British Journal of Multidisciplinary Studies
ISSN: 2978-8110
DOI: 10.32996/bjmss
Journal Homepage: www.al-kindipublisher.com/index.php/jbmss

BJMS
AL-KINDI CENTER FOR RESEARCH AND DEVELOPMENT

| RESEARCH ARTICLE

Contributing Factors to Maritime Accidents

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| ABSTRACT
This study assessed seafarers' perceptions of the contributory factors to maritime accidents at the Protect Marine Deck and Engine Officers' Training and Assessment Center in Carcar City, Cebu, Philippines. The findings served as the basis for a proposed action plan to enhance maritime safety practices. Specifically, the study determined the respondents' profile in terms of age, sea expérience, civil status, educational attainment, and type of vessel boarded; examined their perceptions on the extent of contributory factors to maritime accidents in terms of human, technical, environmental, operational, structural and design, management and regulatory, and piracy and security risks; identified the significant relationship between respondents' profile and their perceptions; and developed an action plan based on the results. The descriptive-correlational research design was employed using a researcher-made questionnaire administered to seafarers enrolled in safety training courses. Frequency counts and percentages were used to describe the respondents' profile; the weighted mean determined the extent of perceived contributory factors; and the chi-square test with Pearson's Contingency Coefficient C measured the significance and strength of relationships between variables. Findings revealed that most respondents were aged 30–49 years, married, had 1–5 years of sea experience, were college graduates, and were assigned to bulk carrier vessels. Human, operational, and management and regulatory factors were perceived as high, particularly fatigue due to long working hours, poor decision-making during critical operations, and weak enforcement of safety policies. Technical, environmental, structural, design, piracy, and security risk factors were perceived as moderate, with equipment failure, adverse weather conditions, ageing vessel components, and a lack of anti-piracy training identified as notable concerns. Statistical analysis showed that only age and vessel type were significantly associated with the selected contributory factors. Age was moderately associated with human factors, while vessel type was moderately associated with structural and design factors. The study concluded that maritime accidents were primarily attributable to human factors, operational lapses, and management weaknesses. It emphasized the need for targeted safety interventions that consider age-related factors and vessel-specific structural conditions to strengthen maritime accident prevention strategies.

| KEYWORDS
Maritime accidents, Contributory factors, Seafarers' perception, Human factors, Maritime safety, Fatigue, Operational risk, Safety management, Vessel type, Descriptive-correlational study

| ARTICLE INFORMATION
ACCEPTED: 01 April 2026 **PUBLISHED:** 24 May 2026 **DOI:** 10.32996/bjmss.2026.4.2.3x

1. Introduction
Maritime accidents are a threat to global trade as cargo movement on sea has many hazards. This study investigates the causes of maritime accidents in order to enhance safety standards and promote safety culture within the maritime industry objectively reducing the frequency of maritime accident. The findings may improve safety in navigation, safety in human lives, and protection of the environment. Maritime transport is the lifeblood of global trade, with approximately 80% of cargo traversing the seas. Due to its importance, the maritime shipping industry faces challenges in maintaining safety as shipping operations have inherent risks such as grounding, collisions, oil spills, and numerous onboard incidents resulting in economic losses, human, social and environmental issues (United Nations Conference on Trade and Development, 2024). Globally, maritime accidents have been linked

to several factors and human error is pointed as the major accident contributor with estimates involving over 75% of incidents. Other factors are contributory, like machinery failure, lack of equipment training and environmental disturbances (International Maritime Organization, 2019). Notable incidents globally, were the grounding of crew ship Costa Concordia in Tuscany, Italy in 2012 (Schroder-Hinrichs et al., 2012), costing the lives of 32 crew and damage the whole ship and salvaging worth more than 2.5 billion dollar, the sinking of M/V Sewol in Korea with 304 casualties, mostly high school students (Kim, 2015), M/T Exxon Valdez incident in Alaska in 1989, though there was no human casualty but the oil pollution stretches 1,300 miles along the Alaskan coastline, the damage of the environment was so huge that the cost for cleanup and punitive penalties reaches more than 11 billion dollars, the effect of damage to the flora and fauna is still visible up to this day (Maki,1991), and finally, the sinking in 90 seconds when water started flooding the car deck of the ferry Herald of Free Enterprise in Zeebrugge, Belgium in 1987, this happens only 20 minutes after departure from port, with 193 casualty in both passenger and crew (Dalgleish et al., 2000) where few of these infamous incidents.

In domestic shipping, the MV Doña Paz tragedy, in 1987 (Perez et al., 2011), the world's deadliest peacetime maritime disaster far surpassing the Titanic in 1912 (Levenson & Granot, 2002), serves as a plain reminder of the overwhelming consequences of losing lives and ships and endangering the maritime environment. M/V Doña Paz tragedy claims the lives of 4,341 and several missing unknown in numbers, M/V Dona Marilyn in 1988, with 389 casualty & 2 missing, M/V Princess of the Orient in 1998 with 70 casualty & 80 missing, and Princess of the Stars in 2008, 437 casualty and 605 missing All of this belongs to same company alone.This study is rooted in national and international legal framework designed to prevent maritime casualties and improve safety. The need to examine accidents and comprehend their causes is openly mandated and supported by various conventions and codes namely: United Nations Convention on the Law of the Sea (UNCLOS), International Convention of Safety of Life at Sea (SOLAS), International Safety Management (ISM) Code, Standards of Training, Certification and Watch Keeping for Seafarers (STCW) Convention, and Casualty Investigation Code. Additional to these international conventions, individual states have their national Laws and Regulation that implements these international standards. The researcher is a Chief Marine Engineer and is affiliated with Protect Marine Deck and Engine Officers of the Phils. Inc. Cebu Branch, as Training Director. The results of this research will enhance our understanding of the different contributing factors and root causes of maritime accidents. The findings of this study will highlight critical areas that have often been overlooked by other researchers and aim to create a new theory for a deeper understanding of the root causes of maritime accidents.

2. Theoretical Background

This study is anchored in Disaster Theory by Yong-kyun Kim & Hong-gyoo Sohn (2013) and supported by Systems Theory by Ludwig Von Bertalanffy (1968) and Resilience Theory by Norman Garmezy (1985).

Disaster Theory hypothesized disasters not as sudden, isolated events but as the result of a gradual progression in which risks build up and escalate over time. The theory argues that disasters develop from the interaction of multiple hidden conditions embedded within involved systems, such as human limitations, organizational weaknesses, environmental pressures, and technical deficiencies. Rather than focusing solely on the final triggering event, Kim and Sohn emphasize that disasters are developed through ineffective controls, unnoticed or ignored warning signs, and normalized deviations from safety standards. This viewpoint in industry operations, accidents often result from prolonged exposure to unsafe practices rather than a single catastrophic failure (Kim & Sohn, 2013). The focal point of Disaster Theory is the notion of escalation and amplification of failures within interconnected systems. Small errors or deviations—such as fatigue-related mistakes, poor decisions, or regulatory non-compliance—may initially appear not important but can interact and build up when systemic safeguards fail. The theory explains how inadequate response mechanisms, weak oversight, and delayed corrective actions allow risks to transmit across system levels, eventually overcoming safety defenses. In industry settings, this process may manifest as the merging of human error, management shortcomings, and adverse environmental conditions, transforming routine operational hazards into major accidents (Kim & Sohn, 2013). Disaster Theory provides a strong framework for examining accidents by shifting the focus from individual fault to systemic connection. It emphasizes the importance of initial risk identification, constant monitoring, and positive intervention to prevent disaster acceleration. The theory supports the contention that effective accident avoidance requires strengthening system-wide resilience through integrated safety management, regulatory enforcement, training, and organizational learning. By enclosing accidents as predictable outcomes of accumulated systemic failures, Kim and Sohn's Disaster Theory offers a comprehensive foundation for understanding contributing factors to accidents and validates the need for wide-ranging, multi-level safety (Kim & Sohn, 2013).

Systems Theory gives a foundational lens for identifying disasters as the consequence of interactions among interconnected components rather than the result of isolated failures. The theory suggests that organizations and operational environments behave as open systems composed of interdependent subsystems (human, technical, organizational, and environmental) that actively exchange information and energy. Systems Theory, therefore, complements Kim and Sohn's Disaster Theory by emphasizing that disasters appear when multiple subsystems altogether reduce or fail, permitting insignificant disturbances to generate across the whole system (Von Bertalanffy, 1968). Systems Theory posits that when feedback loops within the system are weak, such as ineffective safety reporting, inadequate supervision, or poor communication, errors are not corrected in time and instead swell across subsystems. For example, crew fatigue (human subsystem), combined with poor maintenance (technical subsystem) and weak regulatory oversight (management subsystem), can interact in a nonlinear manner to transform routine operational risks into disaster-triggering conditions (Von Bertalanffy, 1968). Furthermore, Systems Theory emphasizes the significance of system resilience and complete intervention. Rather than addressing accidents through single-factor solutions, Systems Theory advocates for strengthening interactions, feedback mechanisms, and adaptability across the entire system. By mounting disaster prevention as a system-wide responsibility, Systems Theory posits that disasters are not sudden or random events but expectable outcomes of systemic weaknesses, thereby providing a robust theoretical foundation for analyzing and mitigating accidents (Von Bertalanffy, 1968).

Resilience Theory highlights the shielding mechanisms that disrupt this process. It points out the capacity of individuals and systems to withstand, absorb, and adapt to, then recover from, adverse or stressful conditions. Emerging from developmental psychology, the theory focuses on the idea that exposure to risk or hardship does not automatically result in negative outcomes. Instead, Resilience Theory stresses the role of protective factors, such as personal experiences, supportive relationships, and adaptive surviving mechanisms, that buffer the impact of stressors. Resilience is therefore understood as an active process rather than a fixed attribute, shaped by the interaction between risk factors and available resources. Through this view, the theory demonstrates that even in high-risk environments, provided that protective mechanisms are present and effectively mobilized, successful adaptation is possible (Garmezy, 1985). Furthermore, Resilience Theory conceptualizes resilience as a developing idea arising from the relationship between vulnerability and protection across the life span. He proposes that results are probabilistic and influenced by intervening variables within the individual and the environment, rather than viewing maladaptation as a direct consequence of stress exposure. Identification of risk factors, such as adversity, instability, or chronic stress, and protective factors that moderate their effects is the focal point of this theory. Experience and support over time strengthened the common adaptive capacity, and resilience is not an exceptional or rare quality, underscoring the Resilience Theory framework. Individual attributes, family support systems, and broader social structures operate at multiple levels as protective influences. By framing resilience as a dynamic and context-sensitive process, the theory provides a foundation for understanding why similar levels of risk may bear different developmental results (Garmezy, 1985). Moreover, Resilience Theory strengthens the preventive angle of Disaster Theory by shifting awareness toward adaptive recovery rather than solely on failure analysis. The theory supports the argument that safety is improved when systems are designed not only to avoid error but also to respond effectively when errors occur. This aligns with Kim and Sohn's statement that disasters are predictable and manageable through early intervention. By integrating resilience-building strategies, such as continuous training, education, safety culture development, and organizational learning, systems can absorb shocks and maintain safe operations (Garmezy, 1985).

Over the past five decades, the shipping industry has significantly improved technical reliability and structural integrity through enhanced hull designs such as double hulls and watertight bulkheads for RO-RO vessels, upgraded stabilization and propulsion systems, and advanced navigation and signaling technologies. Despite these structural and technical advancements, as well as regulatory requirements introduced by the International Maritime Organization, including mandatory Safety Management Systems (SMS), the overall rate of maritime accidents has not markedly declined. This persistent trend highlights that structural design and system reliability alone are insufficient, as 70–85% of maritime accidents are attributed to human error. Contributory human factors include inadequate competence at the operational level, overreliance on increasing automation, weak supervision, and lapses in planning, control, and decision-making during critical situations. Management and regulatory responses emphasize the need for continuous professional training, development of both technical and soft skills such as teamwork and communication, mentorship programs to bridge experience gaps, and structured risk assessment processes within shipping companies and port authorities. Operational risk is further intensified by fatigue-related conditions, underscoring the importance of strict compliance with work–rest hour regulations, proper scheduling, health management, and proactive safety practices to mitigate human-related vulnerabilities onboard vessels (Maternová et al., 2023).

Safe and reliable shipboard operations largely depend on human reliability, recognizing that while human error cannot be completely eliminated, its occurrence can be minimized through systematic assessment and control. A hybrid methodological approach integrating the SOHRA model, entropy weight method, and TOPSIS model has been applied to calculate Human Error Probability (HEP), reducing subjectivity by replacing purely expert-based weighting with entropy-based calculations. The entropy-weighted TOPSIS technique enhances objectivity in evaluating error-producing conditions (EPCs), and comparative analysis indicates that combining MMOHRA, SOHRA, and HEART models yields more consistent and proportionate EPC assessments. This approach is applicable to both deck and engine crew operations, although department-specific models may further improve accuracy due to operational differences. Despite methodological improvements, expert judgment still significantly influences results because of the limited available human error data in maritime contexts. To minimize subjectivity, structured consensus methods such as the Delphi technique and systematic data collection through monitoring and recording systems, similar to investigations conducted by the Marine Accident Investigation Branch and the Australian Transport Safety Bureau, are necessary to generate comprehensive human error databases for more objective risk evaluation (Ma et al., 2022).

Key human contributory factors in maritime accidents include misinformation regarding site conditions, lack of situational awareness, poor teamwork, and incorrect judgment under pressure. A breakdown in bridge resource management was evident when the second officer's warning about navigational obstacles was disregarded by the master, who relied on prior assumptions despite observable risks, while the ship's navigation warning system was turned off. The interconnected nature of these events demonstrates how communication failures, inadequate collaboration, and compromised decision-making amplify operational risks. Such human-centered deficiencies reflect weaknesses in supervision, information flow, and adherence to established safety protocols during navigation. These factors also illustrate how technical safeguards become ineffective when not properly utilized by crew members. The identified issues provide clear bases for strengthening crew training, enhancing coordination and communication, and reinforcing compliance with safety and risk mitigation procedures onboard vessels (Zaib et al., 2022).

Collision reports from Indonesia, Japan, and Hong Kong over a ten-year period involving 145 ships reveal that most accidents occurred during routine or seemingly convenient tasks, emphasizing vulnerabilities in everyday operational activities. A total of 718 error-producing conditions (EPC–4M) were identified, with management factors accounting for the highest proportion (411), particularly deficiencies in lookout duties, inadequate checking procedures, and poor progress tracking. Communication gaps, including ineffective ship-to-ship and crew communication, were also prominent contributors to management-related issues. Human (man) factors ranked second (255), with misperception of collision risk and ambiguous or inconsistent performance identified as major contributory elements. Media factors (29) and machine factors (23) were less significant, indicating that technical failures were comparatively minor contributors relative to managerial and human deficiencies. Variations among the countries analyzed suggest that contextual and operational environments influence accident patterns, reinforcing the need for management-focused interventions, improved communication systems, and strengthened human performance monitoring to reduce collision risks (Bowo et al., 2025).

Maritime occupational safety in Indonesia remains a critical concern due to the nation's heavy reliance on sea transportation. Analysis of 120 documented accidents from 2003 to 2019, including fires, sinkings, groundings, collisions, and mechanical failures, revealed that human error accounted for approximately 72% of cases, followed by technical malfunctions (14%), adverse weather (8%), organizational deficiencies (4%), and cargo overloading (2%). Human-related errors were categorized into unsafe acts, preconditions for unsafe acts, unsafe supervision, and organizational influences, highlighting systemic issues such as fatigue, inadequate training, poor supervision, and weak safety culture. Despite regulatory adoption of the SOLAS and the International Safety Management Code, accidents persist, demonstrating the limitations of compliance-focused approaches. Technical and environmental factors played smaller roles, with shipboard systems and weather-related risks contributing to a lesser extent than human and organizational deficiencies (Maharani & Mustofa, 2025). Maritime transport has become increasingly significant in global shipping, yet the frequency of maritime traffic accidents has also risen over the past two decades, particularly those with serious consequences. Analysis of accident data from 2002 to 2022, considering ship size, age, type, and other characteristics, indicates that small and medium-sized vessels face higher risks of major accidents compared to large ships. Auxiliary ships and bulk carriers were identified as particularly vulnerable, highlighting the need for targeted safety improvements in these vessel categories. Risk modeling using historical accident data demonstrates how different ship characteristics contribute to accident likelihood, providing insights for prioritizing safety interventions (Chen et al., 2023).

Hetherington et al. (2006) found that most incidents arise from combinations of human error, organizational shortcomings, and environmental stressors rather than from isolated technical failures; fatigue, poor communication, and weak safety culture were recurrent latent conditions that increased system vulnerability. The study analyzes the human factors and organizational conditions that influence accidents, shows that failures are more often rooted in systemic and managerial weaknesses than in individual mistakes. And accident prevention should prioritize training, improve leadership coordination and safety management systems, rather than pointing the blame to individuals alone. Rasmussen (1997) developed a comprehensive perspective on accident analysis by modeling risk across hierarchical levels within organizations. He demonstrated how decisions made at regulatory and managerial levels can significantly influence frontline operational safety, particularly when feedback mechanisms are weak or ineffective. According to Rasmussen, accidents in complex environments are not merely random occurrences but emerge from gradual shifts in system behavior, often driven by pressures such as efficiency demands, cost reduction, and organizational constraints. He emphasized that both individuals and organizations continuously adapt to changing conditions. While such adaptations are usually intended to improve performance, they can inadvertently create conditions that lead to unsafe outcomes.

Leveson (2004) found that accidents often stem from inadequate enforcement of safety constraints and flawed control structures rather than from isolated component failures. She emphasized that safety should be understood as the effective control of system constraints, and accidents arise from a loss of control rather than simple equipment malfunction. Accordingly, weak feedback loops, poor coordination across hierarchical levels, and failure to maintain or enforce safety constraints can result in unsafe interactions within the system. Thus, accidents are not merely the product of individual errors but emerge from deficiencies in the overall control structure. Reason (1990) explained that accident causation and human error, particularly in complex, high-risk systems, are not solely due to individual mistakes but to the interaction between human actions and latent organizational failures. He illustrated how multiple layers of defense can be breached when underlying weaknesses align, allowing hazards to pass through safety barriers. Emphasis was placed on organizational influences such as poor supervision, unsafe norms, and inadequate training, which create vulnerabilities within protective layers. In the maritime context, this perspective explains how fatigue, weak supervision, insufficient procedures, and organizational pressures can combine and interact, ultimately leading to catastrophic failures. Rutter (1987) emphasized resilience as a dynamic process shaped by the interaction between risk exposure and protective systems, rather than as a fixed or inherent trait. He explained that resilience develops through ongoing adaptation, in which individuals and organizations respond to challenges by mobilizing available resources and supports to counter potential adverse effects. Hollnagel et al. (2006) articulated key operational principles for resilient systems, namely anticipation, monitoring, response, and learning. These principles highlight organizations' capacity to anticipate potential disruptions, track critical conditions, respond effectively to emerging threats, and continuously learn from experience, capabilities directly applicable to strengthening safety management practices.

Wreathall (2006) explained that resilient organizations sustain safety not by attempting to eliminate all errors, but by enhancing their capacity to adapt to unexpected and changing conditions. He emphasized the importance of flexible decision-making, continuous training, and a strong safety culture in enabling organizations to manage variability and maintain stable operations under pressure. Woods (2015) further highlighted that resilience mechanisms enable systems to absorb shocks, adjust to disruptions, and recover without catastrophic failure. His work underscored the importance of the ability to respond, monitor, anticipate, and learn from disturbances in preventing minor issues from escalating into major accidents. Dawson and McCulloch (2005) identified fatigue as a critical underlying condition that accelerates the progression of disasters in complex socio-technical systems. They argued that fatigue significantly reduces cognitive functions such as attention, decision-making, and situational awareness, thereby increasing the likelihood of operational errors, particularly under emergency conditions. Williamson et al. (2011) further demonstrated that fatigue-related impairment in functioning is comparable to the effects of alcohol intoxication, reinforcing the view that fatigue is a substantial risk factor rather than merely a personal weakness. These findings suggest that chronic fatigue can accumulate unnoticed within routine operations and, when combined with other organizational and operational vulnerabilities, contribute to the escalation of accidents.

3. Objective of the Study

This study assessed the perceptions on the contributing factors to maritime accidents by seafarers, in Protect Marine Deck and Engine Officer's Training and Assessment Center, Carcar City, Cebu, Philippines. Specifically, the study sought answers to the following questions: 1. What is the profile of the respondents in terms of: age; sea experience; civil status; educational attainment; and type of vessel boarded; 2. What is the respondents' perception on the extent of the contributory factors to maritime accidents in terms of: human; technical; environmental; operational; structural and design; management and regulatory; and piracy and security risk?; 3. Is there a significant relationship between the respondents' profile and the perception on the extent of the contributory factors to maritime accidents by the respondents?

4. Research Methodology

This section explains the research methodologies employed in assessing the extent of the contributory factors to maritime accidents in terms of: Research Design, Research Environment, Research Respondents, Research Instruments, Research Procedure.

4.1 Research Design

This study utilized the descriptive-correlational research design with a researcher-made questionnaire to gather the data as experienced by seafarers onboard.

4.2 Research Environment

This study was conducted at Protect Marine Deck and Engine Training and Assessment Center situated in Carcar City, Cebu, approximately 42 kilometers from Cebu City. The center is a recognized maritime training institution that provides mandatory safety and competency courses for seafarers in compliance with national and international maritime standards. It is strategically located in an accessible area within the city, making it conducive for professional training and assessment activities. The institution is equipped with appropriate training facilities that simulate actual maritime conditions, thereby promoting practical learning and skill enhancement among maritime personnel. Its structured training environment, organized course schedules, and compliance with regulatory requirements make it a suitable setting for a study of maritime safety and the contributory factors to maritime accidents.

4.3 Research Respondents

The respondents of this study were fifty (50) trainees, all male, who are active seafarers holding various ranks onboard different types of vessels. The majority of them are employed in international trade and were, at the time of the study, attending mandatory safety and competency courses for certification, upgrading, or renewal. These courses included Advanced Fire Fighting, Personal Survival Technique, Personal Safety and Social Responsibility, Elementary First Aid, Operational Level Course, and Management Level Course. Their varied shipboard positions and length of sea service provided meaningful insights into the contributory factors to maritime accidents. In selecting and involving the respondents, ethical considerations were strictly observed. Participation was voluntary, the purpose of the study was clearly explained, and the respondents were assured that their identities and individual responses would be kept confidential and used solely for academic purposes.

4.4 Research Instruments

The researcher used a survey questionnaire as a research instrument. The questionnaire is composed of two (2) major parts. The first part dealt with the contributory factors to maritime accidents among personnel, including age, sea experience, civil status, highest educational attainment, and type of vessel boarded. The second part deals with the respondents' perception of the extent of the contributory factors to maritime accidents, including human, technical, environmental, operational, structural and design, management and regulatory, piracy, and security. The questionnaire is composed of ten (10) questions each for: personnel profile in terms of age, sea experience, civil status, highest educational experience, and type of vessel boarded and ten (10) questions on the perception of the extent of the contributory factors to maritime accident by the respondents in terms of: human, technical, environmental, operational, structural and design, management and regulatory, and piracy and security. The respondents used the following rating scale to answer the survey items: 4 = strongly agree (high extent), 3 = agree (moderate extent), 2 = disagree (low extent), and 1 = strongly disagree (none).

4.5 Research Procedures

This section presents the gathering and statistical treatment of data.

4.5.1 Gathering of Data. Before conducting the study, a formal letter of request was prepared and addressed to the management of Protect Marine Deck and Engine Training and Assessment Center in Carcar City, Cebu. The letter respectfully sought permission to administer the researcher-developed questionnaire to active seafarers enrolled in various Maritime Safety Courses, namely: Advanced Fire Fighting, Personal Survival Technique, Personal Safety and Social Responsibility, Elementary First Aid, Operational Level Course, and Management Level Course. The purpose of the study, its significance to maritime safety, and the assurance of confidentiality and voluntary participation were clearly stated in the transmittal letter. Upon approval of the request, the researcher coordinated with the training schedules to ensure that the distribution of the questionnaires would not disrupt the regular conduct of classes. The primary data for the study were collected through the administration of a structured questionnaire, personally distributed to the fifty (50) respondents. The researcher explained the objectives of the study, the instructions for completing the instrument, and the rating scale to ensure respondents clearly understood each item. Adequate time was given for them to complete the questionnaire. To clarify vague or incomplete responses and to address any concerns raised by the respondents, the researcher conducted brief personal interviews when necessary. This approach ensured the accuracy, completeness, and reliability of the data collected.

The questionnaire consisted of two major parts. The first part elicited information on respondents' age, sea experience, civil status, highest educational attainment, and type of vessel boarded. The second part determined the respondents' perceptions of the extent of the contributory factors to maritime accidents, including human, technical, environmental, operational, structural, design, management and regulatory, and piracy and security risks. A four-point Likert scale was used, where 4 corresponded to agree (great extent) strongly, 3 to agree (moderate extent), 2 to disagree (low extent), and 1 to disagree (no extent) strongly. In addition to the primary data, secondary data were obtained from relevant books, scholarly journals, maritime publications, training manuals, and credible internet sources. These materials provided theoretical and empirical support for the study and served as a basis for formulating the questionnaire and interpreting the findings. After all questionnaires were retrieved and carefully checked for completeness, the responses were encoded, organized, and prepared for statistical treatment. The compiled data were then submitted to the statistician for proper tabulation, computation, and analysis in accordance with the study's objectives.

4.5.2 Treatment of Data. The following statistical tools were used in the study:

Frequency Count and Per Cent were used to summarize, analyze and interpret the profile of the respondents. Weighted Mean were used to summarize, analyze, and interpret the responses on perceptions of the extents of the contributory factors to maritime accidents by the respondents. The following are the mean ranges, description and interpretation of the summarized responses of the respondents:

Mean Ranges	Description	Interpretation
3.25 – 4.00	Strongly Agree	High Extent
2.25 – 3.24	Agree	Moderate Extent
1.25 – 2.24	Disagree	Low Extent
1.00 – 1.24	Strongly Disagree	None

Chi-square and Pearson Coefficient C will used to determine the significance and strength of the relationship between the respondent’s profile and the perception of the extent of the contributory factors on maritime accidents by the respondents.

5. Results and Discussion

This section presents, analyzes, and interprets data gathered from the study's respondents. The first section presents the demographic profile of the respondents. The second section presents the respondents' perceptions of the extent of contributory factors to maritime accidents. The third section summarizes the hypothesis test results and the significance of the relationship between respondents' profiles and their perceptions of the extent to which contributory factors contribute to maritime accidents.

Profile of the Respondents

This section presents a summary of the respondents' profiles in terms of age, sea experience, civil status, educational attainment, and type of vessel onboard. Table 1 cascades the distribution of the respondents.

Table 1

Profile of the Respondents

	Frequency	Per Cent (%)
Age (in years)		
• 22 – 29	11	22.00
• 30 – 39	19	38.00
• 40 – 49	12	24.00
• 50 - 59	3	6.00
• 60 - 70	5	10.00
Sea Experience (in years)		
• Cadet (Engine/Deck)	6	12.00
• Support Level	3	6.00
• Operational Level	26	52.00
• Management Level	5	10.00
• Chief Engineer/Master	10	20.00
Civil Status		
• Single	13	26.00
• Married	37	74.00
Educational Attainment		
• High School Graduate	2	4.00
• Associate	2	4.00
• Bachelor's Degree	46	92.00
Type of Vessel		
• Container	5	10.00
• Bulk Carriers	17	34.00
• Tankers	14	28.00
• General Cargo	5	10.00
• Reefer Ship	2	4.00
• Others	7	14.00

As shown in Table 1, most of the respondents are 30 to 39 years old (38%), followed by 40 to 49 years old (24%) and 22 to 29 years old (22%). In terms of sea experience, most of the respondents are at the operational level (52%), followed by the chief engineer/master position (20%). Furthermore, most respondents are married (74%) and have a bachelor's degree (92%). In terms of vessel type, most were onboard bulk carriers (34%), followed by onboard tankers (28%). The data suggest that most respondents are mid-career seafarers with operational-level experience, providing practical insights into maritime accidents. Their high educational attainment and married status suggest a mature and responsible workforce. Most respondents work on bulk carriers and tankers, which are known for higher operational risks. The findings are supported by Manalo et al. (2015), who stated that the maritime industry is among the fastest-growing sectors today and employs a large number of individuals from several countries. Filipino seafarers are competitive with others due to their reliability and hardworking nature. The majority of Filipino seafarers are male, married, and aged between 21 and 40. Most seafarers with 0 to 10 years of service in the industry experience challenges on board, with the most common being homesickness, followed by fatigue, family problems, poor communication on board, and poor workplace relationships. These challenges, at times, result in accidents. The findings are also supported by Huerte et al. (2023), who said that a total of 11,831 seafarers who underwent physical medical examination (PEME) at the Nordic Medical Clinic between 2018 and 2022 were used in the study. The age distribution of the seafarers revealed that the majority fell within the 30–39 and 40–49 age groups. Out of the total, approximately 11,186 were male seafarers, outnumbering female seafarers by a ratio of more than 17 to 1. The majority of seafarers were married, with a smaller proportion being single. All of the seafarers included in this study are employed under the same maritime manning agency.

Perception on the Extent of the Contributory Factors to Maritime Accident

This section presents the perception of the extent of the contributory factors of maritime accident by the respondents in terms of human, technical, environmental, operational, structural and design, management and regulatory, piracy and security risks. Tables 2 to 8 and 10 cascade the summary of the responses.

Table 2

Perception on the Extent of the Contributory Factors to Maritime Accident by the Respondents in Terms of Human

Indicators	Mean	Description	Interpretation
1. Long working hours and insufficient rest periods increase the risk of human error on board.	3.76	Strongly Agree	High Extent
2. Lack of attention or poor situational awareness among crew members often leads to unsafe conditions.	3.68	Strongly Agree	High Extent
3. Inadequate training or lack of practical experience contributes to the occurrence of accidents.	3.42	Strongly Agree	High Extent
4. Miscommunication among crew members due to language differences has led to unsafe situations.	3.28	Strongly Agree	High Extent
5. Poor decision-making during high-stress or emergency situations can cause maritime accidents.	3.52	Strongly Agree	High Extent
6. Failure to follow standard operating procedures increases the likelihood of accidents.	3.58	Strongly Agree	High Extent
7. Impairment due to alcohol or drugs among crew members is a serious safety risk.	3.76	Strongly Agree	High Extent
8. Cultural misunderstandings among multinational crew members can hinder teamwork and safety.	2.98	Agree	Moderate Extent
9. Experienced crew sometimes underestimate risks, which can lead to accidents.	3.34	Strongly Agree	High Extent
10. Poor supervision or weak leadership on board contributes to unsafe work practices.	3.48	Strongly Agree	High Extent
Overall Mean:	3.48	Strongly Agree	High Extent

As shown in Table 2, the overall mean for the perception of the extent of the contributory factors to maritime accidents by the respondents, in terms of human factors, is 3.48, which is *interpreted as a high extent* (strongly agree). The top-rated indicators with the highest mean scores are item 1, *long working hours and insufficient rest periods increase the risk of human error on board*, and item 7, *impairment due to alcohol or drugs among crew members, is a serious safety risk*, both with a mean of 3.76 and described as *strongly agree, interpreted as high extent*. The least rated indicators with mean scores below the overall mean are item 8, *cultural misunderstandings among multinational crew members can hinder teamwork and safety* with a mean of 2.98 and described as *agree interpreted as moderate extent*, and item 4, *miscommunication among crew members due to language differences has led to unsafe situations* with a mean of 3.28 and described as *strongly agree interpreted as high extent*. These results imply that the most urgent human-related risks to maritime safety are fatigue and substance impairment, which are widely recognized as critical threats. In contrast, the lower ratings for communication-related and cross-cultural challenges suggest areas that may benefit from targeted training and organizational strategies to improve collaboration and minimize misunderstanding on the board. The findings are supported by Mansyur et al. (2021), who reported that tugboat crew members are susceptible to fatigue during their 24-h work shifts, despite the availability of rest time. The fatigue experienced by seafarers contributes to marine accidents and to metabolic and cardiovascular diseases, both of which have long-term effects. The incidence of fatigue among Indonesian tugboat crewmembers operating on the Mahakam River was considerably high. Working hours, sleep quality, and work-family conflict were strongly associated with fatigue among tugboat crewmembers; therefore, their working and rest hours need to be improved.

The findings are also supported by Zaib et al. (2022), who said that there are many causes of accidents in the maritime industry. System failures or environmental factors can cause them, but the number of accidents caused by these factors is smaller. According to Ren et al. and Marine Insight, the most common causes, such as fires, explosions, ships going missing, and ship collisions, are all the result of human mistakes in some way. Human mistakes were shown to be the most common cause of marine mishaps. Some of the human factors found include lack of awareness of the situation of the surroundings, tiredness, use of substance and/or being medically unfit, being overworked, lack of vigilance, being less attentive, lacking in proper training and qualification, insufficient collaboration, inadequate dissemination of information, absence of safety measures, not using standard guidelines, and being complacent in performing duties.

Table 3

Perception on the Extent of the Contributory Factors to Maritime Accident by the Respondents in Terms of Technical

	Indicators	Mean	Description	Interpretation
1.	Malfunctioning navigation systems increase the likelihood of maritime accidents.	3.36	Strongly Agree	High Extent
2.	Inadequate maintenance of ship machinery can lead to technical failures during operations.	3.55	Strongly Agree	High Extent
3.	Engine failure is a common cause of maritime incidents.	3.22	Agree	Moderate Extent
4.	Outdated or poorly functioning safety equipment compromises onboard safety.	3.48	Strongly Agree	High Extent
5.	Electrical system failures pose a serious risk to ship operations.	3.48	Strongly Agree	High Extent
6.	Lack of regular inspection of technical systems contributes to accidents at sea.	3.48	Strongly Agree	High Extent
7.	Poor design or construction quality of vessels increases accident risks.	3.18	Agree	Moderate Extent
8.	Inadequate technical support during voyages can delay response to mechanical issues.	3.22	Agree	Moderate Extent
9.	Failure of automated systems can lead to loss of vessel control.	3.26	Strongly Agree	High Extent
10.	Improper use or handling of onboard equipment can result in technical failures.	3.34	Strongly Agree	High Extent

Overall Mean:	3.36	Strongly Agree	High Extent

As shown in Table 3, the overall mean for the perception of the extent of the contributory factors to maritime accidents by the respondents, in terms of technical, is 3.36, which is *interpreted as a high extent* and described as strongly agree. The top-rated indicators with the highest mean scores are item 2, *inadequate maintenance of ship machinery can lead to technical failures during operations* with a mean of 3.55, and items 4, *outdated or poorly functioning safety equipment compromises onboard safety*, 5, *electrical system failures pose a serious risk to ship operations*, and 6, *lack of regular inspection of technical systems contributes to accidents at sea*, all with a mean of 3.48 and described as *strongly agree interpreted as high extent*. The least-rated indicator with a mean score below the overall mean is item 7, *poor design or construction quality of vessels increases accident risks*, with a mean of 3.18 and a rating of *agree, interpreted as a moderate extent*. Items 3 *(engine failure)* and 8 *(inadequate technical support during voyages) are common causes of maritime incidents*, with a mean of 3.22, and *are interpreted as having a moderate extent*. These results imply that the most critical technical concerns center on maintenance and inspection practices, underscoring the importance of proactive shipboard upkeep. In contrast, vessel design and voyage technical support are seen as less immediate risks but remain significant opportunities for improvement.

The findings are supported by International Maritime Organization (2020) that the total world fleet comprises 98,140 commercial ships with a gross tonnage (GT) of over 100. Of these, the number of gas carriers, oil tankers, bulk carriers, and container ships grew most rapidly over the year to 2020. Despite the advances in technology, processes, procedures, training, and regulations, a total of 193 vessels exceeding 100 GT were lost over the 3 years from 2017, mainly through sinking (62%), grounding (15%), fire/explosion (10%), machinery damage/failure (6%). The type of cargo and size of vessel have a significant impact on the extent and consequences of an accident at sea. Crude oil alone accounted for around 17–20% of total seaborne goods loaded between 2010 and 2019, and the annual volume of crude oil transported averages around 1,800 million metric tons. In addition to cargo type, the increasing size of vessels can affect safety, effective fire prevention, and salvage in the event of an accident, as highlighted by the recent case of the Ever Given wedged in the Suez Canal.

The findings are also supported by Puisa et al. (2018), who stated that serious maritime incidents and accidents remain widespread, with the last decade filled with dreadful calamities, not least the sinking of the cruise ship *Costa Concordia* and the ferry *MV Sewol*. The decades before were equally depressing, especially the MS *Herald of Free Enterprise capsize* in 1987 due to outdated functioning equipment and poor design features, causing the death of several crew and passengers. At the same time, the safety assurance on modern ships is getting more complicated, partly due to the conventional safety strategy *defence-in-depth* (Carroll, 1998), which requires redundancies and multiple layers of protection, and partly due to new digital technologies, e.g. dynamic barrier management (Pitblado et al., 2016), which introduces extra layers of defense, new interactions and weak couplings (Twomey, 2017).

Table 4

Perception on the Extent of the Contributory Factors to Maritime Accident by the Respondents in Terms of Environmental

	Indicators	Mean	Description	Interpretation
1.	Poor visibility due to fog or heavy rain increases the risk of collisions at sea.	3.20	Agree	Moderate Extent
2.	Rough sea conditions often contribute to navigation difficulties and accidents.	3.18	Agree	Moderate Extent
3.	Strong winds can cause loss of vessel stability or control.	2.96	Agree	Moderate Extent
4.	Sudden weather changes can catch the crew unprepared, increasing accident risks.	3.16	Agree	Moderate Extent
5.	Inadequate weather forecasting or monitoring leads to unsafe navigation decisions.	3.38	Strongly Agree	High Extent
6.	Strong currents or tides can affect vessel maneuverability and safety.	3.26	Strongly Agree	High Extent
7.	Navigating through narrow or congested waterways increases the risk of grounding or collision.	3.36	Strongly Agree	High Extent
8.	Natural obstacles such as icebergs or floating debris pose significant hazards to navigation.	3.26	Strongly Agree	High Extent
9.	Poor anchorage conditions during bad weather increase the likelihood of vessel drifting.	3.42	Strongly Agree	High Extent

10. Environmental factors are not always adequately considered in voyage planning.	2.86	Agree	Moderate Extent
Overall Mean:	3.20	Agree	Moderate Extent

As shown in Table 4, the overall mean for the perception of the extent of contributory factors to maritime accidents among respondents, in terms of environmental factors, is 3.20, which is *interpreted as a moderate extent*. The top-rated indicators with the highest mean scores are item 9, *poor anchorage conditions during bad weather increase the likelihood of vessel drifting*, with a mean of 3.42, and item 5, *inadequate weather forecasting or monitoring leads to unsafe navigation decisions*, with a mean of 3.38, both described as *strongly agree, interpreted as high extent*. The least rated indicators with mean scores below the overall mean are item 10, *environmental factors are not always adequately considered in voyage planning*, with a mean of 2.86, and item 3, *strong winds can cause loss of vessel stability or control*, with a mean of 2.96, both of which are described as *agree interpreted as a moderate extent*. These results imply that anchorage safety and reliable weather forecasting are the most pressing environmental concerns affecting maritime safety. Meanwhile, planning and control measures to address environmental unpredictability offer opportunities to improve maritime operations.

The findings are supported by Dominguez-Pery et al. (2021), who stated that in August 2020, Mauritius declared a state of environmental emergency after the MV Wakashio ran aground due to poor visibility at Pointe d'Esny, spilling oil into an area renowned as a sanctuary for rare wildlife. These types of accidents heighten concerns worldwide, as the damage to marine wildlife and the environment is graphically visible. However, while the frequency of maritime accidents may be declining, a single incident can have catastrophic and long-term consequences for marine ecosystems, the environment, and local economies (Roberts et al., 2002). The findings are also supported by Min and Oh (2024). They said that vessels usually anchor to secure their position at sea. When an external force, such as wind, acts on the vessel, anchors with chains resist the external force through friction on the seafloor. In typical cases, the external force and the frictional force are in equilibrium. However, when the external force increases, the anchors and chains receive upward forces derived from the catenary shape of the chain, so the frictional force due to the anchor and chains is reduced. Moreover, if the external force exceeds a threshold, the anchor and chains on the seafloor cannot play their role, and the anchor is eventually dragged.

Table 5

Perception on the Extent of the Contributory Factors to Maritime Accident by the Respondents in Terms of Operational

Indicators	Mean	Description	Interpretation
1. Inadequate voyage planning increases the risk of maritime accidents.	3.32	Strongly Agree	High Extent
2. Pressure to meet tight schedules often leads to unsafe operational decisions.	3.32	Strongly Agree	High Extent
3. Insufficient manning levels affect the safe operation of the vessel.	3.48	Strongly Agree	High Extent
4. Delays in cargo loading or unloading can compromise vessel stability and safety.	2.70	Agree	Moderate Extent
5. Poor coordination between ship and shore personnel can lead to operational errors.	3.30	Strongly Agree	High Extent
6. Lack of proper documentation and record-keeping affects operational safety.	3.16	Agree	Moderate Extent
7. Incomplete risk assessments before critical operations increase accident potential.	3.50	Strongly Agree	High Extent
8. Ineffective emergency drills reduce crew preparedness for real incidents.	3.46	Strongly Agree	High Extent
9. Non-compliance with safety management system (SMS) protocols contributes to unsafe operations.	3.50	Strongly Agree	High Extent
10. Frequent changes in crew disrupt operational continuity and safety practices.	2.96	Agree	Moderate Extent
Overall Mean:	3.30	Strongly Agree	High Extent

As shown in Table 5, the overall mean for the perception of the extent of the contributory factors to maritime accidents by the respondents in terms of operational is 3.30, which is described as *strongly agree and interpreted as high extent*. The top-rated indicators with the highest mean scores are item 7, *incomplete risk assessments before critical operations increase accident potential*, and item 9, *non-compliance with safety management system (SMS) protocols contributes to unsafe operations*, both with a mean of 3.50 and described as *strongly agree interpreted as high extent*. The least rated indicators with mean scores below the overall mean are item 4, *delays in cargo loading or unloading can compromise vessel stability and safety*, with a mean of 2.70, and item 10, *frequent changes in crew disrupt operational continuity and safety practices*, with a mean of 2.96, both described as *agree interpreted as moderate extent*. These results imply that the most significant operational risks are related to poor risk assessment and SMS non-compliance, which are critical to ensuring safety. In contrast, while still relevant, cargo handling delays and frequent crew changes are seen as less critical but present clear areas for operational improvement.

The findings are supported by Marine Accident Investigation Branch (2020) according to their accident narrative in the operation of ships' movable gantry cranes. The 2/O's lower left leg was crushed as he operated a rail-mounted crane with unguarded rotating machinery using its local controls. Operating the crane from the local controls in the pedestal was unsafe. The method of crane control used by Kommandor Orca's crew was contrary to the method stated in the manufacturer's manual, and the hazards of working at height and operating unguarded machinery had not been identified in the vessel's risk assessment. The crane operation manufacturer's manual stated that the crane was to be remotely controlled from either the bridge station or the wireless remote-control unit on the deck, and that the local hydraulic controls were for emergency use only. The mis-operation of the crane resulted in the amputation of the second officers' lower right leg below the knee. Batalden and Sydnes (2014) noted that the ISM Code originated from Resolution A.741(18) adopted by the 18th session of the IMO Assembly in 1993 and was later made mandatory through its inclusion in SOLAS Chapter IX. They explained that the Code provides a framework for establishing Safety Management Systems in shipping organizations to reduce accidents caused by human error. The authors highlighted that the ISM Code connects different organizational levels, from seafarers to company management and maritime administrations, to promote coordinated safety management. They also pointed out that, despite its implementation, serious accidents still occur, indicating ongoing challenges in addressing human factors and ensuring effective safety management.

Table 6

Perception on the Extent of the Contributory Factors to Maritime Accident by the Respondents in Terms of Structural and Design

	Indicators	Mean	Description	Interpretation
1.	Poor vessel design affects the ship's stability during adverse conditions.	3.28	Strongly Agree	High Extent
2.	Inadequate structural strength increases the risk of hull failure.	3.36	Strongly Agree	High Extent
3.	Defective watertight doors or bulkheads compromise the vessel's ability to withstand flooding.	3.52	Strongly Agree	High Extent
4.	Improper layout of machinery spaces hinders safe and efficient operations.	3.18	Agree	Moderate Extent
5.	Insufficient lifeboat or evacuation system design can delay emergency response.	3.40	Strongly Agree	High Extent
6.	Inaccessible emergency exits or escape routes pose safety hazards.	3.44	Strongly Agree	High Extent
7.	Poor visibility from the bridge affects navigational safety.	3.24	Agree	Moderate Extent
8.	Design flaws in cargo holds or tanks increase the risk of leakage or fire.	3.22	Agree	Moderate Extent
9.	Lack of anti-slip surfaces on decks increases the risk of crew injury and operational mishaps.	3.34	Strongly Agree	High Extent
10.	Inadequate noise and vibration insulation in crew areas affect alertness and overall safety.	3.18	Agree	Moderate Extent
	Overall Mean	3.32	Strongly Agree	High Extent

As shown in Table 6, the overall mean for the perception of the extent of the contributory factors to maritime accidents in terms of structural and design is 3.32, which is described as *strongly agree interpreted as high extent*. The top-rated indicators with the highest mean scores are item 3, *defective watertight doors or bulkheads compromise the vessel's ability to withstand flooding*, with a mean of 3.52, and item 6, *inaccessible emergency exits or escape routes pose safety hazards*, with a mean of 3.44, both described as *strongly agree interpreted as high extent*. The least rated indicators with mean scores below the overall mean are item 4, *improper* *layout of machinery spaces hinders safe and efficient operations*, and item 10, *inadequate noise and vibration insulation in crew areas affects alertness and overall safety*, both with a mean of 3.18 and described as *agree interpreted as moderate extent*. These results imply that critical structural safety features like watertight integrity and emergency accessibility are considered top concerns in vessel design. Meanwhile, internal layout and crew area comfort, although still relevant, are seen as lesser priorities and offer opportunities for design improvements to enhance operational efficiency and crew performance.

The findings are supported by Ruponen et al. (2022) who stated that the risk of ship flooding is known to be affected by numerous factors, with watertight door (WTD) status being one of those. The watertight doors are often mounted in the bulkheads dividing the ships into watertight (WT) compartments to limit the flooding extent in the event of an accident, so that sufficient stability and reserve buoyancy are achieved. Keeping these doors open longer than necessary for safe passage through them by crew compromises the watertight integrity of the ship. In the case of the *Stena Nautica* accident in 2004, the collision damage was limited to a single WT compartment. However, because of several open WTDs, the flooding progressed to several undamaged compartments, endangering ship stability. On the other hand, if work requires crew to frequently pass through the WTDs, there is a serious risk of injury when doors are frequently opened and closed. Normally at sea, all watertight doors should be closed, with so-called Category C doors opened only briefly for the safe passage of people. However, so-called Category "B" doors may be kept open for longer periods during navigation if work in the vicinity of the door requires it, as specified in IMO Circ. 1564. Furthermore, existing ships may have Category "A" WTDs, allowed to be permanently open at sea based on a so called floatability assessment, however, successful closing of open WTDs can be prevented by the deformation of bulkheads and decks as a result of structural damage suffered in the course of collision or grounding. The findings are also supported by Fang et al. (2023) when they said that as the number of tourists choosing water sightseeing increases, construction of passenger ships especially luxury cruises have become a major development trend. In this case, entertainment facilities onboard have gradually been enriched while most structures have increased in size and complexity, providing a more enjoyable experience to passengers. However, it often leads to a more complex layout, which may increase the evacuation risks, especially in an emergency. Therefore, to minimize the evacuation hazard, managers have to develop effective response plans for all possible emergencies.

Table 7

Perception of the Extent of the Contributory Factors to Maritime Accident by the Respondents in Terms of Management and Regulatory

Indicators	Mean	Description	Interpretation
1. Lack of enforcement of international maritime regulations increases the risk of accidents.	3.40	Strongly Agree	High Extent
2. Inadequate implementation of the Safety Management System (SMS) affects shipboard safety.	3.40	Strongly Agree	High Extent
3. Poor monitoring by flag states and port state control contributes to unsafe practices.	3.30	Strongly Agree	High Extent
4. Insufficient company support for crew training and development compromises safety standards.	3.36	Strongly Agree	High Extent
5. Delayed or incomplete audits and inspections reduce regulatory compliance.	3.28	Strongly Agree	High Extent
6. Failure of management to address reported safety concerns increases accident risks.	3.42	Strongly Agree	High Extent
7. Inadequate safety culture within the company affects crew behavior and decision-making.	3.28	Strongly Agree	High Extent
8. Lack of regular review and updating of safety procedures compromises operational safety.	3.24	Agree	Moderate Extent
9. Overemphasis on commercial performance over safety compliance contributes to unsafe conditions.	3.36	Strongly Agree	High Extent
10. Poor communication between ship management and crew leads to ineffective safety implementation.	3.40	Strongly Agree	High Extent
Overall Mean:	3.34	Strongly Agree	High Extent

As shown in Table 7, the overall mean for the perception of the extent of the contributory factors to maritime accidents in terms of management and regulatory is 3.34, which is described as *strongly agree interpreted as high extent*. The top-rated indicators with the highest mean scores are item 6, *failure of management to address reported safety concerns increases accident risks* with a mean of 3.42, and items 1, *lack of enforcement of international maritime regulations increases the risk of accidents*, 2, *inadequate implementation of the Safety Management System (SMS) affects shipboard safety*, and 10, *poor communication between ship management and crew leads to ineffective safety implementation*, all with a mean of 3.40 and described as *strongly agree interpreted as high extent*. The least rated indicators with mean scores below the overall mean are item 8, *lack of regular review and updating of safety procedures compromises operational safety* with a mean of 3.24, and items 5, *delayed or incomplete audits and inspections reduce regulatory compliance*, and 7, *inadequate safety culture within the company affects crew behavior and decision-making*, both with a mean of 3.28 and described as *strongly agree interpreted as high extent*. These results imply that addressing crew safety concerns and enforcing regulatory compliance are the most critical management responsibilities. In contrast, procedural updates and fostering a strong safety culture are slightly less emphasized, indicating opportunities for strengthening internal safety systems and organizational commitment to continuous improvement. The findings are supported by Perez et al. (2011) when they said that the tragedy of the Doña Paz sinking may have resulted from ships of questionable seaworthiness being manned by less-than-qualified mariners. These factors were compounded by an archaic communication system that contributed to the delay in response compounded by lax enforcement of existing laws. The shipping industry must make efforts to upgrade vessels and equipment in compliance with existing IMO regulations. The government must take a proactive stance and provide support to the industry while exerting its power to ensure that laws on maritime safety are strictly followed in accord with international standards.

The findings are also supported Xi et al. (2025) when they said that in order to reduce the frequency of human errors, in 1993, the International Maritime Organization (IMO) issued the International Safety Management Code (ISM) (IMO, 1993), which compels the shipping companies to establish a safety management system (SMS) to ensure safety by improving the behavior of ship officers. Although strengthening the safety management of shipping companies through the implementation of international conventions reduces the occurrence of unsafe human acts, at the same time, serious maritime accidents still occur occasionally (Altinpinar & Başar, 2022). Human factors still play an important role in today's maritime accidents (Erdem et al., 2021), and there is still a long way to go to improve ship officers' safety behavior. Darbra et al. (2007) found that factors such as commercial pressures have an impact on the safety culture of pilots, and the impact of safety culture on the safety behavior of crew members with specific backgrounds, such as pilots, passenger ship crew, container ship crew, etc.

Table 8

Perception of the Extent of the Contributory Factors to Maritime Accident by the Respondents in Terms of Piracy and Security Risks

Indicators	Mean	Description	Interpretation
1. Lack of onboard security measures increases vulnerability to piracy attacks.	3.42	Strongly Agree	High Extent
2. Inadequate crew training on anti-piracy procedures compromises vessel safety.	3.32	Strongly Agree	High Extent
3. Sailing through high-risk piracy zones heightens the risk of maritime incidents.	3.50	Strongly Agree	High Extent
4. Poor communication with coastal authorities reduces the effectiveness of security responses.	3.36	Strongly Agree	High Extent
5. Insufficient intelligence or updates on regional piracy threats exposes vessels to danger.	3.32	Strongly Agree	High Extent
6. Delayed response during security breaches can escalate the risk of accidents.	3.34	Strongly Agree	High Extent
7. Inadequate use of ship protection measures (e.g., razor wires, water cannons) compromises defense.	3.32	Strongly Agree	High Extent
8. Failure to follow Best Management Practices (BMP) for piracy-prone areas increases risk.	3.38	Strongly Agree	High Extent
9. Limited access to armed security personnel affects the vessel's preparedness for threats.	3.34	Strongly Agree	High Extent
10. Psychological stress caused by piracy threats impacts crew performance and decision-making.	3.38	Strongly Agree	High Extent
Overall Mean:	3.37	Strongly Agree	High Extent

As shown in Table 8, the overall mean for the perception of the extent of the contributory factors to maritime accidents by the respondents in terms of piracy and security risk is 3.37, which is described as *strongly agree interpreted as high extent*. The top-rated indicators with the highest mean scores are item 3, *sailing through high-risk piracy zones heightens the risk of maritime incidents*, with a mean of 3.50, and item 1, *lack of onboard security measures increases vulnerability to piracy attacks*, both *strongly agree interpreted as high extent*. The least rated indicators with mean scores below the overall mean are item 2, *inadequate crew training on anti-piracy procedures compromises vessel safety*, and item 5, *insufficient intelligence or updates on regional piracy threats exposes vessels to danger*, item 7, *inadequate use of ship protection measures (e.g., razor wires, water cannons) compromises defense,* with a mean of 3.32 and described as *strongly agree interpreted as high extent*. These results imply that navigating through piracy-prone areas and the psychological impact of security threats are perceived as the most significant concerns. Meanwhile, crew training and real-time intelligence, though still necessary, require enhanced focus to strengthen overall vessel security preparedness.

The findings are supported by Joubert (2023) when she said that Nigerian pirate groups operate and find safe haven in the Niger Delta with several crew members held in captivity in 2019. Crew from the bulk carrier *Bonita*, a very large crude carrier (VLCC) *Nave Constellation*, and the tanker *Duke*, among others were held captives in 2019. The findings are also supported by Berden, et al. (2021) when they said that the human cost of piracy is so high with seafarers being expose to a variety of psychological and physical dangers. In 2010, 1090 seafarers were taken hostage for an average duration of five months, with 488 suffering from physical abuse such as deprivation of food and torture, along with psychological abuse including solitary confinement and mock execution.

Table 9

Summary Table of the Perception on the Extent of the Contributory Factors to Maritime Accident

In terms of:	Mean	Description	Interpretation
• Human	3.48	Strongly Agree	High Extent
• Technical	3.36	Strongly Agree	High Extent
• Environmental	3.20	Agree	Moderate Extent
• Operational	3.30	Strongly Agree	High Extent
• Structural and Design	3.32	Strongly Agree	High Extent
• Management and Regulatory	3.34	Strongly Agree	High Extent
• Piracy and Security Risks	3.37	Strongly Agree	High Extent
Grand Mean:	3.34	Strongly Agree	High Extent

As indicated in Table 9, the overall mean of respondents' perceptions of the extent of the contributory factors to maritime accidents is 3.34, corresponding to a *strongly agree* rating and indicating a *high extent*. Among the indicators, the highest-rated factor is Human, with a mean of 3.48 and a description of *strongly agree* rating and indicating a *high extent*, followed by Piracy and Security Risks, which has a mean of 3.37 and a description of *strongly agree* rating and indicating a *high extent*, and Technical, with a mean of 3.36 and a description of *strongly agree* rating and indicating a *high extent*. On the other hand, the lowest-rated factor is Environmental, with a mean of 3.20 and a description of *agree*, indicating a *moderate extent*. These findings suggest that while human, technical, and security-related factors are perceived as the most critical contributors to maritime accidents, environmental factors may require less immediate attention but should still be considered in accident prevention strategies.

Relationship of the Respondents' Profile and Perceptions of the Extent of the Contributory Factors to Maritime Accidents by the Respondents

Table 10

Relationship of the Respondents' Profile and the Perception of the Extent of the Contributory Factors to Maritime Accident by the Respondents

Paired Variables	df	Computed Chi-Square Value	Critical Value	Decision on Ho	Significance
Age in relation to:					
• Human factors	4	11.765	9.488	Reject Ho	Significant (C=0.44, moderate)
• Technical factors	4	3.400	9.488	Failed to Reject Ho	Not Significant
• Environmental factors	4	6.780	9.488	Failed to Reject Ho	Not Significant
• Operational factors	4	0.694	9.488	Failed to Reject Ho	Not Significant

• Structural and design factors	4	4.165	9.488	Failed to Reject Ho	Not Significant
• Management and regulatory factors	4	1.010	9.488	Failed to Reject Ho	Not Significant
• Piracy and security risk factors	4	0.768	9.488	Failed to Reject Ho	Not Significant
Sea Experience in relation to:					
• Human factors	4	3.626	9.488	Failed to Reject Ho	Not Significant
• Technical factors	4	3.245	9.488	Failed to Reject Ho	Not Significant
• Environmental factors	4	8.260	9.488	Failed to Reject Ho	Not Significant
• Operational factors	4	3.245	9.488	Failed to Reject Ho	Not Significant
• Structural and design factors	4	1.049	9.488	Failed to Reject Ho	Not Significant
• Management and regulatory factors	4	1.354	9.488	Failed to Reject Ho	Not Significant
• Piracy and security risk factors	4	3.494	9.488	Failed to Reject Ho	Not Significant
Civil Status in relation to:					
• Human factors	1	0.005	3.841	Failed to Reject Ho	Not Significant
• Technical factors	1	2.193	3.841	Failed to Reject Ho	Not Significant
• Environmental factors	1	0.691	3.841	Failed to Reject Ho	Not Significant
• Operational factors	1	0.691	3.841	Failed to Reject Ho	Not Significant
• Structural and design factors	1	0.033	3.841	Failed to Reject Ho	Not Significant
• Management and regulatory factors	1	0.936	3.841	Failed to Reject Ho	Not Significant
• Piracy and security risk factors	1	0.017	3.841	Failed to Reject Ho	Not Significant
Educational Attainment in relation to:					
• Human factors	2	1.242	5.991	Failed to Reject Ho	Not Significant
• Technical factors	2	1.652	5.991	Failed to Reject Ho	Not Significant
• Environmental factors	2	4.122	5.991	Failed to Reject Ho	Not Significant
• Operational factors	2	1.652	5.991	Failed to Reject Ho	Not Significant
• Structural and design factors	2	1.652	5.991	Failed to Reject Ho	Not Significant
• Management and regulatory factors	2	2.087	5.991	Failed to Reject Ho	Not Significant
• Piracy and security risk factors	2	1.449	5.991	Failed to Reject Ho	Not Significant
Type of Vessel in relation to:					
• Human factors	5	8.976	11.070	Failed to Reject Ho	Not Significant
• Technical factors	5	10.166	11.070	Failed to Reject Ho	Not Significant
• Environmental factors	5	1.602	11.070	Failed to Reject Ho	Not Significant
• Operational factors	5	9.760	11.070	Failed to Reject Ho	Not Significant
• Structural and design factors	5	16.765	11.070	Reject Ho	Significant (C=0.50, moderate)
• Management and regulatory factors	5	6.030	11.070	Failed to Reject Ho	Not Significant
• Piracy and security risk factors	5	8.974	11.070	Failed to Reject Ho	Not Significant

Furthermore, the obtained Pearson's contingency coefficient (C = 0.44) indicates a moderate strength of association between age and human factors. This moderate relationship implies that while age does not determine perceptions of human contributory factors alone, it plays a substantial role alongside other variables, such as experience, training, rank, and exposure to operational hazards. Older seafarers may draw from accumulated sea experience and past accident encounters, leading to heightened awareness of human limitations and error-prone conditions. Conversely, younger personnel may perceive human factors differently, possibly underestimating their impact due to limited exposure or greater confidence in technical competence. Implications of this finding are significant for maritime safety management and policy development. First, it underscores the need for age-sensitive, experience-based training programs, particularly to address human factors such as fatigue management, bridge/engine room resource management, and error recognition. Training modules should be tailored to bridge generational differences in perception, ensuring that both younger and older seafarers develop a shared understanding of human vulnerabilities in complex maritime systems. Second, shipping companies and maritime authorities may consider integrating mentorship and cross-generational learning approaches, where senior crew members share experiential knowledge with younger personnel to strengthen safety culture. Lastly, this finding supports the inclusion of age as a relevant variable in human factor risk assessments and accident prevention strategies, reinforcing the importance of a systems-based and human-centered approach to reducing maritime accidents. *Type of vessel about structural and design factors*, with a computed chi-square value of 16.765, exceeding the critical value of 11.070, also resulting in the rejection of the null hypothesis and a significant relationship with a Pearson's contingency coefficient *C* of 0.50, described as *moderate*. This finding confirms that the type of vessel operated by respondents is significantly associated with how structural and design factors, such as structural failure, poor vessel design, ergonomic limitation, inadequate redundancy, compartmentalization, machinery layout, and safety system integration, are perceived to contribute to maritime accidents.

Funding: This research received no external funding
Conflicts of Interest: The authors declare no conflict of interest.
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