Determination of Factors Affecting Shipping Safety Performance: Study Literature Review

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Abstract: The purpose of this study is to develop hypotheses related to factors that influence shipping safety performance, especially in the maritime transportation sector in Indonesia. The approach used in this literature review is descriptive qualitative. The data collection technique is to use literature studies or review relevant previous articles. The technique used in this literature review is comparative analysis. The data used in this descriptive qualitative approach were obtained from previous studies relevant to this study and sourced from academic online media such as Thomson Reuters Journal, Springer, Taylor & Francis, Scopus Q2-Q4 Emerald, Elsevier, Sage, Web of Science, Sinta 2-5 Journal, DOAJ, EBSCO, Google Scholar, Copernicus, and digital reference books. The results of this literature review are: 1) Bridge resource management influences maritime safety performance; 2) Facilities and infrastructure influence maritime safety performance; 3) Crewing competence influences maritime safety performance; and 4) Fleet seaworthiness influences maritime safety performance.

Keyword: Maritime Safety Performance, Bridge Resource Management, Facilities and Infrastructure, Crewing Competence, Fleet Seaworthiness

INTRODUCTION

Maritime safety is a critical strategic issue that significantly affects the sustainability of maritime logistics, environmental protection, and the safety of crew and passengers. The integration of modern technologies, such as IoT and AI, into maritime logistics improves operational efficiency and safety while complying with international regulations such as SOLAS and MARPOL, which are essential for minimizing environmental impact and ensuring safe navigation (Palippui, 2024). In addition, effective maritime safety management, supported by data-based technology, is essential for risk analysis and emergency management, thereby promoting a resilient maritime transport system (Xu et al., 2023).

Developing countries such as Indonesia face significant challenges in improving maritime safety performance, as evidenced by high frequency of marine accidents and low compliance with international safety standards. The complexity of maritime operations, including human and organizational factors, contributes to these accidents, with studies showing that human error is the main cause (Jiao et al., 2020). The adoption of advanced technologies, such as Artificial Intelligence (AI), has been proposed to improve navigation and operational safety, but issues such as data quality and cybersecurity remain challenges. In addition, the unique operational challenges of the domestic ferry sector require a comprehensive approach that includes strengthening governance, standardizing regulations, and fostering a safety-conscious culture among maritime workers (Baig et al., 2024).

Improving Bridge Resource Management (BRM) is an important strategy for enhancing maritime safety by reducing human error, which is a significant contributor to maritime accidents. In Indonesia, research shows that inadequate implementation of BRM on ships leads to many deviations, highlighting the need for improved human resource training and better utilization of navigation equipment (Ikram et al., 2023). In addition, addressing human-centered design in ship bridge layouts can significantly reduce cognitive load and improve decision-making, further supporting BRM effectiveness (Guo et al., 2021).
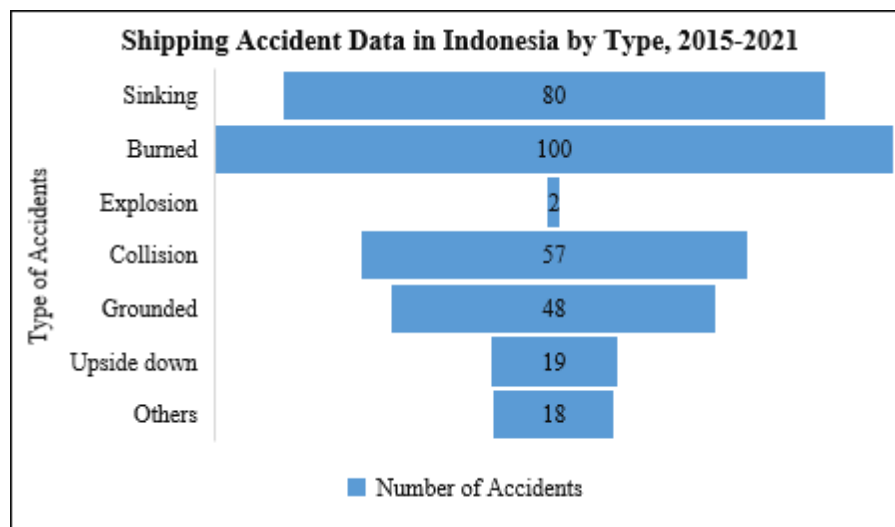
Source: Mustajab, (2024)
Figure 1. Shipping Accident Data in Indonesia by Type, 2015-2021

Based on shipping accident data in Indonesia from 2015 to 2021, it is known that the most dominant type of accident was ship fires (burned) with 100 incidents, followed by ship sinkings (sinking) with 80 incidents. Furthermore, there were 57 collision cases and 48 grounded cases. Upside-down incidents and other categories were recorded at 19 and 18 cases, respectively. The least frequent type of accident was explosion, which occurred only twice during the six-year period.

The high number of fires and sinkings reflects the weak implementation of technical and operational safety management systems on ships. This highlights the need for strengthening maintenance of electrical systems, machinery, and fire detection and response procedures. Additionally, collisions and groundings indicate the need for improvements in navigation systems, crew skills, and enhanced situational awareness, which are core components of Bridge Resource Management (BRM) training.

Compared to the International Maritime Organization (IMO) report on developing countries in Southeast Asia, the proportion of fire and drowning incidents in Indonesia is relatively high. This underscores the need to adopt a system-based and behavior-based approach to maritime safety, emphasizing the importance of layered mitigation against potential system failures (H. B. Santoso & Dillyanto, 2020).

This data reinforces the argument that in order to reduce the rate of shipping accidents, there needs to be synergy between strengthening human resource management through BRM training, providing adequate infrastructure, improving crew competence, and strictly monitoring the seaworthiness of the fleet (Susanto et al., 2021). These findings are consistent with the study's objective of examining the influence of these four factors on national shipping safety performance. Thus, the results not only describe the current situation but also reinforce the urgency of evidence-based mitigation strategies to improve maritime safety performance in Indonesia.

Based on the above background, the following research questions were formulated: 1) Does bridge resource management influence shipping safety performance?; 2) Do facilities and infrastructure influence shipping safety performance?; 3) Does crew competence influence shipping safety performance?; and 4) Does fleet seaworthiness influence shipping safety performance?.

METHOD

This study uses a qualitative descriptive approach with an exploratory-comparative literature review method. The main objective of this design is to explore and compare various empirical and conceptual findings relevant to the factors determining shipping safety performance. This study not only describes the influential variables but also evaluates the logical relationships and practical implications between Bridge Resource Management, facilities and infrastructure, crew competence, and fleet seaworthiness on maritime safety in the maritime transportation sector.

The data in this study were obtained from secondary sources, particularly scientific journal articles indexed in Scopus, Web of Science, DOAJ, Sinta, as well as official documents from international organizations such as the International Maritime Organization (IMO) and national technical reports from the Ministry of Transportation of the Republic of Indonesia. The literature analyzed was selected purposively based on relevant topics, namely bridge resource management (BRM), shipping infrastructure, crew competency, and technical condition of the fleet. Data collection was conducted by reviewing articles published between 2020 and 2025, using keywords such as "maritime safety performance," "bridge resource management," "crew competency," "seaworthiness," and "maritime infrastructure." Articles meeting the selection criteria were then organized into a tabular format to facilitate comparative analysis, (Susanto et al., 2024).

Data analysis was conducted using a literature-based comparative analysis method. Each article was analyzed using a thematic technique based on the emergence of concepts, empirical findings, and relevance to the four main variables of the study. The researcher used a manual coding approach to group each article into thematic categories (e.g., aspects of communication in BRM, port safety standards, crewing training practices, and fleet certification). After grouping, the analysis continued by comparing the relationships between variables and findings across studies. The comparison results were cross-checked to avoid bias and to strengthen the generalization of the findings.

To ensure validity, the researcher triangulated literature between sources, comparing local (Indonesian) study results with international studies. Data reliability was strengthened by evaluating the impact factor of journals, data collection methods in each study, and consistency of results in several similar studies. Additional validation was conducted by referring to policy frameworks and safety standards from the IMO and national regulations.

RESULTS AND DISCUSSION
Results
Based on the background and problem formulation above, the results of this study are as follows:

Maritime Safety Performance
Maritime safety performance measures the effectiveness of the entire shipping system in preventing, reducing, and managing risks and accidents at sea. It reflects how well a shipping company, fleet, or maritime authority maintains the safety of its crew, cargo, vessels, and the marine environment during the shipping process. Typical indicators of this performance include accident frequency, compliance with safety standards, response time to emergencies, and the efficiency of evacuation and rescue procedures (Palippui, 2024).

Indicators or dimensions contained in shipping safety performance variables include: 1) Accident Frequency: The number of accidents or incidents that occur during a specific period of time, regardless of severity; 2) Regulatory Compliance Level: The degree to which national and international safety standards, such as those set by the International Maritime Organization (IMO) and the Safety of Life at Sea Convention (SOLAS), are met; 3) Emergency Response Speed: The time it takes to respond to emergency conditions, such as fires, leaks, or collisions; 4) Effectiveness of Safety Training: How often and effectively the ship's crew and the company conduct evacuation and safety drills (Fan & Yang, 2023b).

The safety performance of shipping has been studied by several researchers, including: (Moreno et al., 2022), (Kara, 2022), (Kretschmann, 2020).

Bridge Resource Management
Bridge Resource Management (BRM) is a safety management approach in shipping that focuses on optimizing the use of human resources and technology on a ship's bridge. BRM promotes cooperation, effective communication, decision-making, situational awareness, and workload management among all crew members involved in navigation. BRM aims to minimize human error that could lead to accidents and ensure every bridge team member clearly understands their duties and can act in a coordinated manner (W. Santoso & Yulianto, 2024).

The indicators or dimensions contained in the bridge resource management variable include: 1) Team Communication: The quality of communication among bridge team members in both routine and emergency conditions; 2) Situational awareness: The ship's crew's ability to understand the ship's surroundings, position, and potential risks; 3) Decision-making: The accuracy and speed of decisions related to navigation and safety; 4) Workload management: How the team divides responsibilities to avoid fatigue or task overload (Guo et al., 2021).

Bridge resource management has been studied by several researchers, including: (Ikram et al., 2023), (Zhang & Chen, 2024).

Facilities and Infrastructure

In the context of shipping, facilities and infrastructure refer to all physical facilities and infrastructure that support safe and efficient operations. Facilities include tools and equipment such as navigation systems, safety equipment, radio communication systems, and the ship itself. Infrastructure includes ports, docks, watchtowers, and logistics and repair services. The quality and availability of these facilities and infrastructure are critical to operational readiness and responsiveness to emergency situations at sea (Luthfiyah, 2024).

Indicators or dimensions found in the facilities and infrastructure variable include: 1) Completeness of Navigation Equipment: The availability and reliability of modern navigation equipment, such as radar, GPS, AIS, and sonar; 2) The quality of safety equipment. The availability and condition of equipment such as lifeboats, life jackets, fire extinguishers, and emergency signals; 3) The physical condition of infrastructure. The suitability of docks, port facilities, and passenger or cargo terminals; 4) Port Technology Support: Vessel tracking systems (VTS), port automation systems, and ship-to-shore communication facilities (Fajar et al., 2023).

The facilities and infrastructure have been studied by several researchers, including: (Salim et al., 2023), (Mahani F,A., Nasution, 2022).

Crew Competence

Crew competence refers to the ability and qualifications of the ship's crew to perform operational, technical, and safety tasks during voyages. Competence includes technical knowledge, navigational skills, crisis management, an understanding of international regulations (such as STCW), and work experience at sea. High crew competence is essential to avoid operational errors and ensure safe and efficient voyages (Gundić et al., 2021).

The indicators or dimensions contained in the crewing competency variable include: 1) Certification and Licensing: Crew members must possess STCW and BST certificates and other specialized training certificates according to their position; 2) Sea Experience: The number of years and types of vessels operated by the crew member; 3) Navigation and Operational Skills: Practical skills in maneuvering vessels, reading nautical charts, and operating navigation equipment; 4) Managerial and communication skills: Ability to organize tasks, work in a team, and communicate with other crew members and port authorities (Fan & Yang, 2023a).

Crewing competence has been studied by several researchers, including: (Masterson et al., 2020), (MacLeod, 2021), (Griffioen et al., 2021).

Seaworthy Fleet

The seaworthiness of a fleet refers to the technical and administrative ability of a ship or fleet to sail in accordance with legal provisions and maritime safety regulations. Aspects of seaworthiness include the integrity of the ship's structure, readiness of the engine and navigation systems, safety equipment, and official certificates from the shipping authority. Seaworthy vessels have undergone inspection and meet the international standards set by organizations such as the International Maritime Organization (IMO) (Schinas & Metzger, 2023).

Indicators or dimensions contained in the fleet seaworthiness variable include: 1) Seaworthiness Certificate Status: Validity of official certificates from the shipping authority that the ship is seaworthy; 2) Technical inspection results: Results of periodic technical inspections of the engine system, ship structure, and safety equipment; 3) Vessel age and

modernity: The age of the fleet, its compliance with the latest safety standards, and the availability of modern navigation technology; 4) Maintenance and Repair History: Frequency and quality of routine vessel maintenance, including dry-docking records and engine system overhauls (Ofurumazi et al., 2024).

The seaworthiness of the fleet has been studied by several researchers, including: (Schinas & Metzger, 2023), (Alfianto et al., 2023).

Previous Research

Table 1. Previous Research

No	Author (Year)	Research Results	Similarities With This Article	Differences With This Article
1.	(W. Santoso & Yulianto, 2024)	BRM Situational Awareness Variables Affect Maritime Safety Performance	This article has similarities in examining the BRM variable in the independent variable and examining the Shipping Safety Performance variable in the dependent variable.	The difference lies in the other independent variables studied, including the Situational Awareness variable.
2.	(Untailawal et al., 2024)	-Variables of facilities and infrastructure affect shipping safety performance through capabilities at the Merauke Class III Type A District Navigation Office -Training variables affect shipping safety performance through capabilities at the Merauke Class III Type A District Navigation Office	This article has similarities in examining the variables of Facilities and Infrastructure as independent variables and examining the variable of Shipping Safety Performance as the dependent variable.	-The difference lies in the other independent variables studied, including the Training variable. And the intervening variable is Ability -There is a research object, which was conducted at the Merauke Type A Class III Navigation District Office
3.	(Wiyono & Kuncowati, 2020)	-Leadership style variables influence shipping safety performance -Crew competency variables influence shipping safety performance	This article has similarities in examining crew competency variables as independent variables and examining shipping safety performance variables as dependent variables.	The difference lies in the other independent variables studied, including leadership style variables.
4.	(Muna et al., 2021)	Seaworthiness variables of the fleet affect the safety performance of shipping in the Kutaraja ocean fishing port (pps)	This article has similarities in examining the seaworthiness variables of the fleet as independent variables and examining the shipping safety performance variables as dependent variables.	There is a research object, which is conducted at the Kutaraja ocean fishing port (PPS)

Discussion

Based on the problem formulation, research results, and relevant previous studies, the discussion in this study includes:

1. The Influence of Bridge Resource Management on Shipping Safety Performance

Based on a literature review and relevant previous studies, it was found that bridge resource management (BRM) has a significant influence on shipping safety performance in maritime transportation companies.

To improve shipping safety performance through bridge resource management, every marine transportation company in Indonesia must do the following: 1) Team communication: All bridge crew members must establish open, clear, and mutually confirming communication when performing navigation and maneuvering tasks. Important information such as route changes, weather conditions, and warnings from navigation systems must be communicated accurately without hierarchical barriers. Effective team communication prevents miscommunication that could potentially cause maritime incidents; 2) Situational awareness: The crew must have a full understanding of the ship's position, surrounding conditions, movements of other ships, and changes in the marine environment; 3) Decision-making: Every decision on the bridge must be based on accurate data and agreed upon by the team on duty; 4) Workload management: The division of tasks among the bridge crew must be evenly distributed and in accordance with each individual's capacity.

If every maritime transportation company is able to consistently implement the four aspects of bridge resource management, it will have a positive impact on shipping safety performance, including: 1) Accident frequency: The rate of maritime accidents such as collisions, fires, or capsizing will decrease because appropriate preventive measures have been taken through a robust BRM system; 2) Regulatory compliance: Effective implementation of BRM demonstrates compliance with national (Ministry of Transportation, DJPL) and international (IMO, SOLAS) safety standards, thereby enhancing the company's adherence to regulations; 3) Emergency response speed: Teams trained in BRM will be faster and more accurate in handling emergency situations because they have established procedures, smooth communication, and clear roles in incident handling; 4) Effectiveness of safety training: BRM promotes an adaptive safety culture. Safety drills such as fire drills, abandon ship drills, and navigational emergency drills become more effective because they are based on a solid understanding of the roles and responsibilities of each crew member.

The results of this study are in line with previous research conducted by (W. Santoso & Yulianto, 2024), which states that there is an influence between bridge resource management and shipping safety performance.

2. The Influence of Facilities and Infrastructure on Shipping Safety Performance

Based on a literature review and relevant previous studies, it was found that facilities and infrastructure have a significant influence on shipping safety performance in maritime transportation companies.

To improve shipping safety performance through facilities and infrastructure, every marine transportation company in Indonesia must do the following: 1) Complete navigation equipment: Every ship must be equipped with modern navigation equipment such as radar, AIS, GPS, ECDIS, and gyrocompass. This equipment assists the crew in monitoring maritime traffic, avoiding collisions, and mapping safe routes; 2) Quality of safety equipment: Equipment such as life jackets, lifeboats, fire extinguishers, and emergency alarms must be

available in sufficient quantities and tested regularly; 3) Physical condition of infrastructure: Port facilities such as docks, loading stairs, loading and unloading equipment, and operational control rooms must be in good condition, safe, and in accordance with technical standards; 4) Port technology support: Ports must be equipped with modern monitoring systems such as VTS (Vessel Traffic Services), CCTV surveillance, and digital communication systems between ports and ships.

If every maritime transport company is able to consistently implement these four aspects of facilities and infrastructure, it will have a positive impact on shipping safety performance, including: 1) Accident frequency: Accidents such as collisions, groundings, fires, and accidents at docks can be drastically reduced because ships and ports are better prepared technically; 2) Regulatory compliance: Infrastructure that meets IMO, SOLAS, and national regulations reflects a company's adherence to maritime safety rules, which is also a key factor in audits and certifications; 3) Emergency response speed: The availability of effective communication tools and systems accelerates response times to incidents. This reduces the impact of losses and maximizes the potential for rescue; 4) Effectiveness of safety training: Safety drills such as evacuation, fire, and fuel spill simulations will be optimal if supported by realistic facilities and equipment that match real-life scenarios.

The results of this study are in line with previous research conducted by (Untailawal et al., 2024), which states that there is a relationship between facilities and infrastructure and shipping safety performance.

3. The Influence of Crewing Competence on Shipping Safety Performance

Based on a literature review and relevant previous studies, it was found that crewing competence has a significant influence on shipping safety performance in maritime transportation companies.

To improve shipping safety performance through crew competence, every shipping company in Indonesia must do the following: 1) Certification and licensing: Every crew member must have an official certificate in accordance with STCW regulations, which includes basic safety training, firefighting, first aid, and watchkeeping training; 2) Sea experience: The number of hours at sea and experience navigating various sea conditions are important parameters in shaping the resilience and accuracy of decision-making by the crew; 3) Navigation and operational skills: Mastery of navigation systems, ship engines, maneuvering, and standard operating procedures (SOPs) are key to maintaining stability and safety in various weather conditions and dense shipping traffic; 4) Managerial and communication skills: The ability to communicate clearly, work in a team, manage conflicts, and make decisions under high pressure is very important, especially for senior crew and ship officers.

If every maritime transportation company is able to consistently implement these four aspects of crewing competence, it will have a positive impact on voyage safety performance, including: 1) Accident frequency: Competent crew tend to make fewer mistakes and are able to anticipate and prevent incidents or accidents; 2) Regulatory compliance: Crew members who understand national and international regulations are more disciplined in following safety protocols, including port inspections and IMO regulations; 3) Emergency response speed: Trained seafarers can respond quickly and appropriately to emergencies such as fires, collisions, or hazardous material spills, thereby minimizing loss of life and property; 4) Effectiveness of safety training: With a strong foundation of competence, safety training

becomes more effective because trainees can understand, absorb, and apply the material optimally in real situations.

The results of this study are in line with previous research conducted by (Wiyono & Kuncowati, 2020), which states that there is a relationship between crewing competence and shipping safety performance.

4. The Influence of Fleet Seaworthiness on Maritime Safety Performance

Based on a literature review and relevant previous research, it was found that fleet seaworthiness has a significant influence on maritime safety performance in maritime transportation companies.

To improve maritime safety performance through fleet seaworthiness, every maritime transportation company in Indonesia must do the following: 1) Maritime safety certification status: Every ship must have a seaworthiness certificate issued by a maritime authority, such as a Ship Safety Certificate (SKK) and an International Ship and Port Facility Security (ISPS) Code compliance certificate, as proof of passing technical and operational safety standards evaluations; 2) Technical inspection results: Vessels must undergo regular inspections by surveyors from authorized port authorities or classification societies. Good inspection results indicate that navigation systems, firefighting systems, communication systems, and vessel structures are in optimal condition for sailing; 3) Age and modernity of the vessel: Older vessels are more prone to engine failure, structural corrosion, or incompatibility with the latest safety technologies; 4) Maintenance and repair history: Complete documentation of routine maintenance and technical repairs is an important indicator in assessing the seaworthiness of a vessel. Ships that are consistently maintained are less likely to experience sudden damage or technical problems during voyages.

If every shipping company is able to consistently implement these four aspects of fleet seaworthiness, it will have a positive impact on shipping safety performance, including: 1) Accident frequency: Seaworthy ships tend to be safer from system failures, leaks, or accidents caused by technical conditions of the ship; 2) Regulatory compliance rate: A fleet that meets seaworthiness standards is more likely to pass safety audits, port inspections, and international certifications, thereby reducing the risk of penalties or vessel detention; 3) Emergency response speed: Vessels equipped with properly functioning emergency systems, such as water pumps, lifeboats, and communication devices, can respond to critical conditions more quickly and effectively; 4) Effectiveness of safety training: Crew members working on ships that meet seaworthiness standards can participate in more realistic and operational training, improving their preparedness and ability to deal with emergency situations.

The results of this study are in line with previous research conducted by (Muna et al., 2021), which states that there is a relationship between fleet seaworthiness and shipping safety performance.

Conceptual Framework

Based on the problem formulation, relevant previous studies, and the results and discussion of the above study, among others:
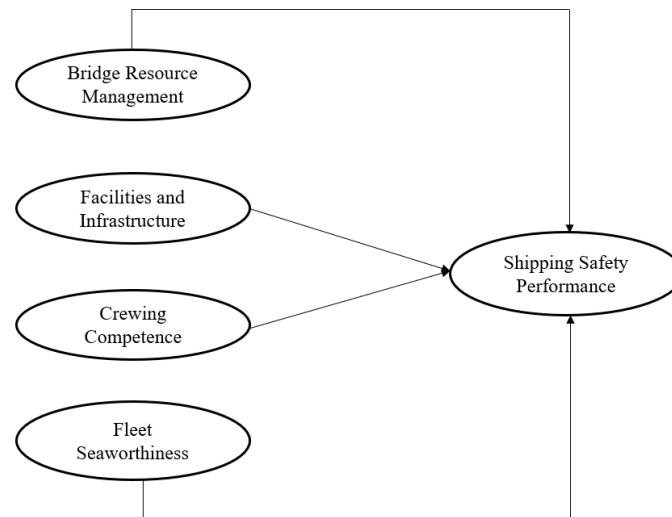
Figure 2. Conceptual Framework

Based on Figure 2 above, bridge resource management, facilities and infrastructure, crew competence, and fleet seaworthiness affect shipping safety performance. In addition to the independent variables above that influence the dependent variable (shipping safety performance), there are other variables that influence shipping safety performance, including:
1) Work Safety Culture: (Kalteh et al., 2021), (Zhang et al., 2020), (Berry et al., 2020).
2) Maritime Surveillance: (Gamage et al., 2023), (Rekavandi et al., 2025), (Dupont et al., 2020).
3) Quality of Continuing Education: (Forsetlund et al., 2021), (Neuwirth et al., 2021), (King et al., 2021).

CONCLUSION

Based on the results and discussion above, the following conclusions can be drawn from this study:
1) Bridge resource management affects shipping safety performance;
2) Facilities and infrastructure affect shipping safety performance;
3) Crewing competence affects shipping safety performance;
4) Fleet seaworthiness affects shipping safety performance.

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