alan sağlık çalışanlarının göçmenlere ve yabancılara hizmet sunuyor olması nedeniyle sağlık çalışanlarının zenofobi ve göçmenlere yönelik tutumlarının değerlendirilmesi önem arz etmektedir. Son yıllarda özellikle Ortadoğu ülkelerinden Türkiye'ye doğru yaşanan yoğun göç hareketliliği nedeniyle yerel halk ve göçmenler arasında sosyal uyum ve entegrasyon sorunları yaşanmaktadır. Göçmenlerin misafirlik süresinin uzaması ve dahi misafirliğin kalıcı olarak değişmesiyle bireylerin göçmenlere yönelik olumsuz tutumları ortaya çıkmaya başlamıştır. Bununla birlikte yabancı korkusu ve yabancı düşmanlığı olarak bilinen zenofobi toplumlar arasında olduğu gibi kurumlar içerisine de nüfuz etmiştir. Bu kurumların başında sağlık kurumları ve dolayısıyla burada görev yapan sağlık çalışanları gelmektedir.

Amaç ve Yöntem

Çalışmanın Amacı

Sağlık hizmeti sunumunda zenofobi ve çalışanların göçmenlere yönelik tutum düzeylerinin belirlenerek arasındaki ilişkilerin demografik değişkenlere göre belirlenmesidir.

Çalışmanın Tipi

Çalışma nicel araştırma yöntemiyle gerçekleştirilmiş ve tanımlayıcı nitelikte bulgular ortaya konulmuştur.

Çalışmanın Evreni ve Örneklemi

Araştırmanın evrenini Konya il merkezinde çalışmakta olan 21.719 sağlık çalışanı oluşturmaktadır (TÜİK 2023). Çalışmanın örnekleminin çalışmanın yapıldığı tarihte izinli raporlu olmayan çalışmayı kabul eden sağlık çalışanları oluşturmaktadır. Örneklem boyutunu hesaplamak için Evreni bilinen grupta örneklem büyüklüğünü hesaplama formülü (Kılıç 2012) kullanılmıştır.

Çalışmanın Sınırlılıkları

Araştırmaya 18 yaş ve üzerinde olan verilerin toplandığı tarihte izinli raporlu olmayan çalışmaya katılmaya gönüllü sağlık çalışanları dahil edilmiştir. Sağlık çalışanı olmayan bireyler dahil katılmadığından bu durum araştırmanın sınırlılığını ifade etmektedir. Ayrıca veriler çevrimiçi yöntemlerle toplandığı için teknolojik alet yetersizliği bulunan katılımcılar araştırmaya dahil edilememiştir. Bu doğrultuda yaş sınırı ve meslek bakımından sınırlılıklar içerdiğinden araştırma sadece belirli bir kesime genellenebilmektedir.

Çalışmanın Verilerinin Toplanması

Araştırmada veriler, anlık, kesitsel ve boylamsal olarak zaman dilimi açısından sınıflandırılmaktadır (Büyüköztürk ve ark 2013).Buna göre araştırma için ihtiyaç duyulan veriler belirlenen bir zaman dilimi aralığında toplanmıştır. Araştırmacı tarafından veriler, 01.11.2024-01.12.2024 tarihleri arasında çevrimiçi anket yönteminden faydalanılarak elde edilmiştir.

Çalışma Verilerinin Değerlendirilmesi

Katılımcılara elektronik ortam üzerinden ulaştırılan anketler sonucunda elde edilen veriler bilgisayar ortamında gerekli hata kontrolü yapıldıktan sonra Google Forms üzerinden Excel dosyasına aktarılmıştır. Excel üzerinde hazır hale getirilerek değer atamaları yapılan veriler, analiz aşamasına geçmek için Statistical Package for Social Sciences (SPSS 21) programına aktarılmıştır. Analizler için birtakım testlerden önce verilerin normal dağılım gösterip göstemerdiğine bakılmıştır. Elde edilen verilerin normallik analizinin yapılması hususunda çarpıklık ve basıklık katsayıları incelenmiştir. Skewness (Çarpıklık) ve kurtosis (Basıklık) katsayılarının +1,5 ile -1,5 aralığında olması gerektiği vurgulanmaktadır. Bu değerler arasında çıkan bir sonuç, verilerin normal dağılım gösterdiğine işaret etmektedir (Aminu ve Shariff 2014, Tabachink ve Fidell 2013).

Çalışma Etiği

Araştırmada kullanılacak ölçekler (Sağlık Hizmeti Sunumunda Zenofobi Ölçeği, Sağlık Çalışanının Göçmenlere Yönelik Tutum Ölçeği) için ölçeklerin Türkçe geçerliliğini ve güvenilirliğini yapan kişiler ile elektronik posta yoluyla irtibat kurularak gerekli izinler alınmıştır. Katılımcılara Bilgilendirilmiş Onay Formu ile çalışma hakkında bilgilendirme yapılıp daha sonra rızaları alınarak ilgili anketi doldurmaları istenmiştir. Araştırmanın gerçekleştirilmesine başlamadan önce Selçuk Üniversitesi Sağlık Bilimleri Fakültesi Girişimsel Olmayan Klinik Araştırmalar Etik Kurulundan 30.10.2024 tarihli ve 977 sayılı kararı ile, araştırmanın etik kurallara uygunluğu onaylanmış ve böylece araştırma süreci için etik kurul izni resmi olarak verilmiştir.

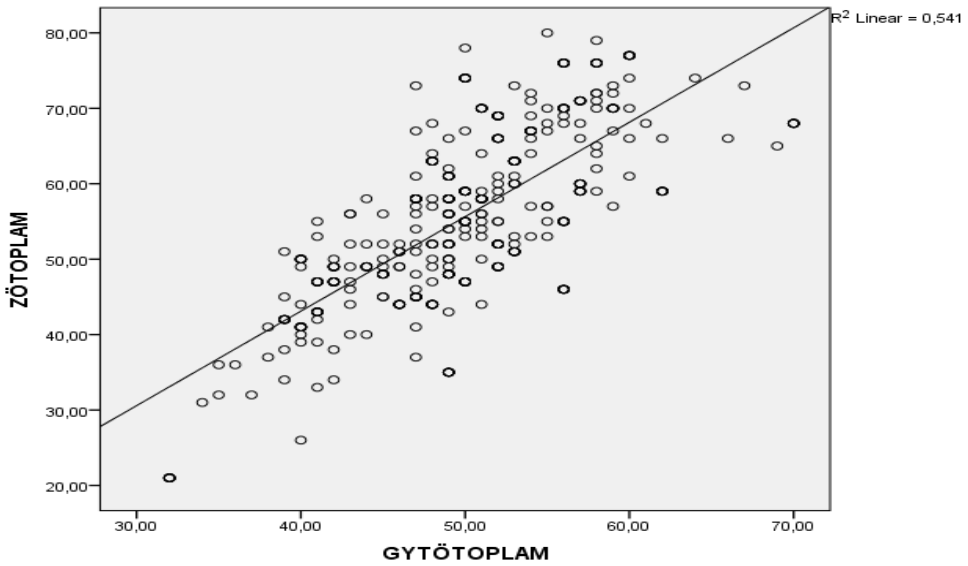
Bulgular ve Tartışma

Sağlık çalışanlarının göçmenlere yönelik tutumlarının ve zenofobinin, sağlık hizmetlerinin kalitesi, erişilebilirliği ve etkililiği üzerinde doğrudan etkileri olabilir. Sağlık profesyonellerinin göçmenlere yönelik tutumu ve zenofobi düzeylerine yönelik yapılan çalışmaların artırılması, sağlık çalışanlarının tutumlarının iyileştirilmesi ve sağlık hizmetlerine olan güvenin pekiştirilmesi açısından büyük bir öneme sahiptir. Çalışmanın sonuçları, hem sağlık politikaları geliştiren yetkililer hem de sağlık çalışanlarının eğitim süreçleri açısından değerli bir rehber olabilir. Bu doğrultuda araştırmanın amacı kapsamında sağlık çalışanlarının hizmet sunumunda zenofobi ve göçmenlere yönelik tutumlarının incelenmesi yapılmıştır.

Araştırma kapsamında 400 sağlık çalışanı katılımcıya ulaşarak katılımcıların tanımlayıcı özelliklerine ait bulguları incelendiğinde; %50,5'i 21-33 ve %49,5'i 34-58 yaş aralığında yer almaktadır. Sağlık çalışanlarının %40,8'i erkek %59,2'si kadındır. Katılımcıların %71,8'i evli iken %28,2'si ise bekardır. Diğer taraftan %35,8'i lise-önlisans, %42,2'si lisans, %22'si lisansüstü-doktora eğitim durumuna sahiptir. Sağlık çalışanlarının %69'u hemşire %17'si doktorlar ve %14 ile sağlık teknisyeni ve teknikerler oluşturmaktadır. Sağlık çalışanlarının mesleki toplam süreleri %38 1-8yıl %31,8 9-16 yıl ve %31,8 17-33 yıl aralığındadır. Mesleğini isteyerek seçen sağlık çalışanları oranımız %71,8'ken mesleğini istemeyerek seçenler %29,2'dir. Anadilleri dışında başka bir dil bilenlerin sayısı %33,5 sadece anadillerini konuşanların oranı %66,5'dir. Katılımcılardan göçmen sağlığı ile ilgili eğitim alanlar %5,3'ken göçmen sağlığı ile ilgili eğitim almayan oranı %94,7'dir. Son olarak göçmenlerden herhangi bir hastalık bulaşabileceğini düşünen sağlık personeli oranı %76,5 herhangi bir hastalık bulaşacağını düşünmeyen sağlık çalışan oranı %23,5'dir.

Sağlık çalışanlarının zenofobi ve göçmenlere yönelik tutum ölçeğiyle sosyo-demografik ilişkileri arasında anlamlı bir fark bulunamamıştır.

Çalışmamızda sağlık çalışanlarının meslek grupları ile göçmenlere yönelik tutumlar arasında da anlamlı bir fark bulunmamıştır. Literatür taramasında bulguyu destekleyen Portekiz çalışmasında da doktorlar ve hemşireler ile diğer sağlık personeli arasında göçmenlere yönelik tutum skorlarında istatistiksel açıdan önemli bir farklılık gözlemlenmemiştir. (Dias ve ark 2012). Diğer yandan Danimarka da yapılan bir çalışmada doktorlar ve hemşireler göçmenlere yönelik tutumlarda yardımcı hemşirelerden daha olumlu puan almış, bu da mesleki rol farklılıklarının tutumlar üzerinde etkili olabileceğini göstermiştir (Nielsen ve ark 2004).



Şekil 1 Sağlık Çalışanlarının Zenofobi Ve Göçmenlere Yönelik Tutum Varyans Grafiği

Bu araştırmada sağlık çalışanlarının zenofobi ve göçmenlere yönelik tutumları arasında güçlü düzeyde pozitif bir ilişki saptanmıştır ($r = .736$, $p < .01$), ve bu değişkenlerin %54,16'sının zenofobi tarafından açıklandığı bulunmuştur. Bu sonuç, zenofobi ile kültürel hoşgörü, etnik merkezcilik ve önyargı gibi farklı tutum yapıları arasındaki güçlü ilişkileri gösteren önceki araştırmalarla uyumluluk sergilemektedir (Güngör ve ark 2024, Smith ve ark 2022). Örneğin, Van'daki hemşireler üzerinde yapılan bir çalışmada, etnik merkezcilik puanları ile zenofobi arasında pozitif ilişkiler gözlemlenmiş ve açıklanan varyans oranı %23,1 olarak rapor edilmiştir (Güngör ve ark 2021). Uluslararası çapta ise PLOS One'da yayımlanan bir Güney Afrika çalışması, sağlık profesyonellerinin göçmenlere yönelik sosyal dışlayıcı tutumları ile zenofobik davranışları arasında anlamlı pozitif bağlantı olduğunu göstererek benzer sonuçlara ulaşmıştır (Evans ve ark 2021).

Tablo 1 Sağlık Çalışanlarının Hizmet Sunumunda Zenofobi ve Göçmenlere Yönelik Tutum Ölçekleri Arasında Regresyon Analizi

Bağımlı Değişken	Bağımsız Değişken	B	sh	t	F	P	R^2
Sağlık Çalışanlarının Hizmet Sunumunda Zenofobi	Sağlık Çalışanlarının Göçmenlere Yönelik Tutum	,432	,020	21,666	469,396	,000	,541

Sonuç ve Öneriler

Sağlık hizmeti sunumunda zenofobi ve çalışanların göçmenlere yönelik tutum düzeylerinin belirlenerek arasındaki ilişkilerin demografik değişkenlere göre belirlenmesi amacıyla yapılmış olan bu çalışmaya demografik veriler kapsamında çoğunluğu 21-33 yaş grubunun oluşturduğu (%50,5), katılımcılarının çoğu (%59,2) kadınlardan oluşan, medeni hal bakımından %71,8 oranında evli olduğu, eğitim durumlarının %42'sinin Lisans düzeyinde olduğu görülmüştür. Araştırmamıza katılımlarıyla destek veren sağlık profesyonellerinin meslek grubu ağırlığının %69 ile hemşirelerden oluşan, meslekteki toplam geçirdikleri sürenin 17-33 yıl olan grubun oranı %31,8, mesleği isteyerek seçmiş olanlarında %71,8 oranında olduğu belirlenmiştir. Katılımcıların %66,5'i anadil dışında farklı bir dil bilmezken, göçmen sağlığı eğiti almamış olanların oranı ne yazık ki %94'7'dir. Son olarak göçmenlerden size herhangi bir hastalık bulaşacağını düşünenlerin oranı %76,5 olduğu saptanmıştır.

Ölçekler arasında yapılan pearson korelasyon ve regresyon analizine göre araştırma kapsamında sağlık çalışanlarının hizmet sunumunda zenofobi ile sağlık çalışanlarının göçmenlere yönelik tutum düzeyleri arasında güçlü düzeyde pozitif ve anlamlı bir ilişki bulunmuştur. Sağlık çalışanlarının hizmet sunumunda zenofobiden gerçekleşen değişimin %54,1'inin göçmenlere yönelik tutum tarafından açıklandığı görülmüştür. Sağlık çalışanlarının hizmet sunumunda zenofobi arttıkça göçmenlere yönelik tutumda arttığı görülmektedir.

Bu araştırmanın sonuçlarına göre öneriler şu sekilde sıralanabilir;

Kapsayıcı Eğitim Programları Düzenlenmeli:

Sağlık çalışanlarına yönelik kültürel farkındalık ve empati geliştirme odaklı eğitim programları oluşturulmalıdır. Bu eğitimler, çalışanların farklı kültürlerle daha etkili iletişim kurabilmelerine ve göçmenlerin sağlık ihtiyaçlarını daha iyi anlayabilmelerine olanak tanıyacaktır.

Göçmen sağlığına yönelik özel eğitimler arttırılmalı, sağlık çalışanlarının bu konuda daha fazla bilgi sahibi olmaları sağlanmalıdır. Bu eğitimler, göçmenlerin karşılaştığı sağlık problemleri ve bunlarla ilgili tedavi süreçleri hakkında daha derinlemesine bilgiler sunmalıdır.

Mesleki Deneyimin Artırılması Teşvik Edilmelidir:

Çalışanların mesleki deneyimlerinin artırılması için farklı sağlık kurumlarında görev alacakları rotasyonlar, uzmanlık eğitimleri ve çok kültürlü çalışma ortamları sağlanmalıdır. Bu tür deneyimler, sağlık çalışanlarının kültürel farklılıkları daha iyi anlamalarına ve göçmenlere yönelik tutumlarının iyileşmesine yardımcı olacaktır.

Deneyimli sağlık çalışanlarının daha genç çalışanlarla bilgi ve deneyim paylaşımına yönelik programlar düzenlenmelidir.

Medya ve Toplum Temelli Eğitimler Düzenlenmelidir:

Toplumda göçmenlere yönelik olumsuz algıların giderilmesi adına, sağlık çalışanlarına yönelik değil, toplum geneline yönelik de eğitimler yapılmalıdır. Bu eğitimler, göçmenlerin sağlık sistemine entegre olmasını kolaylaştıracak, aynı zamanda sağlık çalışanlarının göçmenlere yönelik tutumlarını da pozitif yönde etkileyecektir.

Medya temsilleri, göçmenler ve sağlık çalışanları arasında sağlıklı bir ilişki kurulmasına yönelik olmalıdır. Negatif göçmen temsillerinden kaçınılmalı, sağlık çalışanları ve göçmenler arasındaki olumlu etkileşimler öne çıkarılmalıdır.

Göçmen Sağlığı Politikaları Geliştirilmelidir:

Sağlık sektörü ve kamu politikaları, göçmen sağlığına yönelik özel düzenlemeler getirmelidir. Bu düzenlemeler, hem göçmenlerin sağlık hizmetlerine erişimini kolaylaştırmalı hem de sağlık

çalışanlarının kültürel farkındalık ve empati ile bu hizmetleri sunmalarına olanak tanımalıdır.

Göçmenlere yönelik sağlık hizmetlerinin daha erişilebilir ve etkili olabilmesi için, yerel yönetimler ve sağlık kuruluşları arasında işbirliği ve koordinasyon sağlanmalıdır.

Göçmen Sağlığına Dair Psikolojik Destek Sağlanmalıdır:

Sağlık çalışanlarının göçmenlere yönelik tutumlarını etkileyebilecek en önemli faktörlerden biri olan psikolojik baskılar ve göçmen sağlığına dair endişeler, çalışanlara yönelik profesyonel destekle ele alınmalıdır. Sağlık çalışanları için psiko-sosyal destek programları sunulmalıdır.

Teşekkür

Kendisini tanıdığım günden bugüne kadar hayatın birçok alanında katkılarını sunan, bilgi ve tecrübeleriyle yol göstererek hayatıma yeni boyutlar kazandıran, yüksek lisans sürecimin başarıyla tamamlanmasında, akademik ve bireysel anlamdaki gelişimimde önemli katkıları olan değerli danışmanım Prof. Dr. Handan Ertaş'a en içten duygularımla teşekkür ederim.

Bugünlere gelmemde üzerimde emekleri çok olan kıymetli anne-babama, hayatımın her alanında desteğini esirgemeyen yol arkadaşım çok sevgili eşime ve dünyaya gözlerini yeni açmış olan canım kızım Ayça Beren'ime sonsuz teşekkürlerimi sunuyorum.

Kaynakça

Dias, S., Gama, A., Cargaleiro, H., & Martins, M. O. (2012). Health Workers' Attitudes Toward İmmigrant Patients: A Cross-Sectional Survey İn Primary Health Care Services. Human Resources For Health, 10(14), 1–13.

Evans, M. R., Manda, J., & Tshabalala, M. (2021). Social Exclusion And The Perspectives Of Health Care Providers On Migrants İn Gauteng Public Health Facilities, South Africa. PLOS ONE, 16(1), E0244080.

Güngör, M. (2017). Bir Kimlik İnşası Olarak Ulus-Devlet Yurttaşlığı Ve Yurttaşlık Kavramının Dönüşümü. Mersin Üniversitesi Eğitim Fakültesi Dergisi, 13(2), 438-464.

Güngör, S., Tosun, B., & Prosen, M. (2021). Investigation The Relationship Between Xenophobic Attitude And İntercultural Sensitivity Level İn Nurses. Nurse Education Today, 107, 105104.

Smith, J., García, H., & Müller, P. (2022). Does Length Of Professional Experience Affect Xenophobic Attitudes Among Health Practitioners? A Mixed-Method Study. Journal Of Health Services Research & Policy, 27(1), 58–65.

Tabachnick, B. G., & Fidell, L. S. (2013). Using Multivariate Statistics (6th Ed.), Boston: Allyn And Bacon.

Nielsen, A. S., Krasnik, A., Michaelsen, J. J., & Nørredam, M. L. (2004). Health Professionals' Knowledge, Attitudes, And Experiences İn Relation To İmmigrant Patients: A Questionnaire Study At A Danish Hospital. Scandinavian Journal Of Public Health, 32(1), 287–295.

Büyüköztürk Ş, Kılıç Çakmak E, Akgün ÖE, Karadeniz Ş, Demirel F, 2013. Bilimsel

Cenkci, Z., & Nazik, E. (2018). Sığınmacı Ve Mülteci Kadınların Yaşadığı Sorunlar Ve Sunulan Sağlık Hizmetleri. Anadolu Hemşirelik Ve Sağlık Bilimleri Dergisi, 21(4), 293–299.

Kılıç, S. (2012). Örnek Büyüklüğü, Güç Kavramları Ve Örnek Büyüklüğü Hesaplaması. Journal Of Mood Disorders, 2(3), 140-2.

Kaldık, B. (2021). Uluslararası Göç Bağlamında Sığınmacılara Yönelik Yabancı Düşmanlığının İncelenmesi: Türkiye'de Zenofobi Üzerine Bir Uygulama. Bingöl Üniversitesi İktisadi Ve İdari

Bilimler Fakültesi Dergisi, 5(Uluslararası İktisadi Ve İdari Bilimler Kongresi: Krizler, Belirsizlikler Ve Arayışlar Özel Sayısı), 69-96.

Rahimaghaee, F. Ve Mozdbar, R. (2017). Cultural İntelligence And İts Relation With Professional Competency İn Nurses. Nurs Pract Today, 4(3), 115–124.

Davidov, E. Ve Semyonov, M. (2017). Avrupa Toplumlarında Göçmenlere Yönelik Tutumlar. Uluslararası Karşılaştırmalı Sosyoloji Dergisi , 58 (5), 359-366.

Demirel, B., & Çamur, G. (2023). SOSYAL HİZMET BÖLÜMÜ ÖĞRENCİLERİNİN GÖÇMENLERE YÖNELİK TUTUMLARINA İLİŞKİN BİR ARAŞTIRMA. Sosyal Politika Ve Sosyal Hizmet Çalışmaları Dergisi, 4(2), 231-247.

Özmete, E., Yıldırım, H. & Duru, S. (2018). Yabancı Düşmanlığı (Zenofobi) Ölçeğinin Türk Kültürüne Uyarlanması: Geçerlik Ve Güvenirlik Çalışması. Sosyal Politika Çalışmaları Dergisi, 18(40/2), 191-209.

Just, A., & Anderson, CJ (2015). Çifte Bağlılıklar? Göçmenlerin Göçe Karşı Tutumları. Politika Dergisi , 77 (1), 188-201.

Yeşildağ, İ. (2022). GÖÇMEN KARŞITLIĞINA ETKİ EDEN FAKTÖRLER. Sosyoloji Notları, 6(1), 24-47.

Yeşildağ, İ. (2022). Göçmen Karşıtlığına Etki Eden Faktörler: Pandemi Süreci Özelinde Bir Analiz. Sosyoloji Notları, 6(1), 24–40.

Başaran, CH (2022). Zenofobi Ve Medikal Zenofobi'yi Yeniden Düşünmek. Türk Halk Sağlığı Dergisi, 20(3), 458-473

Hiçdurmaz, Z. (2023). Göçmenlerin Ötekileştirilmesinde Kolektif Bir Duygu Olarak Zenofobi. Dumlupınar Üniversitesi Sosyal Bilimler Dergisi(75), 373-384.

Türkiye İstatistik Kurumu (Tüik), 2023. Sağlık Personeli Sayılarının İllere Göre Dağılımı, Erişim Adresi: Https://Data.Tuik.Gov.Tr/Kategori/Getkategori?P=Saglik-Ve-Sosyal-Koruma-101, Erişim Tarihi 29.09.2024.

A REVIEW OF CONTEMPORARY FURNITURE TRENDS AND EDUCATIONAL CONCEPTS FOR FURNITURE DESIGN

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ABSTRACT

This study comprehensively examines the transformation in the furniture industry over the past decade due to the impact of digital technologies. The research addresses the effects of digitalization and technological innovations on furniture design, production processes, personalization opportunities, and user experiences. In this context, the study aims to reveal the scope and level of the contributions that this technological transformation may provide to furniture design education. Within this framework, it evaluates how technologies such as automation, the Internet of Things (IoT), artificial intelligence, 3D printing, and augmented/virtual reality (AR/VR) increase production efficiency and transform the interaction between the user and the product. The proliferation of smart furniture, the development of online customization tools, the contribution of robotic systems to production performance, the use of sustainable materials, and the integration of biophilic design approaches constitute the core components of the study. In addition, emerging materials, flexible supply chains, circular economy strategies, and Product Lifecycle Management (PLM) are addressed as key factors shaping future sustainable production systems. The findings indicate that furniture has gone beyond being merely a functional object and has become an interactive, environmentally conscious, and user-centered component of life. Moreover, users actively participate in the design process through digital technologies. These developments demonstrate that furniture design programs need to update their pedagogical frameworks, integrate digital production technologies into curricula, and develop interdisciplinary and sustainability-oriented competencies in future designers. Ultimately, the convergence of nature and technology directs the future of furniture design toward a creative, sustainable, and human-centered path, making it essential for design education to equip students with digital literacy, technological adaptability, and sustainable design thinking.

Keywords: Furniture Design Education, Contemporary Furniture Trends, Digital Transformation

Introduction

The furniture industry is an important sector due to its economic scale and its role in social life. In recent years, the industry has undergone rapid transformation due to the impact of digitalization. Technologies such as automation, augmented reality (AR), the Internet of Things (IoT), additive manufacturing, and 3D printing are at the center of this transformation (Rame et al., 2023). These

innovations offer manufacturers the opportunity to design personalized products, create low-cost prototypes, and improve production efficiency. They also provide significant advantages in terms of speed, quality, and sustainability (Gayda et al., 2023; Jarža et al., 2023; Yang & Du, 2022). These technologies enable the development of smarter and more environmentally friendly furniture. At the same time, they strengthen the sector's competitiveness and sustainable design approach (Biliri et al., 2017; Rame et al., 2023).

The purpose of this study is to examine the transformation in furniture development and production over the past decade, driven by digital technologies (Fig 1.). The study addresses changing user expectations, advances in production technologies, and the impact of digitalization on the furniture industry. In this context, it aims to reveal how these technological developments contribute to furniture design education and provide insights for both researchers and industry stakeholders regarding the future of the sector. In line with the study's structure, contemporary developments are examined under three main categories: design processes, production technologies, and sustainable design approaches. Within these categories, the discussion focuses on digitalization, smart and technology-integrated furniture, online customization tools, augmented and virtual reality (AR/VR), compact and modular furniture, additive manufacturing (3D printing), robotic automation, the Internet of Things (IoT), artificial intelligence (AI), local production and flexible supply chains, biophilic design approaches, and emerging materials.

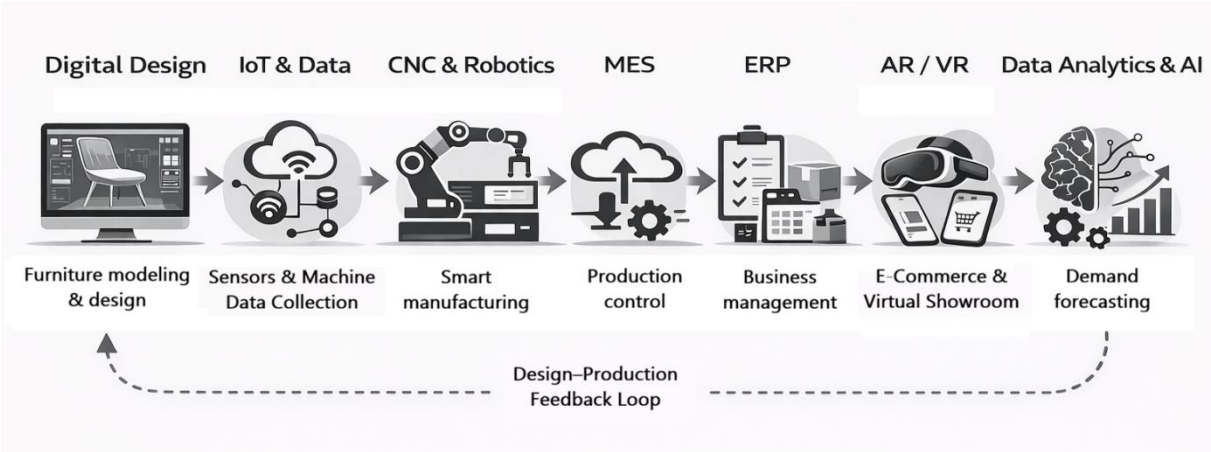


Figure 1. Digital transformation workflow in the furniture industry (Created by the authors, 2026).

A Review of Contemporary Furniture Trends

Design Process: User-Centered and Digital Approaches

Digitalization

Digitalization refers to the integration of digital technologies in the furniture industry to optimize supply chains, increase production efficiency, expand digital design capabilities, and respond more quickly to customer demands (Liu, 2023). In this context, the development of digital design tools has transformed human-product interaction and increased the diversity of user experiences through smart furniture, online customization, and user-centered design approaches (Novak & Loy, 2018). However, digital transformation presents challenges, including high implementation costs, technological resistance, limited digital skills, and traditional management practices, especially for small-scale furniture businesses (Kallmuenzer et al., 2025; Sharma et al., 2023). Despite these challenges, digitalization promotes innovation, efficiency, and sustainability, thereby strengthening the furniture industry's global competitiveness and capacity to adapt to the future (Navarro et al., 2008).

Smart and technology-integrated furniture

Smart furniture refers to innovative products equipped with smart technologies that can exchange data over a network connection and aim to enhance user comfort (Krejcar et al., 2019; Maulana et al., 2024). Such furniture adapts to environmental conditions through sensors and automatic control systems, detects user needs, and optimizes ergonomics (Yu et al., 2024). Supported by technologies such as the Internet of Things (IoT), machine learning (ML), and cyber-physical systems (CPS), these systems integrate physical structures with digital data (Oliveira et al., 2022; Sivils et al., 2018). With their multifunctional capabilities, smart furniture improves quality of life by enhancing lighting, climate control, posture tracking, and energy efficiency (Wulanda, 2024). However, the widespread use of these technologies raises privacy concerns and may negatively affect user comfort (Pirinen et al., 2025).

Online customization tools: 3D product configurators

3D product configurators are digital tools that enable users to visualize and personalize products online interactively. In this regard, research shows that users find three-dimensional (3D) product representations more informative and interactive than two-dimensional (2D) images, which increases satisfaction with the shopping experience (Ozok & Komlodi, 2009). Furthermore, the use of 3D configurators on e-commerce platforms allows customers to customize products in real time, thereby increasing not only user satisfaction but also business efficiency (Puzhenko & Kotsiubynskyi, 2024). Consequently, businesses gain a competitive advantage in the market by offering personalized options while keeping production costs under control (Gutai et al., 2023).

Augmented and virtual reality applications (AR/VR)

With digital transformation, augmented reality (AR) and virtual reality (VR) technologies offer significant innovations in furniture design and user experience. These technologies enhance the user experience by enabling real-time visualization of features such as color, size, and material in interior design and furniture shopping. In addition, they accelerate the design process and help manufacturers respond more quickly to changing market demands (Gayda et al., 2023). In particular, VR allows users to experience spaces in virtual environments and increases satisfaction in terms of aesthetics, ease of use, and the quality of information (Kim & Hyun, 2022; Tang et al., 2023; Wu & Han, 2023). Similarly, AR allows users to visualize furniture in their living spaces at actual scale, making the shopping experience more realistic (Mori et al., 2016; Sreedhar et al., 2022; Wei et al., 2022).

Compact, multifunctional, and modular furniture

Compact, modular, and multifunctional furniture refers to designs that save space, adapt to different forms, and serve multiple functions (Merriam-Webster, n.d.-a, n.d.-b, n.d.-c). In this context, the function of a piece of furniture directly influences its design and structural decisions. As living spaces continue to shrink, the need for furniture that can serve multiple purposes has increased; however, such designs may not always provide full comfort for every function. Nevertheless, multifunctionality also gives brands a significant advantage by enabling them to adapt to changing user needs (Smardzewski, 2015).

Production Process and Technological Applications

Additive manufacturing (3D printing)

The integration of additive manufacturing (AM) technologies into the furniture production process, from design to final finishing, significantly increases flexibility, speed, and environmental efficiency in production (Prykhodko, 2025). At the same time, this technology offers designers a wide range of creativity in terms of shape, color, and size. Different types of 3D printers also allow selection of materials suitable for the intended purpose (Nicolau et al., 2022). Furthermore,

combining 3D printing technology with eco-friendly composites paves the way for more innovative, customizable, and resource-efficient furniture production in the future (Prykhodko, 2025). 3D printing offers advantages over traditional methods in terms of speed, flexibility, precision, and sustainability in furniture production. However, industrial-scale implementation also requires integration with automation and robotic systems.

Robotic automation

Automation and industrial robots are innovative systems that provide speed, precision, and flexibility in furniture production. These technologies reduce costs while increasing production efficiency and quality, enable the realization of complex designs, and increase the added value of labor, allowing workers to move into more skilled areas (Gayda et al., 2023; Graetz & Michaels, 2018; Guo & Su, 2023; Huang et al., 2021; Rame et al., 2023; Urhal et al., 2019). This development increases production precision in the furniture sector while also expanding design diversity. However, limited process flexibility, high investment and maintenance costs, and technical knowledge requirements make widespread adoption of these technologies difficult (Shakeri, 2024). Therefore, robotic automation in furniture production requires careful planning and technical expertise.

IoT

The Internet of Things (IoT) is a technology that enables different smart devices to interact by sharing data over the internet (Akpakwu et al., 2017; Zhou et al., 2018). In the field of interior design and home automation, IoT improves quality of life by offering users comfort, energy efficiency, and security (Habib et al., 2024; Williams, 2024). These systems manage many functions, such as fire safety, health monitoring, lighting, and energy management, using real-time data (Ito et al., 2003). However, data collection processes and the risk of unauthorized access raise security and privacy concerns (Farooq et al., 2015; Khadam et al., 2024). Therefore, the growing use of IoT technologies underscores the need for secure infrastructure and ethical data management practices.

AI integration

Artificial intelligence (AI) is a field of computer science that aims to develop systems that mimic human-like thinking and problem-solving abilities (Boden, 2018; Fabio, 2022; Triantafyllou, 2024). AI-based tools that combine human cognition with machine learning establish a knowledge network that supports creativity, improves knowledge management, and allows designers to focus on aesthetic goals (Chen et al., 2025). Consequently, the integration of artificial intelligence technologies into furniture design suggest the future development of systems that can predict user trends, guide aesthetic decisions, and contribute to the design process as creative partners (Elfayoumy et al., 2025). Today, the integration of AI into furniture production is driving significant transformation across the industry by improving design, production, and quality control processes. Machine learning and predictive analytics used by AI systems increase efficiency and environmental awareness in supply chains, providing businesses with advantages in inventory and logistics management. In the long term, AI is seen as a tool that increases competitiveness and supports sustainability in the furniture industry (Korshi et al., 2025).

Local production and flexible supply chains

Understanding the regional impacts of local furniture production is important. The use of local resources reduces costs, supports regional economies and employment, and decreases dependence on imported products while increasing production capacity (Eckelman et al., 2001). The integration of local production with production networks increases knowledge and resource sharing, expands supply opportunities, enhances flexibility, shortens delivery times, and supports

dynamic production with a wider range of products. Ecologically, it supports climate resilience and closed-loop life cycles (Markert & Krenz, 2024).

Flexible supply chains are crucial in the furniture industry to maintain competitive strength and quickly adapt to changing market demands. Technologies such as IoT, Big Data Analytics, and Cloud Computing support the growing demand for e-commerce by making logistics processes smarter and more real-time. They will continue to do so in the future (Yu et al., 2016). Flexible logistics supports risk management, improves coordination between suppliers and manufacturers, and enhances customer satisfaction through more efficient supply and distribution processes (Maldonado-Guzman et al., 2017).

Sustainable Design Approaches

According to the United Nations Brundtland Commission, sustainability means meeting the needs of the present without compromising the ability of future generations to meet their own needs (UN, 1987). In this context, sustainable product design aims to reduce the environmental impacts of a product throughout its life cycle using innovative technologies (Peralta et al., 2021). From a product perspective, Life Cycle Assessment (LCA) describes the analysis of environmental impacts in all processes, from raw material extraction to recycling (Vieira et al., 2016). Similarly, Product Lifecycle Management (PLM) is an approach used to manage and track the entire product life cycle from the idea stage to disposal (Stark, 2022).

To address the environmental impacts throughout the product life cycle, the circular economy promotes strategies such as reuse, repair, and remanufacturing (EEA, 2024; Fullerton et al., 2022). Approaches such as “design for recycling” and “designing from recycling” aim to reduce waste while extending product life (Berwald et al., 2021; IKA, 2025). Circular design and longevity are among the most important themes in the circular economy. Circular design is an approach that aims to prevent waste and pollution before they occur based on material selection and design decisions that determine the product's life cycle. Integrating circular principles into the design process extends product life, optimizes resource use, and reduces environmental impact at the outset (EMF, n.d.).

Biophilic approach in furniture and interior design

Biophilic design is an approach that aims to strengthen the intrinsic bond humans have with nature. Conceptually, it is based on the instinctive tendency to interact with life forms in nature and maintain this bond (Kellert et al., 2011). This approach enables users to reconnect with nature by integrating forms, materials, and processes that represent nature in artificial environments into the design (Heath, 2018).

In furniture and interior design, the biophilic concept involves integrating forms inspired by nature, natural materials, daylight, botanical elements, and textures reminiscent of nature into the design process. These elements create feelings of calmness, belonging, and balance in users (Kellert et al., 2011). By reestablishing the connection between humans and nature at the spatial level, biophilic design aims to create an aesthetic and functional unity while contributing to reduced stress, improved cognitive performance, and enhanced mental well-being (Kellert & Calabrese, 2015; Yin et al., 2018).

Emerging materials

Sustainable and next-generation material selection reduces environmental impacts by minimizing waste and energy consumption while enhancing resource efficiency (Ahmad et al., 2023). Bio-based materials obtained from nature can be converted into products such as biofuel, bioenergy, and composites (Shahinur et al., 2020). Emerging materials are classified into bio-based, composite, and recycled materials. Sustainable natural materials such as wood, bamboo, cork, and

flax are widely used in interior and furniture design. In recent years, biological and experimental materials such as seaweed, oyster shells, straw panels, bamboo and mycelium have attracted attention as emerging materials (Hales, 2025). Furthermore, composite materials made from wood chips and recycled plastic offer a sustainable alternative for indoor and outdoor furniture, due to their durability and longevity (Trex, n.d.).

3. Findings - Comparison of Key Concepts and Their Influence

Table 1 summarizes the key concepts discussed in the study and their effects on production, design, sustainability, user experience, and future impact. The scores reflect the authors' assessment based on general trends identified in the literature.

Table 1. Comparative parameters of influential concepts in the furniture industry (Created by the authors, 2025).

	Effects				
Concepts	**Product Manufacturing**	**Product Design and Development**	**Product Sustainability**	**User Experience and Involvement**	**Impactance in the Future**
Digitalization	4	4	2	4	4
Online Customization Tools	4	4	2	4	4
Smart and Tech-Integrated Furniture	4	4	2	4	4
Compact, Multifunctional, and Modular Furniture	3	4	3	4	4
Additive Manufacturing	4	4	2	3	3
3D Printing	4	4	2	3	2
Robotic Automation	4	4	2	2	4
IoT	4	4	2	4	4
Artificial Intelligence (AI)	4	4	2	4	4
Local Production and Flexible Supply Chains	3	3	4	3	3
Sustainability	2	2	4	1	3
Biophilic Environment and Furniture	1	3	3	2	2
Emerging Furniture Materials	1	1	3	1	3
– No impact, 1 Low impact, 2 Average impact, 3 High impact, 4 Exceptional impact					

The results indicate that digitalization, online customization tools, smart furniture, IoT, and artificial intelligence have strong effects on manufacturing processes, design development, and user experience. This shows that digital technologies play an important role in the ongoing transformation of the furniture industry.

While local production and sustainability make strong contributions to environmental performance, biophilic design and emerging materials also support sustainability as important design approaches. Compact, multifunctional, and modular furniture shows a more balanced impact across design, sustainability, and user experience. These trends respond to changing spatial conditions and lifestyle needs. Overall, the table suggests that the interaction of digital technologies, sustainable production strategies, and user-centered design approaches will shape the future of the furniture industry.

Conclusion and Recommendations

The conclusion summarizes the impact of new trends on education and furniture manufacturers, and their Influence on the general public or users. The results are as follows:

(A) Impact on education: Generations Z and Alpha are growing up with digital tools, and therefore educators must keep pace with these constant changes. Among the most prominent topics today are digitalization and its implications for design and production. Compact or smart furniture, AR/VR, AI, modular design, 3D printing, robotics, IoT, flexible supply chains, sustainability, emerging materials, etc. short but continuously updated modules could be added alongside the core subjects. Educators can contribute to the learning process by using digital pedagogy methods to personalize learning and increase student motivation. First and foremost, hybrid methods (hands-on) should be tried instead of only theoretical or practical methods. According to Andac Guzel (2020), students want design courses to be both practical and theoretical and to include preparation for working life, such as materials, production methods, artistic skill development, qualified internships, and on-site learning (Andac Guzel, 2020). In this context, course content should support practical training according to departmental capabilities. Technical tours, case studies, workshops, and seminars on robotics, IoT, materials, and production should be offered (in person or online), so students can examine design, modeling, and production methods using up-to-date software. Public or private sector collaborations should be established to help students gain a realistic perspective on professional life.

(B) Impact on Furniture Manufacturing: Digital tools provide advantages in decision-making, quality control, and production automation. Smart furniture requires a stronger digital infrastructure, sensor systems, and data security. 3D configurators and AR/VR applications improve production flexibility, planning, and customer interaction. Artificial intelligence, 3D printing, and robotic systems increase efficiency and accuracy in design and production. Although IoT-based manufacturing can be challenging for small businesses due to high infrastructure costs, a phased transition and policy support can facilitate adoption. In addition, flexible supply chains and the use of local resources can improve cost efficiency and delivery performance. Providing transparent information about material impacts and product life cycles can strengthen sustainability and user trust. Models such as second-hand furniture sales and rentals also support environmentally friendly approaches. As material diversity increases, manufacturers should follow current trends and offer sustainable options. A multidisciplinary workforce, including expertise in computer modeling and electronics, is essential for this transition.

(C) Impact on the general public or users: Digital tools such as 3D configurators and AR/VR technologies allow users to examine furniture in real time and support decision-making through more realistic experiences. Artificial intelligence, smart furniture, and IoT-enabled systems can offer more personalized and functional living environments, while modular, compact, and multifunctional furniture can improve space utilization and quality of life. At the same time, users expect an age-friendly design, clear product explanations, and strong data protection. In addition, biophilic design, transparent material information, low-cost personalization via 3D printing, and sustainable options such as local production and second-hand products can support user trust and sustainability.

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5. References

Ahmad, S., Sharma, J., & Gambhir, V. (2023). *Handbook of Sustainable Materials: Modelling, Characterization, and Optimization*. CRC Press. https://books.google.com/books?id=lXGwEAAAQBAJ

Akpakwu, G. A., Silva, B. J., Hancke, G. P., & Abu-Mahfouz, A. M. (2017). A survey on 5G networks for the Internet of Things: Communication technologies and challenges. *IEEE Access*, *6*, 3619-3647.

Andac Guzel, T. (2020). A Study On Viewpoint Of Students About Interior Design And Furniture Design Education Reference. *Socıal Mentalıty and Researcher Thınkers Journal (Smart Journal)*, *6*(31), 674-679. https://doi.org/http://dx.doi.org/10.31576/smryj.510

Berwald, A., Dimitrova, G., Feenstra, T., Onnekink, J., Peters, H., Vyncke, G., & Ragaert, K. (2021). Design for Circularity Guidelines for the EEE Sector. *Sustainability*, *13*(7), 3923. https://www.mdpi.com/2071-1050/13/7/3923

Biliri, E., Lampathaki, F., Arvanitakis, A., Michalitsi-Psarrou, A., Martin, J., Gigante, F., Sales, V., & Nunez, M. J. (2017). Manufacturing Intelligence in Furniture Product-Service Design. OTM Confederated International Conferences" On the Move to Meaningful Internet Systems",

Boden, M. A. (2018). What is artificial intelligence? In *Artificial Intelligence: A Very Short Introduction* (pp. 0). Oxford University Press. https://doi.org/10.1093/actrade/9780199602919.003.0001

Chen, Y., Qin, Z., Sun, L., Wu, J., Ai, W., Chao, J., Li, H., & Li, J. (2025). GDT framework: integrating generative design and design thinking for sustainable development in the AI era. *Sustainability*, *17*(1), 372.

Eckelman, C., Haviarova, E., Zui, H., & Gibson, H. (2001). Considerations in the design and development of school furniture for developing regions based on local resources. *Forest Products Journal*, *51*(6).

EEA. (2024). *Circular economy*. https://www.eea.europa.eu/en/topics/in-depth/circular-economy

Elfayoumy, A. H., Abdel Rahman, A., & Oreaba, A. A. S. (2025). AI-Driven Furniture Design: Bridging Creativity and Manufacturability in the Digital Age. *International Design Journal*, *15*(2), 105-113.

EMF. (n.d.). *Circular design: turning ambition into action*. Ellen MacArthur Foundation Retrieved November 18, 2025 from https://www.ellenmacarthurfoundation.org/topics/circular-design/overview

Fabio, M.-A. (2022). What is Artificial Intelligence? *International Journal of Research Publication and Reviews*, *03*, 1947 - 1951 , publication_type = article.

Farooq, M. U., Waseem, M., Mazhar, S., Khairi, A., & Kamal, T. (2015). A review on internet of things (IoT). *International journal of computer applications*, *113*(1).

Fullerton, D., Babbitt, C. W., Bilec, M. M., He, S., Isenhour, C., Khanna, V., Lee, E., & Theis, T. L. (2022). Introducing the circular economy to economists. *Annual Review of Resource Economics*, *14*(1), 493-514.

Gayda, S., Kushpit, A., & Huber, Y. M. (2023). Analysis of implementation of industry 4.0 principles in furniture production. *Forestry, Forest, Paper and Woodworking Industry*, *49*, 73-84.

Graetz, G., & Michaels, G. (2018). Robots at work. *Review of economics and statistics*, *100*(5), 753-768.

Guo, Q., & Su, Z. (2023). The application of industrial robot and the high-quality development of manufacturing industry: From a sustainability perspective. *Sustainability*, *15*(16), 12621.

Gutai, A., Havzi, S., Nikolic, D., & Dakic, D. (2023). Potential of Mass Customization using Product Configurators. 2023 22nd International Symposium INFOTEH-JAHORINA (INFOTEH),

Habib, M. R., Yusuf, M. A., Warnasuriya, W. N., Sunny, K., Rahaman, M. M., Khan, M. R. K., Saha, P. P., & Alam, M. T. (2024). A comprehensive review on the advancement of home automation system. 2024 Second International Conference on Intelligent Cyber Physical Systems and Internet of Things (ICoICI),

Hales, L. (2025, 13 Jun 2025). Algae bricks and oyster shell walls: What's on the horizon for eco-friendly building in Australia? . *The Guardian*. https://www.theguardian.com/environment/2025/jun/14/algae-bricks-and-oyster-shell-walls-whats-on-the-horizon-for-eco-friendly-building-in-australia

Heath, O. (2018). *Creating positive spaces using biophilic design*. Oliver Heath Design.

Huang, G. Q., Vogel-Heuser, B., Zhou, M., & Dario, P. (2021). Digital technologies and automation: The human and eco-centered foundations for the factory of the future [TC Spotlight]. *IEEE Robotics & Automation Magazine*, *28*(3), 174-179.

IKA. (2025). *Döngüsel Tasarım Raporu: Temel İlkeler, Politika ve Düzenlemeler, İyi Uygulama Örnekleri ve Geleceğe Yönelik Öneriler*. İstanbul: İstanbul Kalkınma Ajansı

Ito, M., Iwaya, A., Saito, M., Nakanishi, K., Matsumiya, K., Nakazawa, J., Nishio, N., Takashio, K., & Tokuda, H. (2003). Smart furniture: improvising ubiquitous hot-spot environment. 23rd International Conference on Distributed Computing Systems Workshops, 2003. Proceedings.,

Jarža, L., Čavlović, A. O., Pervan, S., Španić, N., Klarić, M., & Prekrat, S. (2023). Aditivne tehnologije i njihova primjena u dizajnu i proizvodnji namještaja. *Drvna industrija*, *74*(1), 115-128.

Kallmuenzer, A., Mikhaylov, A., Chelaru, M., & Czakon, W. (2025). Adoption and performance outcome of digitalization in small and medium-sized enterprises. *Review of Managerial Science*, *19*(7), 2011-2038.

Kellert, S., & Calabrese, E. (2015). The practice of biophilic design. *London: Terrapin Bright LLC*, *3*(21), 2021-2009.

Kellert, S. R., Heerwagen, J., & Mador, M. (2011). *Biophilic design: the theory, science and practice of bringing buildings to life*. John Wiley & Sons.

Khadam, U., Davidsson, P., & Spalazzese, R. (2024). Exploring the Role of Artificial Intelligence in Internet of Things Systems: A Systematic Mapping Study. *Sensors*, *24*(20), 6511. https://www.mdpi.com/1424-8220/24/20/6511

Kim, H., & Hyun, K. H. (2022). Understanding Design Experience in Virtual Reality for Interior Design Process. *CAADRIA proceedings , publication_type = article*.

Korshi, R. S., Sabah, S., & Habib, M. M. (2025). ARTIFICIAL INTELLIGENCE-DRIVEN SUPPLY CHAIN MANAGEMENT: A LITERATURE REVIEW ON THE WOODEN FURNITURE INDUSTRY.

Krejcar, O., Maresova, P., Selamat, A., Melero, F. J., Barakovic, S., Husic, J. B., Herrera-Viedma, E., Frischer, R., & Kuca, K. (2019). Smart furniture as a component of a smart city—definition based on key technologies specification. *IEEE Access*, *7*, 94822-94839.

Liu, S. (2023). Analysis of digital transformation of furniture market in the context of big data application. *Applied and Computational Engineering*, *4*, 105 - 110. https://doi.org/10.54254/2755-2721/4/20230363

Maldonado-Guzman, G., Pinzón-Castro, S. Y., & Valdez-Bocanegra, H. G. (2017). Logistics flexibility and customer satisfaction in spain's furniture industry. *International Business Research*, *10*(8), 161-172.

Markert, J. C., & Krenz, P. (2024). Local Production Networks of SMEs: The Future of Producing Locally? In *Global collaboration, local production: Fab City als Modell für Kreislaufwirtschaft und nachhaltige Entwicklung* (pp. 281-295). Springer.

Maulana, F. I., Kurniawan, B. K., Pramono, A., Purnomo, A., Abdulah, M. E. B. Z., & Mohamed, M. (2024). Trends in Scientific Research in Smart Furniture: A Bibliometric Analysis in Decade from 2014-2023. 2024 International Conference on ICT for Smart Society (ICISS),

Merriam-Webster. (n.d.-a). Compact. In *Merriam-Webster.com dictionary*. Retrieved November 17, 2025, from https://www.merriam-webster.com/dictionary/compact

Merriam-Webster. (n.d.-b). Modular. In Retrieved November 17, 2025, from https://www.merriam-webster.com/dictionary/modular

Merriam-Webster. (n.d.-c). Multifunctiol In *In Merriam-Webster.com dictionary*. Retrieved November 17, 2025, from https://www.merriam-webster.com/dictionary/multifunction

Mori, M., Orlosky, J., Kiyokawa, K., & Takemura, H. (2016). A transitional ar furniture arrangement system with automatic view recommendation. 2016 IEEE International Symposium on Mixed and Augmented Reality (ISMAR-Adjunct),

Navarro, J., Hayward, P., & Voros, J. (2008). How to solve a wicked problem? Furniture foresight case study. *Foresight*, *10*(2), 11-29.

Nicolau, A., Pop, M. A., & Coșereanu, C. (2022). 3D Printing Application in Wood Furniture Components Assembling. *Materials (Basel)*, *15*(8). https://doi.org/10.3390/ma15082907

Novak, J. I., & Loy, J. (2018). Digital technologies and 4D customized design: challenging conventions with responsive design. In *Handbook of research on human development in the digital age* (pp. 403-426). IGI Global Scientific Publishing.

Oliveira, P. F., Calado, J. S., Sarraipa, J., & Jardim-Gonçalves, R. (2022). A framework for embedded hardware on furniture smartification design. *IFAC-PapersOnLine*, *55*(2), 493-498.

Ozok, A. A., & Komlodi, A. (2009). Better in 3D? An empirical investigation of user satisfaction and preferences concerning two-dimensional and three-dimensional product representations in business-to-consumer e-commerce. *Intl. Journal of Human–Computer Interaction*, *25*(4), 243-281.

Peralta, M. E., Alcalá, N., & Soltero, V. M. (2021). Weighting with life cycle assessment and cradle to cradle: A methodology for global sustainability design. *Applied Sciences*, *11*(19), 9042.

Pirinen, A., Ehrenberg, N., & Mäkinen, R. (2025). Sharing space, time, and technology: the lived experience of smart home technologies in cohousing. *Housing Studies*, 1-23.

Prykhodko, O. (2025). 3D printing in the production of furniture and interior elements. *World Journal Of Advanced Research and Reviews*, *26*(03), 1146 - 1153 https://doi.org/10.30574/wjarr.2025.26.3.2208

Puzhenko, V., & Kotsiubynskyi, V. (2024). Automation of the process of integration of 3d product configurators in electronic commerce system.

Rame, R., Purwanto, P., & Sudarno, S. (2023). Transforming the furniture industry in the digital age. *Jurnal Riset Teknologi Pencegahan Pencemaran Industri*, *14*, 53-69.

Shahinur, S., Ullah, A. S., & Hasan, M. (2020). Developing Successful Biobased Product: Key Design and Manufacturing Challenges.

Shakeri, S. (2024). *Robots and Wood: A match made in manufacturing heaven*. https://parametric-architecture.com/robots-and-wood-a-match-made-in-manufacturing-heaven/

Sharma, M., Raut, R. D., Sehrawat, R., & Ishizaka, A. (2023). Digitalisation of manufacturing operations: The influential role of organisational, social, environmental, and technological impediments. *Expert Systems with Applications*, *211*, 118501.

Sivils, P., Rieger, C., Amarasinghe, K., & Manic, M. (2018). Integrated Cyber Physical Assessment and Response for Improved Resiliency. In *The Internet of Things for Smart Urban Ecosystems* (pp. 51-74). Springer.

Smardzewski, J. (2015). *Furniture design* (Vol. 201510). Springer.

Sreedhar, R., Samudrala, N., Tan, N., & Sadalgi, S. (2022). Search with space: Find and visualize furniture in your space. Adjunct Proceedings of the 35th Annual ACM Symposium on User Interface Software and Technology,

Stark, J. (2022). Product lifecycle management (PLM). In *Product lifecycle management (volume 1) 21st Century paradigm for product realisation* (pp. 1-32). Springer.

Tang, Y. M., Lau, Y.-y., & Ho, U. L. (2023). Empowering Digital Marketing with Interactive Virtual Reality (IVR) in Interior Design: Effects on Customer Satisfaction and Behaviour Intention. *Journal of Theoretical and Applied Electronic Commerce Research*, *18*(2), 889-907. https://www.mdpi.com/0718-1876/18/2/46

Trex. (n.d.). *Composite decking and recycled wood materials*. Retrieved 10.23.2025 from https://www.trex.com/

Triantafyllou, S. (2024). Artificial Intelligence: An Overview. In *Preprints*: Preprints.

UN. (1987). *Report of the world commission on environment and development: Our common future*. U. N. (UN).

Urhal, P., Weightman, A., Diver, C., & Bartolo, P. (2019). Robot assisted additive manufacturing: A review. *Robotics and Computer-Integrated Manufacturing*, *59*, 335-345.

Vieira, D. R., Calmon, J. L., & Coelho, F. Z. (2016). Life cycle assessment (LCA) applied to the manufacturing of common and ecological concrete: A review. *Construction and Building Materials*, *124*, 656-666.

Wei, H., Tang, L., Wang, W., & Zhang, J. (2022). Home environment augmented reality system based on 3d reconstruction of a single furniture picture. *Sensors*, *22*(11), 4020.

Williams, B. (2024). *Building Smart Devices and Home Automation Systems with Raspberry Pi and IoT: A Comprehensive Guide for Hobbyists and DIY Enthusiasts*. Barrett Williams. https://books.google.com/books?id=3OAaEQAAQBAJ

Wu, S., & Han, S. (2023). System Evaluation of Artificial Intelligence and Virtual Reality Technology in the Interactive Design of Interior Decoration. *Applied Sciences*, *13*(10), 6272. https://www.mdpi.com/2076-3417/13/10/6272

Wulanda, D. (2024). Smart Furniture: Konsep Interior Kamar Indekos. *DESKOVI: Art and Design Journal*, *7*(2), 189-196.

Yang, S., & Du, P. (2022). The application of 3D printing technology in furniture design. *Scientific Programming*, *2022*(1), 1960038.

Yin, J., Zhu, S., MacNaughton, P., Allen, J. G., & Spengler, J. D. (2018). Physiological and cognitive performance of exposure to biophilic indoor environment. *Building and Environment*, *132*, 255-262. https://doi.org/https://doi.org/10.1016/j.buildenv.2018.01.006

Yu, M., Lian, J., & Liang, Z. (2024). Integrated Mechanical and Electronic Design and Comfort Optimization in Smart Furniture. *Journal of Computer Technology and Electronic Research*, *1*(2).

Yu, Y., Wang, X., Zhong, R. Y., & Huang, G. Q. (2016). E-commerce logistics in supply chain management: Practice perspective. *Procedia Cirp*, *52*, 179-185.

Zhou, W., Jia, Y., Peng, A., Zhang, Y., & Liu, P. (2018). The effect of IoT new features on security and privacy: New threats, existing solutions, and challenges yet to be solved. *IEEE Internet of things Journal*, *6*(2), 1606-1616.

THE SOCIOLOGY OF ALGORITHMIC GOVERNANCE: POWER, DATA, AND CONTROL IN DIGITAL SOCIETIES

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ABSTRACT

With the intensification of digitalization in contemporary societies, the functions of algorithms have expanded significantly. Algorithms are no longer merely tools shaping the digital realm; they have evolved into power mechanisms that configure the social order. This article aims to analyze the relationships between power, data, and control by examining algorithmic governance from a sociological perspective. Drawing upon Foucault's concepts of biopower and discipline, Zuboff's framework of surveillance capitalism, and Luhmann's systems theory, this study investigates how algorithmic governance reproduces inequalities, restricts autonomy, and transforms social belonging. The central argument of this study is that algorithmic systems are not objective tools reflecting social reality; on the contrary, they are instruments that reconstruct reality by filtering data. By shaping political discourses through social media platforms, contemporary societies are reconfiguring the social distribution of power. This situation displaces traditional modes of political participation and causes political engagement to be formed within the opaque architectures of digital platforms rather than in physical public squares. Furthermore, through surveillance capitalism—which utilizes human experience as raw material to collect behavioral data far exceeding what is necessary—individuals are subjected to predictive modeling and behavioral modification. Consequently, the modern individual becomes both a subject of exploitation and a participant in the system, sacrificing their freedom to sustain the mechanism. Ultimately, through imperceptible algorithmic manipulations, the individual loses their symbolic existence and free will. From this vantage point, the article sociologically deconstructs three dimensions of algorithmic governance: how it restructures power relations, the implications of data collection and processing practices for social control, and its tangible effects on digital inequality and individual autonomy. The findings demonstrate that algorithms are not neutral; instead, by disseminating specific normative and political preferences, they deepen social fragmentation and surveillance. The original contribution of this article lies in positioning the algorithm not merely as a technical aspect of digitalization, but as a sociological phenomenon. In this context, three empirical cases—situated at the intersection of digital platforms, state structures, and surveillance capitalism—are interpreted to reveal the various manifestations and social consequences of algorithmic power.

Keywords: Algorithmic governance, surveillance capitalism, data power, digital inequality, biopower, platform politics

ALGORITMIK YÖNETIMIN SOSYOLOJISI: DIJITAL TOPLUMLARDA GÜÇ, VERI VE KONTROL

Özet

Günümüz toplumlarında dijitalleşmenin yoğunlaşmasıyla beraber algoritmaların işlevleri de genişlemektedir. Algoritmalar artık sadece dijital dünyayı şekillendiren araçlar değil toplumsal düzeni biçimlendiren iktidar mekanizmalarına dönüşmüştür. Bu makale, algoritmik yönetimi sosyolojik bir perspektiften ele alarak güç, veri ve kontrol arasındaki ilişkileri çözümlemeyi amaçlamaktadır. Bu bağlamda Foucault'nun biyoiktidar ve disiplin kavramları, Zuboff'un gözetim kapitalizmi çerçevesi ve Luhmann'ın sistem teorisinden yararlanılarak algoritmik yönetimin eşitsizlikleri yeniden üretme, özerkliği sınırlandırma ve toplumsal aidiyeti dönüştürme biçimleri incelenmektedir. Çalışmanın temel argümanı algortimik sistemlerin toplumsal gerçekliği nesnel biçimde yansıtan araçlar olmadığı tam tersine verileri filtleyerek yeniden kurgulayan araçlar olduğudur. Günümüz toplumları sosyal medya platformları aracılığıyla siyasi söylemlerini şekillendirerek gücün toplumsal dağılımını yeniden biçimlendirmektedir. Bu durum geleneksel yöntemdeki siyasal katılımın örgütlenme biçimini yerinden ettiği gibi siyasal katılımın meydanlar yerine dijital pltformların opaque inşalarında şekillenmesine neden olur. İnsan deneyimini hammadde olarak kullanarak gerekli olandan çok daha fazla veri toplayan gözetim kapitalizmi aracılığıyla da bireyin ne yapacağını önceden bilme ve onu bu yöne sevk etmeye maruz kalmaktadır. Dolayısıyla modern birey, gözetim kapitalizminde hem sömüren hem de sömürülen biri haline gelerek özgürlüğünü kaybederek sistemi besler. Bu sürecin sonunda birey fark edemediği algoritmik manipülasyonlar aracılığıyla sembolik varoluşu ve özgür iradesini kaybeder. Bu perspektiften hareketle makale, algoritmik yönetimin üç boyutunu sosyolojik olarak çözümlemektedir: iktidar ilişkilerini nasıl yeniden yapılandırdığı, veri toplama ve işleme pratiklerinin toplumsal kontrol açısından ne anlama geldiği ve dijital eşitsizlik ile birey özerkliği üzerindeki somut etkileri. Çalışma sonucunda elde edilen bulgular algoritmaların nötr olmadığını, tam tersine bazı normatif ve siyasal tercihleri yaygınlaştırarak toplumsal ayrışma ve denetimi derinleştirdiğini ortaya koymaktadır. Makalenin özgün katkısı ise algoritmayı sadece dijitalleşme olarak ele almak yerine onu sosyolojik bir olgu olarak konumlandırmasıdır. Bu kapsamda dijital platformlar, devlet yapıları ve gözetim kapitalizmi ekseninde üç ampirik vaka yorumlanarak algoritmik iktidarın farklı görünümleri ve toplumsal sonuçları ortaya konulmaktadır.

Anahtar Kavramlar: Algoritmik yönetim, gözetim kapitalizmi, veri iktidarı, dijital eşitsizlik, biyoiktidar, platform politikalar

LONDON SOVEREIGN SCHOOL

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February 13, 2026

This Official Protocol Declaration is hereby issued by London Sovereign School (hereinafter referred to as "the Institution"), a duly constituted academic and research entity operating within the United Kingdom and possessing full legal personality under applicable UK law.

Pursuant to the Institutional Charter, Academic Regulations, and Internal Statutes, the Senate of the Institution, at its duly convened session held on **14 January 2026**, did hereby adopt and enact Resolution **No. 2026/7**, whereby it is formally decreed that the scientific event specified hereunder shall be organized under the official auspices and academic supervision of the Institution. The said event shall be deemed an official academic undertaking of London Sovereign School and shall be conducted in strict conformity with principles of academic integrity and all applicable legal and regulatory provisions in force.

By virtue of the aforesaid Resolution, the academicians and designated officials serving within the Organizing Committee, Scientific Committee, Advisory Board, and related academic bodies have been duly nominated and ratified by the Senate. The list of appointed members constitutes an integral and legally operative part of this Declaration.

This Declaration shall enter into force upon issuance and remain in full force and effect unless otherwise amended by Senate resolution.

Dr. Mariam S. OLSSON
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Dr. Ekaterina LOMIA
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Title and Venue of the Scientific Event: 13th New York Conferenc
Official Date(s) of the Event: March 15-18, 2026 New York
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13TH INTERNATIONAL NEW YORK CONFERENCE ONEVOLVING TRENDS IN INTERDISCIPLINARY RESEARCH & PRACTICES
MARCH 15-18, 2026

MANHATTAN, NEW YORK CITY

Invitation for a conference

01.02.2023

REF: Akademik Teşvik

İlgili makama;

13. Uluslararası New York Kongresi, 15-18 Mart 2026 tarihleri arasında Manhattan, New York City'da 34 farklı ülkenin (Türkiye 75 bildiri- Diğer ülkeler 91 bildiri) akademisyen/araştırmacılarının katılımıyla gerçekleşmiştir

Kongre 16 Ocak 2020 Akademik Teşvik Ödeneği Yönetmeliğine getirilen "Tebliğlerin sunulduğu yurt içinde veya yurt dışındaki etkinliğin uluslararası olarak nitelendirilebilmesi için Türkiye dışında en az beş farklı ülkeden sözlü tebliğ sunan konuşmacının katılım sağlaması ve tebliğlerin yarıdan fazlasının Türkiye dışından katılımcılar tarafından sunulması esastır." değişikliğine uygun düzenlenmiştir.

Bilgilerinize arz edilir,

Saygılarımla

Muntazır Mehdi

Committee Member

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