

PSYCHOLOGICAL AND BEHAVIORAL FACTORS IN MARITIME TRANSPORTATION SAFETY: SYSTEMATIC LITERATURE REVIEW AND BIBLIOMETRIC ANALYSIS

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Abstract. The role of the maritime shipping industry is highly crucial because 90% of the world's trade activities are conducted by sea transport. Despite this, the management of maritime transportation poses numerous risks, and 80-85% of marine accidents are attributed to human factors and errors. Psychological and behavioral considerations of the crew, as human elements, play a significant role in the cause of maritime transport accidents. This systematic literature review and bibliometric analysis study aimed to visualize the existing evidence on the psychological and behavioral causes of maritime transportation accidents, with the subsequent goal of identifying helpful strategies that could lead to accident reduction through the adoption of psychological and behavioral interventions. The results of the thematic analysis indicate that fatigue, mental workload, psychosocial stress, experience, skills, communication, trust, and unsafe acts are some of the related psychological and behavioral factors influencing maritime transportation accidents. The results also generate policy suggestions for relevant parties, such as shipping companies and governments, to develop psychological and behavioral safety management in the shipping industry.

Keywords: Psychological Factor, behavioral factor, safety, accident, maritime.

1. Introduction

Maritime transportation plays a crucial role in international trade as it transports more than 90% of the world's cargo volume (Qiao et al., 2021). Therefore, the sustainability and security of the maritime transportation sector are essential for the smooth operation of the global supply chain. Despite significant advancements in technology and regulations, the rate of accidents in the maritime transportation sector remains relatively high and continues to be a primary concern in safety management. These accidents not only result in material and environmental losses but also jeopardize the safety of crew members and negatively impact the reputation of the shipping industry.

To enhance maritime safety, the International Maritime Organization (IMO) has adopted various safety regulations, including the International Safety Management (ISM) Code and the Standards of Training, Certification, and Watchkeeping of Seafarers (STCW Convention) (Rajapakse et al., 2025). Various factors, including technical, natural, and human related factors, can cause maritime transportation accidents. Data indicates that 80-85% of accidents in maritime transportation are due to human error (Hasanspahić et al., 2021). One important dimension of human factors are the psychological and behavioral aspects of individuals. The isolated work conditions and distance from family members often lead to frustration among crew members, and this frustration can trigger deviant behaviors during task execution, which results in accidents (Rajapakse, 2025). From the perspective of crew behavior, unsafe behaviors account for 19.1% of the causes of accidents (Hasanspahić et al., 2021).

Therefore, a thorough understanding of the psychological and behavioral factors that influence crew members is essential for developing effective and sustainable safety management strategies in maritime transportation. Therefore, a systematic study of the role of psychological and behavioral factors in maritime safety management is necessary.

This study employs two approaches, a Systematic Literature Review (SLR) and a bibliometric analysis, to explore various studies related to psychological and behavioral factors, as well as safety management, in maritime transportation. The Systematic Literature Review will provide a synthesis of previous research on the theme of psychological and behavioral factors in maritime safety management. On the other hand, bibliometric analysis allows researchers to quantitatively measure and map the development of the role of psychological and behavioral factors in maritime safety management based on scientific publication data and collaboration patterns among authors or institutions. By combining these two research methods, it will be possible to map academic focuses and emerging themes in studies related to the role of psychological and behavioral factors in maritime transportation safety management. This study aims to identify the psychological and behavioral factors that contribute to maritime safety, ultimately leading to the development of effective strategies for reducing maritime transportation accidents through targeted psychological and behavioral approaches.

2. Literature

Maritime safety is a fundamental component of sea transportation at both national and international levels. The primary aim of maritime safety systems is to safeguard human life, protect vessels and cargo, and maintain the sustainability of the marine environment. Globally, maritime safety is governed by international conventions established by the International Maritime Organization (IMO), including the Safety of Life at Sea (SOLAS) 1974, the International Safety Management (ISM) Code, the Standards of Training, Certification, and Watchkeeping (STCW) Convention, and the International Convention for the Prevention of Pollution from Ships (MARPOL). These conventions establish minimum standards for the safety, training, and operational management of merchant vessels, which all member states are required to adhere to.

At the national level, the government has implemented regulations to enhance maritime safety. Law No. 17 of 2008 on Shipping defines four essential components of the transportation system: hardware, software, lifeware (human resources), and organoware (organizational systems) (Nikson, 2009).

The human factor is the leading cause of maritime transport accidents, with data showing that 80–85% of incidents result from human error (Hasanspahić et al., 2021). A crucial aspect of the human factor involves psychological and behavioral elements. Psychological factors encompass internal processes, including cognition, emotion, motivation, perception, and personality, that shape attitudes and responses to environmental stimuli. Myers, D.G. (2010) states that psychology examines mental processes, including thinking, memory, emotion, and decision-making, all of which govern human behavior. Psychological factors thus guide both conscious and unconscious actions.

Behavioral factors, in contrast, refer to observable and measurable actions that result from how individuals interact with their environment. These factors reflect a person's internal psychological state externally. Skinner, B.F. (1953), a leading behaviorist, argued that behavior arises from stimulus-response relationships shaped by reinforcement. Bandura, A. (1977)

contended that behavior is determined by both environmental influences and cognitive processes through the concept of reciprocal determinism.

3. Methodology

This study employs two methodological approaches, namely systematic literature review and bibliometric analysis. The use of these two methods aims to systematically and comprehensively identify, categorize, and integrate research related to psychological and behavioral factors in maritime transportation safety management.

Combining a systematic literature review (SLR) and bibliometric analysis in a single study offers significant advantages and benefits, as both methods complement each other in providing a thorough and objective review of the scientific literature. This approach will lead to a comprehensive and holistic understanding of the psychological and behavioral factors in maritime safety management, providing information about research areas within this topic that require further investigation.

Systematic Literature Review (SLR)

The systematic literature review method used in this study follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The PRISMA guidelines offer a structured and systematic framework for conducting comprehensive and holistic literature reviews. To produce this holistic synthesis, the following steps are applied in the systematic literature review process:

- 1). The databases used in this research include Scopus and ScienceDirect. To obtain relevant literature for the research theme, the search used the keywords "Psychological or behavioral factors in maritime or marine safety or accident," with a publication date range of 2020-2025.
- 2). To maintain relevance, several inclusion criteria were used, including (a) articles discussing psychological and behavioral factors in safety or accident analysis in maritime settings, (b) published within the years 2020–2025, (c) peer-reviewed articles, (d) articles in English and accessible in full text. For exclusion criteria, articles that do not focus on the maritime field were excluded from the analysis process.

Table 1: Summary of Selected Articles

No	Author	Title	Methodology	Finding
1	Qiao et al. (2021)	Cognitive Gap and Correlation of Safety-I and Safety-II: A Case of Maritime Shipping Safety Management	Mixed method study, fuzzy AHP (Analytic Hierarchy Process) and correlation analysis	Significant perceptual differences between crew members and experts regarding Safety I and Safety II.
2	Hasanspahić et al., (2021)	The Role of the Human Factor in Marine Accidents	Quantitative study on accident reports, HFACS-MA method	A major contributing factor is unsafe acts and preconditions.
3	Moreno et al., 2022	Relationship between Human Factors and a Safe Performance of Vessel Traffic Service Operators: A systematic qualitative-based review in maritime safety	Systematic review with PRISMA methodology and bibliometric analysis	Human factors, including fatigue, workload, teamwork, resilience, communication, and trust, significantly influence VTSO performance.
4	Moreno et al., (2023)	Fatigue as a key human factor in complex	Quantitative study, descriptive analysis, Spearman's	Increased fatigue and mental workload during night shifts and less than 8 hours of sleep.

No	Author	Title	Methodology	Finding
		sociotechnical systems: Vessel Traffic Services	correlation, t-Student test, and ANOVA	
5	Ali et al. (2023)	A Study of Psychometric Instruments and Constructs of Work- Related Stress among Seafarers	Qualitative study, systematic literature review	Work-related stress among seafarers is a multidimensional construct influenced by physical, social, personal, technological, work, and external factors.
6	Fan et al., 2023	Incorporation of Seafarer Psychological Factors into Maritime Safety Assessment	experimental research using neurophysiological data (fNIRS, EEG, eye-tracking)	Significant differences in neurophysiological activity between distraction and non- distraction conditions and between experienced and inexperienced groups. The mental workload was high during decision-making periods.
7	Ronca et al., 2023	Neurophysiological Assessment of An Innovative Maritime Safety System in Terms of Ship Operators' Mental Workload, Stress and Attention in the Full Mission Bridge Simulator	Experimental research using a full mission ship bridge simulator	HURID (Human Risk-Informed Design) reduces mental workload and stress while improving attention.
8	Rajapakse & Emad, (2023)	Fatigue, an unsolved puzzle that continues contributing to accidents at sea	A qualitative study with 63 crew members, thematic analysis, and coding	Several factors contribute to crew fatigue, which can cause cognitive and physical impairments, thereby increasing the risk of accidents.
9	Fan & Yang, (2024)	Accident Data-driven Human Fatigue Analysis in Maritime Transport Using Machine Learning	Quantitative study using LASSO and Bayesian Network methods	The model identifies significant risk factors contributing to fatigue. Findings confirm that fatigue, as a human factor, is closely related to environmental conditions (light, visibility), accident types, and ship conditions.
10	Yorulmaz & Basol, (2024)	Yacht Crews' Perceptions of Ethical Climate, Safety Climate, Psychological Capital, and Psychological Well-being in Turkiye	A quantitative study, a survey of 339 yacht crew members	Perceptions of ethical and safety climates have a significant influence on the psychological well-being of crew members.
11	Sanchez- Gonzalez et al., (2024)	Screening for Anxiety, depression, and Poor Psychological Well-being in Spanish seafarers	Cross-sectional survey with 170 crew members, correlation study	Spanish seafarers have a sufficiently good awareness system regarding their mental health, enabling early detection of psychological disorders.
12	Liu et al., (2025)	Task Allocation Considering Shipping Safety: Workload Resilient Interval for Inland Passenger Ship Seafarers optimal safety	Experimental study with 30 crew members	A low workload can lead to inattention, while an excessive workload can result in fatigue and cognitive impairments.

No	Author	Title	Methodology	Finding
		performance in real navigation		
13	Rajapakse & Emad, (2025)	Workplace frustration leading to task deviation and accidents at sea – A sociocultural perspective on the maritime human element	A qualitative study with in-depth interviews with 61 crew members	Crew frustration is a complex phenomenon rooted in physical, social, psychological, and organizational conditions. This frustration triggers task deviation, increasing the risk of accidents.

Bibliometric Analysis

To obtain a comprehensive understanding, bibliometric analysis is conducted as a complement to the systematic literature review approach. Bibliometric analysis is carried out with the help of VOSviewer software. Bibliometric analysis aims to measure and map the development of a scientific field based on publication data, identifying research trends and emerging topics in maritime safety management, particularly in the areas of psychology and behavior. The steps involved in bibliometric analysis include:

1). Data Collection:

The data used in the bibliometric analysis is sourced from Scopus and ScienceDirect databases, as the data indexed in these databases has undergone rigorous review processes, ensuring the reliability and reputation of the data. The keywords used for data retrieval are the same as those used for the systematic literature review, namely “Psychological or behavioral factors in maritime or marine safety or accident.” To obtain a broader range of bibliometric data and a longer publication timeframe, the publication period is extended from 2005 to 2025.

2). Co-Occurrence Analysis:

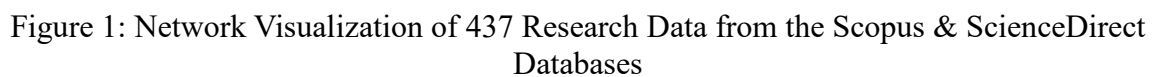
Co-occurrence analysis is conducted on the collected data to identify research trends related to psychological and behavioral factors in maritime safety and accidents. The analysis is performed using bibliometric analysis with VOSviewer. VOSviewer helps researchers understand the intellectual structure of a field and identify emerging research trends or gaps that may not be apparent through other methods.

Integration of Systematic Literature Review and Bibliometric Analysis

The interpretations obtained from the systematic literature review and bibliometric analysis are subsequently integrated to provide a comprehensive and complete understanding. The qualitative findings from the systematic literature review are integrated with the patterns and insights gained from the bibliometric analysis. The integration of qualitative and quantitative findings will offer a robust interpretation of the existing conditions and phenomena, as well as potential future developments related to psychological and behavioral factors in the maritime context.

4. Result and Discussion

Subsequently, this section will present the results of the systematic literature review analysis, which will be integrated with the results of the bibliometric analysis. Various thematic findings from the systematic literature review will be discussed, along with supporting data obtained from the bibliometric analysis.



The purple cluster groups terms related to human factors, including psychological, organizational, and environmental influences that affect the performance and safety of seafarers. Meanwhile, the green cluster focuses on occupational health, with an emphasis on the demographics of seafarers, including age and gender, highlighting the importance of health evaluations tailored to worker characteristics. The light blue cluster is more focused on mental health aspects, such as fatigue and stress, which can affect working conditions and increase accident potential. The yellow and pink clusters highlight themes related to risk perception and trust within maritime organizations, emphasizing risk and safety culture.

The relationships between the key terms are complex and reflect the integration of multidisciplinary research in maritime safety. For instance, the terms maritime safety, human factors, and Bayesian networks have robust connectivity, indicating that maritime safety risk analysis often involves statistical approaches that integrate human variables.

The close relationship between terms such as fatigue, mental health, and stress highlights the importance of recognizing that the psychological conditions of seafarers are critical factors in maritime safety. On the other hand, the connection between risk perception, safety culture, and trust highlights the importance of psychosocial factors and organizational culture in shaping safety behavior, a key element in developing effective safety interventions.

The theme of behavioral research is closely linked to various other key terms, including decision-making, safety management, and personnel training. This indicates that behavioral

research is also heavily focused on how decisions are made in the maritime context, how safety management is organized, and the role of personnel training in improving performance to reduce accident risks. This connection emphasizes that behavioral aspects are crucial in the development of safety systems and decision-making in the complex maritime environment.

Behavioral and psychological factors are also closely linked with terms such as technology and management, including decision support systems, safety culture, and risk assessment. This relationship indicates that the research approach not only focuses on measuring and managing risks from an individual perspective but also seeks to understand how technical and organizational conditions influence maritime safety. This reflects a holistic paradigm that integrates human and technological aspects to enhance maritime safety.

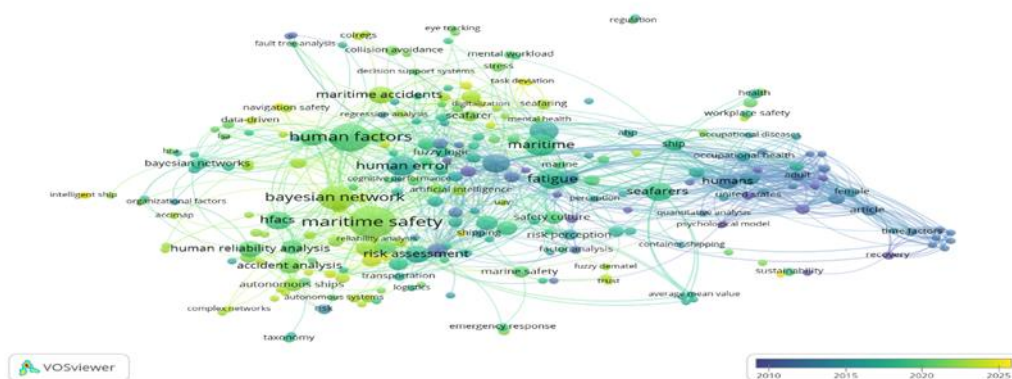


Figure 2: Overlay Visualization of 437 Research Data from the Scopus & ScienceDirect Databases

In the bibliometric overlay visualization above, the thematic evolution of maritime safety research over more than a decade is displayed, with an emphasis on how the research focus has shifted over time. Temporally, the map clearly outlines topics that dominated the early 2010s, such as Bayesian networks, accident analysis, and organizational factors. These topics served as the methodological and conceptual foundation in maritime safety research, indicating that during this period, studies were primarily focused on the application of statistical methods and systematic risk analysis. This reflects a stable and structured research phase, where quantitative approaches became the backbone for understanding and anticipating accidents and risks in the maritime environment.

Over time, there has been a shift in attention towards more human- and psychology-oriented issues, reflected in the green color associated with terms like human error, fatigue, and risk assessment. This suggests that research began to integrate cognitive and psychosocial aspects in understanding maritime accidents, positioning humans not only as statistical objects but as key actors with limitations and potentials that need to be deeply understood. Additionally, terms such as safety culture and mental health began to emerge as important focal points, signaling a growing awareness of the role of organizational culture and psychological well-being in safety and performance within the maritime sector.

Topics related to psychological and behavioral factors occupy a significant position and are worth analyzing in more depth. Terms such as human factors, human error, mental health, stress, fatigue, and risk perception appear quite prominently with relatively large node sizes, indicating a high frequency of occurrences and their critical role in maritime safety research.

One such low-density topic is trust. In the maritime context, trust is crucial, whether between ship crews, between humans and automated systems, or within organizational relationships. However, it appears to be underexplored. The research focused on how trust influences

decision-making, communication, and coordination in critical situations could make a significant contribution to operational safety and efficiency.

Another topic showing low density is mental workload and task deviation, which are related to cognitive workload and task deviation. While fatigue and stress have been extensively studied, specific aspects of how cognitive load and task deviation impact behavior and job performance in the maritime environment remain relatively under-examined. A deeper understanding of this topic could aid in developing more effective decision support systems and task designs.

The themes of psychological models and perception also show a tendency towards low density, indicating that psychological models and studies on risk perception and the working environment have not become a primary focus in maritime safety research. However, these aspects are crucial for understanding how seafarers and maritime workers process information and respond to complex and risky situations. Additionally, behavioral themes such as personnel training also still show low density, suggesting that further exploration is possible.

Some findings from the bibliometric analysis are consistent with the findings from the systematic literature review conducted based on 13 studies sourced from the Scopus and ScienceDirect databases related to the psychological and behavioral aspects of maritime safety and accidents, as outlined in the following points:

Human Factors as a Key to Maritime Safety

Human factors have been identified as a significant contributing factor to the majority of maritime accidents. Hasanspahić et al. (2021) revealed that approximately 80-85% of maritime incidents are directly related to human failure, particularly in the context of fatigue, situational unawareness, and cognitive errors. The complexity of interactions between humans, technology, and the working environment on ships presents significant challenges in maintaining operational safety. Therefore, a deep understanding of human factors is crucial for designing effective interventions to enhance maritime safety (Hasanspahić et al., 2021; Moreno et al., 2022). This study emphasizes the need for a holistic approach that focuses not only on technical and procedural aspects but also on the psychological and social conditions of crew members.

This is supported by findings from the bibliometric analysis, where themes such as human factors and human error have become primary topics in the field. Human factors and human error have expanded into various other themes, such as psychology, behavior, and health aspects. This demonstrates that human factors are a crucial element in efforts to enhance maritime safety. The overlay visualization in the bibliometric analysis illustrates the time trend of the established focus on human factors since the early 2010s, which has continued to dominate up to the present. The green-to-yellow hues in the themes of human error and human factors indicate increased or consistent attention over time. Data from the density visualization confirms the highest concentration of these terms in bright yellow, indicating a very high frequency of occurrence in the literature, making them the central focus of maritime safety research.

Fatigue and Mental Workload

Physical and mental fatigue have consistently been found to be significant factors that decrease crew performance, thereby increasing the risk of accidents. Rajapakse et al. (2023) explained that fatigue arises not only from long working hours but also from crew shortages, unstable shift patterns, and high cognitive demands in a dynamic work environment.

Neurophysiological approaches such as Electroencephalography (EEG), used by Fan et al. (2023) and Ronca et al. (2023), provide quantitative evidence that fatigue causes a decline in brain function critical for decision-making and alertness. Empirical studies have shown that fatigue leads to decreased hazard detection ability, slower reactions, as well as navigation and communication errors, which can potentially result in incidents such as collisions and grounding (Rajapakse et al., 2023; Fan et al., 2024). Both excessive and too low mental workload also contribute to performance decline, as per the Yerkes-Dodson inverted U curve theory (Liu et al., 2025).

The bibliometric study reveals a significant emphasis on the themes of fatigue and mental load, with central nodes on the network map indicating that fatigue is a significant topic in maritime safety studies. The overlay visualization of the bibliometric analysis shows that topics related to fatigue and mental load have emerged as research themes in maritime safety since 2015. Data from the density visualization highlights high concentration and density for the term "fatigue," indicating strong attention to these issues. However, mental workload themes still do not show high data density, leaving room for further research development in the future.

Psychosocial Stress and Organizational Culture

In addition to fatigue, psychosocial stress and organizational culture play a crucial role in determining maritime safety levels by affecting behavior, psychological well-being, and crew performance. A study by Rajapakse et al. (2025) revealed that psychosocial stress arising from work-related frustration due to excessive physical load, social isolation, interpersonal conflicts, and unmet expectations contributes to task deviation, which increases the risk of accidents at sea. Chronic frustration can disrupt concentration, impair decision-making, and lead to behavior that deviates from safety procedures.

Additionally, research by Yorulmaz et al. (2024) emphasized that a positive organizational culture, characterized by a strong ethical climate and safety climate, significantly contributes to crew psychological well-being. A healthy organizational culture fosters open communication, trust among crew members, and adequate social support, collectively enhancing motivation, job satisfaction, and adherence to safety standards. The psychological capital of crew members, which encompasses optimism, resilience, and self-efficacy, serves as a moderator that amplifies the positive effects of organizational culture on psychological well-being, thereby promoting safe work behavior and reducing maritime incidents (Yorulmaz et al., 2024). Therefore, managing psychosocial stress and developing a supportive organizational culture are key aspects of sustainable maritime safety improvement strategies.

Bibliometric data from network visualization shows that safety culture, risk perception, and organizational factors form their cluster (Cluster 5 in purple), which is related to human factors and safety. This indicates research integrating organizational and social dimensions in maritime safety management. Overlay visualization data indicate that this theme falls within the green to yellow range, suggesting an increased focus on safety culture, risk perception, and organizational factors over the past decade. Density data shows that this theme has not yet reached high concentration, leaving substantial opportunities for further research.

Influence of Experience and Skills

The experience and skills of crew members play a crucial role in enhancing maritime safety through cognitive capacity building, informed decision-making, and effective workload management. Moreno et al. (2022) stated that work experience, particularly as a Vessel Traffic

Service (VTS) operator, serves as a significant mitigating factor against the negative impacts of fatigue and stress. More experienced operators can manage their mental workload more effectively, maintain alertness, and make faster and more accurate decisions in complex and dynamic situations. This experience also contributes to the development of situational skills and adaptation to changing operational conditions, thereby enhancing performance resilience and reducing the risk of human error.

Moreno et al. (2023) demonstrated that technical skills and specific knowledge related to tasks in the VTS environment significantly strengthen operators' performance in managing heavy maritime traffic. These skills help operators interpret data, communicate effectively, and anticipate potential risks before they escalate into incidents. Therefore, continuous training and adequate field experience are crucial in preparing crew members to meet high work demands and maintain navigational safety.

The theme related to experience and skills can be associated with clusters such as training, simulation, human performance, and decision-making, with smaller node sizes indicating that these areas, though important, are less dominant in research. The overlay visualization indicates that personal training has long been a point of focus, as shown by darker hues; however, the small node size suggests that relatively little research has been conducted on this topic. Decision-making and human performance exhibit brighter hues, indicating that research on these topics has emerged over the last decade. Density visualization data shows that research related to these themes has not yet reached high concentration, leaving room for further development.

Communication and Trust

Effective communication and trust are critical aspects that complement each other in ensuring maritime safety. Moreno et al. (2022) emphasized the importance of standardizing communication through the use of Standard Marine Communication Phrases (SMCP) to reduce the risk of misunderstandings between crew members from different cultural and linguistic backgrounds. Poor communication can lead to fatal miscommunication, whereas smooth communication supports timely and accurate coordination, minimizing operational errors. Non-verbal communication and an understanding of social context also play a vital role in decision-making in dynamic work environments.

Trust, as the foundation of interpersonal relationships within teams, plays a role in strengthening communication and cooperation in the maritime environment. Research indicates that trust between crew members and between crew and management enhances information flow, collaboration, and the effectiveness of decision-making (Rajapakse et al., 2025; Yorulmaz et al., 2024). A healthy and supportive organizational culture facilitates the building of this trust, thus improving psychological well-being and reducing the risk of procedural deviations. Trust can also moderate the adverse effects of stress and mental workload, helping crew members stay resilient and focused in high-pressure situations. Therefore, enhancing communication and trust is not only a technical strategy but also a critical psychosocial strategy in holistic maritime safety management.

Communication and trust can be linked to safety culture and communication in the bibliometric analysis, but with small nodes and fewer connections, indicating an area that has not been extensively explored in research. This is also evident from the density visualization, where the concentration of safety culture themes has not yet shown high density. The overlay

visualization suggests that this theme has evolved over the past five years but has yet to garner significant attention.

Unsafe Behavior

Unsafe behavior is a dominant factor contributing to maritime accidents. In the maritime context, such behaviors include errors, violations, and neglect of operational rules that can endanger the safety of ships, crew members, and the surrounding environment. Hasanspahić et al. (2021) stated that unsafe acts are central to maritime accidents, with various forms such as skill-based errors, rule-based mistakes, and routine and exceptional violations. Rajapakse et al. (2025) highlighted that unsafe behavior is closely related to task deviation, which can arise from frustration, fatigue, or work pressure, significantly contributing to maritime accidents.

Individual, organizational, environmental, and technical factors can trigger unsafe behavior. Individual factors such as fatigue, mental overload, distraction, and lack of alertness are primary causes of unsafe behavior (Fan et al., 2023; Hasanspahić et al., 2021). Fatigue can trigger cognitive impairments, reduced attention, and increased decision-making errors, leading to unsafe behavior (Yang, 2024). Organizational factors also play a significant role, including a lack of management support, poor communication, and an inadequate safety culture (Rajapakse, 2025; Hasanspahić et al., 2021). Environmental factors may include adverse weather conditions and suboptimal working environments. Technical factors can involve system designs that are not user-friendly or fault-tolerant, leading to operational errors (Qiao et al., 2021).

Unsafe behavior is the starting point in a series of events that eventually lead to accidents. Unsafe behavior leads to hazardous conditions or situations that directly or indirectly cause incidents or accidents. Hasanspahić et al. (2021) explained that maritime accidents generally occur as a result of a series of human errors, where unsafe behavior is a crucial element that breaches various safety layers.

In bibliometric data, unsafe behavior can be linked to the "task deviation" node. The bright yellow color indicates that research related to this topic in the maritime context has developed rapidly in the last five years. In terms of density, the data shows that it has not yet reached a high concentration, leaving room for further research exploration.

Interventions and Practical Implications

From these findings, managing human factors must be done comprehensively and in a multidimensional manner. This includes increasing the number and quality of crew members to prevent excessive fatigue, implementing more adaptive shift schedules, and designing user-friendly technology (human-centered design). Additionally, strengthening a safety culture that supports open communication, stress management, and psychological well-being is crucial to reducing task deviations and improving safety (Rajapakse et al., 2025; Yorulmaz et al., 2024). Regular psychological screenings and mental health training programs are also recommended to detect and address psychological issues before they impact performance. Regulations should be aligned with the realities of onboard work, taking into account sleep quality and crew recovery (Sanchez-Gonzalez et al., 2024). A psychologically healthy crew will reduce unsafe behavior, thereby lowering the risk of accidents and enhancing maritime transportation safety.

Achieving this requires organizational support to build an inclusive and supportive safety culture, which forms the foundation for the success of these interventions. Therefore,

multidimensional and multi-party approaches are necessary to enhance maritime safety, incorporating psychological and behavioral strategies for crew members.

Challenges and Future Research Directions

The challenges and research opportunities related to human factors, particularly psychological and behavioral aspects, in maritime safety remain vast and strategic, given the complexity and dynamics of the ever-evolving shipping industry. Several psychological and behavioral aspects have yet to receive significant attention in current research, including self-efficacy, self-regulation, burnout, and the impact of social isolation.

From a behavioral perspective, there is still room for further research. How personal training, safety behavior, safety leadership, decision-making in emergencies, and adaptation to technological changes in maritime (automation) can be studied further. Initial research on psychological and behavioral factors in maritime safety has opened up opportunities for further research on these themes.

5. Conclusion

Human factors have proven to play a central role in ensuring maritime safety, as evidenced by their contribution to over 80% of maritime incidents and accidents. Various studies analyzed confirm that shipping safety depends not only on technology, regulations, and procedures but is also heavily influenced by psychological conditions, behavior, and social dynamics in the maritime work environment. Factors such as fatigue, mental workload, stress, ineffective communication, and low trust among crew members have been identified as key contributors to performance decline and increased operational risks at sea.

Fatigue and work stress are not only the result of long working hours or insufficient sleep but are complex manifestations of organizational pressures, administrative burdens, job insecurity, and social isolation. Unsafe behavior is often an adaptation to suboptimal working conditions that cause various psychological pressures. In this context, there is a need to design multidimensional interventions capable of addressing the psychological issues and unsafe behavior that can trigger maritime accidents.

With an interdisciplinary and integrative approach, the future of maritime safety can evolve to be more proactive, predictive, and human-centered. By placing humans at the center of maritime systems not as sources of error but as adaptive elements that need to be understood and supported maritime safety can be improved sustainably and holistically.

Future research should focus on psychological and behavioral aspects that have not been fully explored. Psychological aspects such as self-efficacy, self-regulation, burnout, and the effects of social isolation remain ripe for further exploration. Certain behavioral aspects, such as safety leadership, safety behavior, decision-making in emergencies, personal training, simulation, and adaptation to maritime technological changes (automation), also present opportunities for future study.

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