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ASSESSING THE ROLE OF INTERNATIONAL MARITIME HEALTH REGULATIONS IN CONTROLLING EPIDEMICS

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Abstract
Large passenger vessels, including cruise ships, are highly susceptible to infectious diseases, as evidenced by the recent COVID-19 pandemic and previous health incidents associated with other viruses and ailments. Managing severe disease outbreaks within the marine sector is a considerable challenge, focusing on mitigating the substantial dangers of uncontrolled transmission through risk management for shipping operations or alternative ship designs. This study addresses the difficulty by including health considerations into marine safety assessment, considering shipping businesses' daily risk management practices, the Formal Safety Analysis (FSA), and the Risk-Based Design (RBD) methodology. Health risk assessment is integrated into the structure concerning significant epidemics, addressing their likelihood of recurrence and repercussions. The outcome is a systematic and formalized procedure derived from the FSA, constructed by RBD requirements. Utilizing an appropriate risk metric, the system must evaluate health hazards and risk control alternatives while factoring in cost-effectiveness and additional factors in an in-depth evaluation. Future actions involve the integration of the structure into shipping and dissemination scenarios for actual installation and adaptation to industrial requirements, while taking into account lessons learned and procedures from the medical sector.
Keywords – Maritime, Health, Epidemics, Safety

1. INTRODUCTION

The emergence of the COVID-19 pandemic has profoundly affected every economy, as it is unparalleled in this era [1]. The maritime sector, particularly cruises, has been significantly impacted since 2020 [2][19]. The epidemic has imposed challenges on the worldwide cruise tourism sector and economy, including crew and passenger isolation, vessel entry limits, travel prohibitions, and the urgent requirement for medical care for the afflicted [11]. The entire economic impact of the cruise business declined by $92.4 billion (58.5%) from 2019 to 2020, while employment in the sector decreased by 595k (52.7%). The effect is demonstrated by the significant decline in global cruise ship passengers, which fell from 24.5 million in 2019 to 5.8 million in 2020 (-79%), and 2.7 million in 2022 (-85%). The initial instances of SARS-CoV-2 on cruise ships were detected in early 2020, leading to epidemics, notably the well-publicized example of the Diamond Princess in late February 2021, which led to 15 confirmed fatalities [12]. Seventy-eight ships and 105 journeys were linked to COVID-19 cases before October 2021 [3].

This reflects the ramifications of the COVID-19 epidemic, as numerous governments implemented No Sail Orders beginning in March 2021 [16][20]. Global cruises were compelled to resume in the summer of 2022 to alleviate the financial impact from the pandemic, implementing various preventative and monitoring protocols and vaccination mandates [4][18]. Alongside COVID-19, other hazards associated with infections, such as norovirus, swine flu, and food and waterborne illnesses, should be acknowledged [13][22].

From 2015 until the summer of 2022, the data system documented 35 health-related events in Europe, including 16 associated with foodborne infections, 5 with tuberculosis, and 3 with legionella, amongst other illnesses. More health-related incidents are documented globally, with a significant rise in onboard infections, particularly during the COVID-19 pandemic [14].

The COVID-19 pandemic has undeniably created a challenging new reality concerning outbreaks of infectious diseases on big passenger vessels, which have demonstrated significant susceptibility to pandemics. Addressing these factors is crucial for the shipping sector to enhance its adaptability to disruptive occurrences [5][21]. This presents a significant difficulty, as passenger vessels serve as vectors for infection or facilitate the transmission of illnesses. Massive passenger blood vessels, characterized by semi-closed environments that include extensive living and sleeping areas, community water reserves, plumbing systems, ventilating and sanitation facilities, and centralized food production, are particularly susceptible to transmissible illnesses. The continuous influx of individuals from across the globe heightens the disease risk [15].

2. BACKGROUND

The governance architecture governing marine concerns during the COVID-19 pandemic consists of multiple pertinent international treaties, the distinct roles of flag nations and port nations, and the processes involved in official decision-making [6]. This paradigm must consider varying distributions of legal authority among states based on the specific activities occurring within various maritime zones, alongside the practical reality that 'flags of convenience' do not fulfill all anticipated legal obligations [17].

Among the numerous measures implemented by states to curb the spread of COVID-19, limitations on port access emerged as a critical shipping concern during the global epidemic, especially impacting the maritime and cruise sectors and travelers and crews aboard vessels seeking disembarkation points. The principal treaty governing maritime law delineates oceanic areas into various naval zones and establishes the rights and obligations of governments inside those zones. However, it mainly overlooks the rights and responsibilities concerning port entry. Standard global laws and agreements governing international commerce and services uphold the power of states over their harbors, permitting vessel entry only with the coastline state's approval, except in cases of emergency or force majeure. Governments were affirming their sovereign powers over border control by closing their marinas and denying access to seamen, passengers on cruises, and other individuals at sea [9].

The World Health Organisation (WHO) cannot independently resolve all marine issues, and other international organizations' initiatives have significantly enhanced the global law structure [7]. Coherence and uniformity in strategy are necessary for coordinating the efforts of these groups, which the Joint Working Group has formed. However, the WHO is not yet included. If these groups attain coherence, any consensus standard would be pertinent to executing the provisions, as the Convention aims to integrate general contracts, rules, and norms established by relevant international organizations [8]. The WHO's conversations on suggested changes to revise universally applicable agreements concerning pandemics are essential to tackle maritime problems and enhance the safety of sailors, travelers on cruises, and all people at sea during future pandemics [10].

3. MARITIME SAFETY EVALUATION

The legal structure for the shipping sector has been solidified by the International Maritime Organization (IMO) Agreements, along with associated Protocols, modifications, and Decisions, all of which have been incorporated into national rules and are carried out by the vessel's flag state or the Port States. Rules pertain to ship design and activities, typically prescribing standards to guarantee a requisite baseline level of safety grounded in available information and historical experience. The regulatory structure is conceptually constructed around safety. Several hazards continue jeopardizing individuals, assets, and the ecosystem at sea. At the same time, technical advancements and the implementation of innovative systems within the sector yield adverse outcomes concerning safety. It is imperative to perpetually evaluate safety to facilitate its improvement and to foresee emerging or systemic threats. Three tiers of safety evaluation are delineated and encapsulated within the safety evaluation standards established by the Coding, the IMO Formal Safety Analysis (FSA) Rules, and the Risk-based Engineering paradigm, which pertain to: i. Routine marine activities, II. architecture prioritizing safety, and iii. The rule-making procedure of the IMO.

The IMO Decision MSC.275 has enacted several revisions to the ISM Code. A change was adopted that formally mandates shipping businesses to evaluate the hazards to vessels, persons, and the environment resulting from their onboard activities, clarifying the previously implied requirements of different ISM Code articles. In this regard, every action that negatively impacts the business's operations and profitability must be assessed, and suitable procedures should be enacted to ensure that all hazards are either mitigated or kept at an appropriate level. Every business must implement a systematic and formalized risk evaluation process inside its Safety Management Services (SMS) and guarantee its fleet and office workers are well-acquainted and adequately informed regarding the risk evaluation programme. The procedure typically encompasses four fundamental steps, which are elaborated upon in Fig. 1.

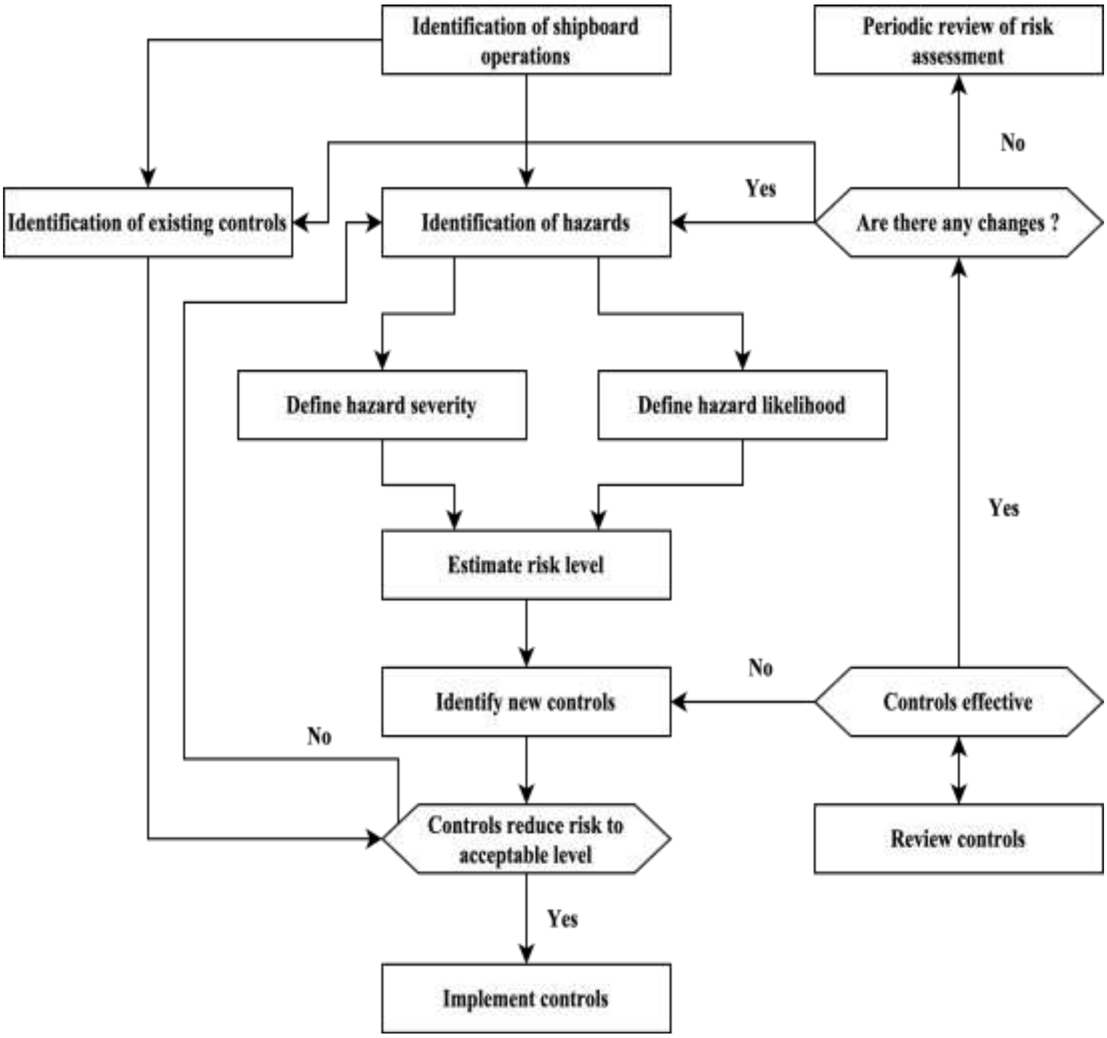

Fig. 1. Risk assessment model

The FSA is explicitly delineated in the IMO's FSA Regulations. The FSA is an organized strategy designed to improve maritime safety concerning life, wellness, marine life, and assets, employing risk evaluation and Cost-Benefit Analysis (CBA). The primary objective of the FSA is to facilitate the assessment of new safety requirements by juxtaposing them with current standards. In addition to the rule-making procedure, the FSA offers a structure that facilitates safety assessments for both ship design and maritime activities. The FSA procedure consists of the following steps:

- Recognition of risks
- Risk Assessment
- Risk Control Strategies (RCOs)
- CBA
- Suggestions for decision-making

The processes generally mirror the threat management approach previously outlined, but incorporate CBA, which introduces the notion of cost-effectiveness for the risk reduction attained from an RCO. RCOs are collections of Risk Management Strategies (RMS) implemented in step 3, facilitating risk mitigation according to the risk evaluation of the identified risks. The process is illustrated in Fig. 2. Multiple methodologies is employed, as per the directives, for risk analysis, including Fault Tree Evaluation (FTA), Event Tree Evaluation (ETA), and Bayesian Systems (BS), as well as for recognizing hazards, such as failure modes and Effect Evaluation and Hazard and Operation Investigations. Sensitivity and ambiguity analyses are incorporated to address parameter unpredictability and supplementary instruction on Human Reliability Evaluation (HRE). The risk score is employed for risk prioritization using probability and consequence indices, as shown by the justification of the previously outlined risk matrix and the corresponding tables in the recommendations.

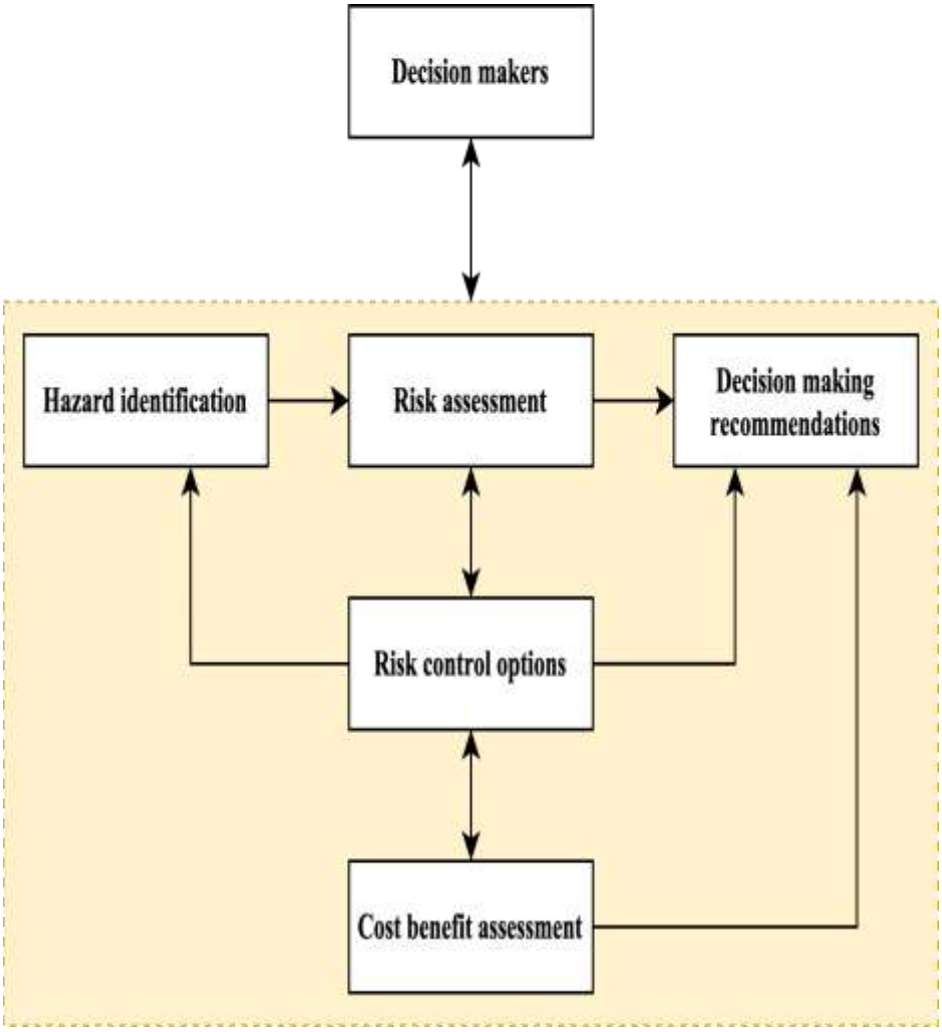

Fig. 2. FSA methodology

The existing rules and regulations for ship design comprise prescriptive restrictions from significant IMO conventions. Yet they have frequently demonstrated an inability to reconcile demands and to adapt to technological advancements that offer new design possibilities. In this regard, the Risk-Based Design (RBD) framework has evolved into an advanced design methodology where security is prioritized as a design aim. The objective of the RBD procedure is to furnish evidence concerning the safety degree for a particular design and then demonstrate that this safety degree is within reasonable limits or has improved compared to prior assessments. RBD is intricately linked to the previously outlined RMS and the FSA, wherein most FSA steps—recognizing hazards, evaluating risks, and mitigation options—are integrated into the ship design procedure.

The execution of RBD conforms to the subsequent principles:

- Safety must be assessed by a formalized approach (i.e., risk assessment) and an appropriate risk meter, as outlined in the FSA recommendations.
- Safety measurement must be incorporated into the ship design procedure with additional goals (e.g., aesthetics, cost, efficiency, usefulness).
- Utilization of parametric frameworks and rapid, precise first-principles techniques (e.g., fire spread modeling, evacuation scenarios) that offer insights for hazard detection and risk assessment.

4. RESULTS AND DISCUSSIONS

Fig. 3 effectively illustrates the structure for integrating health risk evaluation into the comprehensive safety evaluation method within the maritime sector. In step 1, the preliminary risk is evaluated (health risk evaluation), establishing the health danger level (step 2) for a specific area, a ship area, or the whole ship. In step 3, all relevant RCOs, comprising various Risk Control Procedures (RCPs), are determined, precisely described, and presented as ship design options or operational strategies. Step 4 presents the identified RCOs for assessment via health risk analysis by FSA rules. In contrast, step 5 provides an in-depth evaluation encompassing aesthetic standards, cost effectiveness, and other factors. In this situation, CBA is employed to evaluate cost-efficiency. After the assessment, deployment in either architecture or activities ensues, recalibrating the medical risk rating.

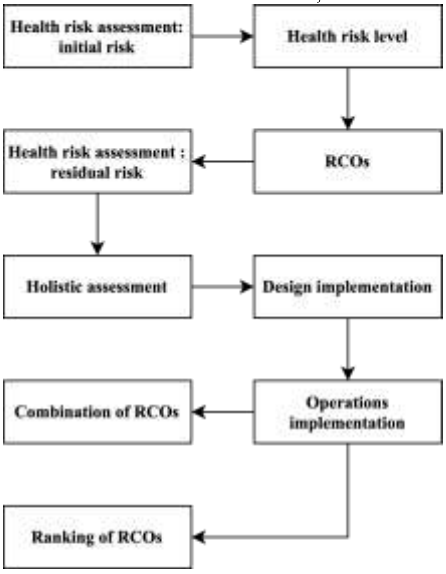

Fig. 3. Framework overview

Different combinations of RCOs might be proposed in the suggestions phase for managing a potential outbreak, depending on their evaluation and execution. At the same time, their prioritization is crucial for future instances. Two primary loops are delineated in the proposed architecture. The first pertains to the creation of RCOs, focused on enhancing their efficacy, while the second relates to their execution, which yields further insights regarding their success.

Health risk categories can be classified into green, yellow, and red. This classification can be utilized alongside the relevant risk measurement and acceptance of risk standards, as detailed below.

The green level denotes either an absence or a minimal count of documented cases concerning operations, and a place with reduced vulnerability in terms of architecture. The yellow level denotes a precarious condition in an operating setting, characterized by infected individuals with a significant risk of critical transmission aboard the ship. In naval architecture, the yellow level indicates a considerable possibility for spatial dispersion. Control procedures must be instituted to mitigate the actual or perceived threat concerning operations and architecture.

The red operating level signifies that the ship is at risk of an uncontrolled propagation, which could give rise to a severe epidemic. The ship's structure's red rating indicates significant danger for the designated area. Control procedures are essential, and activities might have to be paused during the cruise.

5. CONCLUSION

The necessity to manage health-related hazards emerged during the COVID-19 epidemic and its effects on the shipping sector. Still, it can be linked to several instances involving additional transmissible illnesses such as gastroenteritis and influenza. This work establishes the basis for creating a methodology that integrates assessment of health risks within the context of marine safety evaluation. The primary problem involves integrating health considerations, such as epidemiological risk estimation, into the marine safety evaluation management, about the ISM Code, the IMO's FSA, or the RBD structure, which encompasses hazard recognition, risk evaluation, and the detection of RCOs. This method establishes a systematic and formalized process for medical risk evaluation, incorporating appropriate risk measures.

The suggested structure serves merely as an initial step for evaluating health hazards and implementing risk controls on passenger vessels, whether about shipping operations or ship layout, as its effective development and adaptation to user and business requirements necessitate application in ship instances and dissemination scenarios. It is essential to integrate the suggested structure and health risk evaluation with the expertise and procedures from the healthcare domain, within the scope of maritime safety. The two should enhance the structure's execution using existing medical situations and data.

Key factors encompass the diverse transmission channels and the range of ship areas while accounting for equipment, airflow, and sanitation standards, the demographics, instruction, and occupations of the people impacted, and inspection considerations. Further investigation of epidemiological risk evaluation is essential for integration. This research is currently underway as part of the Good Sailing initiative.

REFERENCES

1. Siddique, A., Shahzad, A., Lawler, J., Mahmoud, K. A., Lee, D. S., Ali, N., ... & Rasool, K. (2021). Unprecedented environmental and energy impacts and challenges of the COVID-19 pandemic. Environmental Research, 193, 110443.
2. Vakhguelt, V., & Jianzhong, A. (2023). Renewable Energy: Wind Turbine Applications in Vibration and Wave Harvesting. Association Journal of Interdisciplinary Technics in Engineering Mechanics, 1(1), 38-48.
3. Millefiori, L. M., Braca, P., Zissis, D., Spiliopoulos, G., Marano, S., Willett, P. K., & Carniel, S. (2021). COVID-19 impact on global maritime mobility. Scientific reports, 11(1), 18039.
4. Chandravanshi, N., & Neetish, K. (2023). Diurnal Variations in Greenhouse Gas Emissions from a Macrophyte-Covered River. Aquatic Ecosystems and Environmental Frontiers, 1(1), 11-15.
5. Lau, Y. Y., Chen, Q., Poo, M. C. P., Ng, A. K., & Ying, C. C. (2024). Maritime transport resilience: A systematic literature review on the current state of the art, research agenda, and future research directions. Ocean & Coastal Management, 251, 107086.
6. Nazarova, J., & Bobomuratov, T. (2023). Evaluating the Clinical Utility of Genetic Testing in Guiding Medication Selection. Clinical Journal for Medicine, Health and Pharmacy, 1(1), 64-72.
7. Chang, Y. C., Zhao, X., Jian, A., & Tan, Y. (2024). Frontier issues in international ocean governance: Japan's discharge of nuclear-contaminated water into the sea. Marine Pollution Bulletin, 198, 115853.
8. Iyer, R., & Deshpande, N. (2024). Nanotechnology and their Applications in Chiral and Achiral Separating Mechanisms. Engineering Perspectives in Filtration and Separation, 1(1), 7-13.
9. Lin, L. Y., Tsai, C. C., & Lee, J. Y. (2022). A study on the trends of the global cruise tourism industry, sustainable development, and the impacts of the COVID-19 pandemic. Sustainability, 14(11), 6890.
10. Malhotra, R., & Iyer, A. (2024). Developing an Effective Training System for Interventional Pulmonology Education through Digital Learning. Global Journal of Medical Terminology Research and Informatics, 1(1), 1-8.
11. Oyenuga, A. (2021). Perspectives on the impact of the COVID-19 pandemic on the global and African maritime transport sectors, and the potential implications for Africa's maritime governance. WMU Journal of Maritime Affairs, 20(2), 215-245.
12. Trisiana, A. (2024). A Sustainability-Driven Innovation and Management Policies through Technological Disruptions: Navigating Uncertainty in the Digital Era. Global Perspectives in Management, 2(1), 22-32.
13. Testa, G. (2025). Social Media Crisis Communication in the Tourism and Hospitality Sector: An Empirical Investigation in the Cruise Industry. In Social Media and Crisis Communication in the Cruise Industry: Analysing the Effects of the Covid-19 Pandemic (pp. 111-141). Cham: Springer Nature Switzerland
14. Sethupathi, S., Singaravel, G., Gowtham, S., & Sathish Kumar, T. (2024). Cluster Head Selection for the Internet of Things (IoT) in Heterogeneous Wireless Sensor Networks (WSN) Based on Quality of Service (QoS) By Agile Process. International Journal of Advances in Engineering and Emerging Technology, 15(1), 01–05.
15. Shawoo, Z., Maltais, A., Dzebo, A., & Pickering, J. (2023). Political drivers of policy coherence for sustainable development: An analytical framework. Environmental Policy and Governance, 33(4), 339-350.
16. Hawthorne, E., & Fontaine, I. (2024). An Analysis of the Relationship Between Education and Occupational Attainment. Progression Journal of Human Demography and Anthropology, 1(1), 22-27.
17. Salman, N. A., Al-Noor, S. S., & Khalaf, K. A. (2024). Effect of dose level of three hormones on egg production and thermal accumulated period during induced spawning of grass carp (Ctenopharyngodon idella). International Journal of Aquatic Research and Environmental Studies, 4(1), 1-11. http://doi.org/10.70102/IJARES/V4I1/1
18. Veera Boopathy, E., Peer Mohamed Appa, M.A.Y., Pragadeswaran, S., Karthick Raja, D., Gowtham, M., Kishore, R., Vimalraj, P., & Vissnuvardhan, K. (2024). A Data Driven Approach through IOMT based Patient Healthcare Monitoring System. Archives for Technical Sciences, 2(31), 9-15. https://doi.org/10.70102/afts.2024.1631.009
19. Abed, F. S. (2024). Optimization of Expression and Purification of Recombinant One of Central Nervous System Enzyme (Acetylcholinesterase). International Academic Journal of Science and Engineering, 11(1), 40–47. https://doi.org/10.9756/IAJSE/V11I1/IAJSE1106
20. Yadav, R. K., Mishra, A. K., Jang Bahadur Saini, D. K., Pant, H., Biradar, R. G., & Waghodekar, P. (2024). A Model for Brain Tumor Detection Using a Modified Convolution Layer ResNet-50. Indian

Journal of Information Sources and Services, 14(1), 29–38. https://doi.org/10.51983/ijiss-2024.14.1.3753

21. Bakhronova, D., Narziyeva, M. M., Yuldosheva, N., Zayniyeva, U., Yusupov, J., Uralov, B., ... & Khikmatov, N. (2025). Intelligent Information Security System for Language and History Education Using Machine Learning-based Intrusion Detection Algorithm. Journal of Internet Services and Information Security, 15(1), 520-529. https://doi.org/10.58346/JISIS.2025.I1.034
22. Guo, Z., Ramli, M. F., & Cui, R. (2024). Image Recognition of New Year Pictures based on Machine Learning. Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications, 15(3), 543-557. https://doi.org/10.58346/JOWUA.2024.I3.034
23. Kadhim, M. J. H., Alradha, R. M., Jawad, H. K., Al-Dabbagh, B., & Al-Khafaji, Z. (2024). Investigating the Effect of the Yellow Chlorophyll on the Characteristics of Liquid Polyethylene Glycol for Liquid Electrolyte Solar Cells. Natural and Engineering Sciences, 9(2), 244-256. https://doi.org/10.28978/nesciences.1479785
24. Abdullah, D. (2024). Enhancing cybersecurity in electronic communication systems: New approaches and technologies. Progress in Electronics and Communication Engineering, 1(1), 38–43. https://doi.org/10.31838/PECE/01.01.07
25. Flammini, F., & Trasnea, G. (2025). Battery-powered embedded systems in IoT applications: Low power design techniques. SCCTS Journal of Embedded Systems Design and Applications, 2(2), 39–46.
26. Uvarajan, K. P. (2024). Integration of blockchain technology with wireless sensor networks for enhanced IoT security. Journal of Wireless Sensor Networks and IoT, 1(1), 23-30. https://doi.org/10.31838/WSNIOT/01.01.04
27. Hamimi, Z. (2024). Low-complexity deep learning architectures for robust signal detection in massive MIMO systems. Electronics, Communications, and Computing Summit, 2(3), 114–119.
28. Fang, W., Yong, Z., & Hua, L. (2024). Cultural Impacts of Mass Tourism at Hidden Costs for Local Communities in 2025. Journal of Tourism, Culture, and Management Studies, 1(2), 50-60.
29. Bennett, L., Harris, C., & Cooper, E. (2024). A Framework for Implementing Lean Six Sigma in Service-Based Businesses. National Journal of Quality, Innovation, and Business Excellence, 1(1), 16-21.
30. Veerappan, S. (2025). Finite element-based modeling of stress distribution in 3D-printed lattice structures. Journal of Applied Mathematical Models in Engineering, 1(1), 44–53.