INTERNATIONAL MULTIDISCIPLINARY JOURNAL OF RESEARCH FOR INNOVATION, SUSTAINABILITY AND EXCELLENCE
Published by: RISEJOURNALS.ORG | Online ISSN: 3028-032X | Print ISSN: 3028-0370
VOLUME 3, ISSUE NO. 11

Identifying Human Factors In Maritime Accidents: Basis For Preventive Measures And Strategies

DOI: 10.5281/zenodo.19547914

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Abstract:

This study explores how crew experience affects human errors leading to maritime accidents, aiming to improve safety. The research examines cognitive, social, and organizational factors that contribute to accidents and whether these factors vary by age, experience, or vessel type. Using a mixed-methods approach, with survey questionnaire and interviews, most common human factors contributing to maritime accident are fatigue, memory lapses, ineffective communication, lack of social support, insufficient training, and complex procedures, alongside the severity of human factors. The study found no significant differences in accident causes based on demographics. However, fatigue, situational awareness, poor communication, and inadequate training were identified as key contributors to accidents across all crews. Furthermore, learning from past mistakes, strategies to leverage experience, influence of experience on decision-making, and effective strategies for maintaining safety and preventing errors are the preventive measures and strategies that could address the maritime accident associated with human factors. The study recommends better rest, training, and communication practices to enhance safety. These findings emphasize the need for consistent safety protocols and ongoing training in the maritime industry. Further research is needed to assess the long-term impact of these preventive measure.

Keywords: Human Factors, Maritime Accidents, Preventive Measures, Strategies

Introduction:

Nature of the Problem

Safety at sea is a major concern, as maritime accidents pose significant threats to both human life and the environment (Luo & Shin, 2019). With millions of tons of cargo and countless passengers being transported across the world's oceans daily, the maritime sector is crucial to global trade, transportation, and logistics (Mrozowska, 2021). However, human factors continue to be a significant contributor to marine accidents despite technological advancements (Coraddu et al., 2020).

The knowledge that human error remains a significant contributing factor to maritime accidents, despite advancements in navigation, communication, and vessel control systems, justifies a closer examination of the human aspects of maritime accidents. To handle the intricate interactions between technology, human operators, and the demanding marine environment, human-centered approaches to maritime safety have gained significance.

Current State of Knowledge

The study carefully examines the organizational, social, and cognitive factors that lead to mishaps in maritime environments. The study examines situational awareness, stress-induced decision-making, and the effect of training on skill development in the cognitive domain. The effects of social elements on marine safety are examined, including communication failures, cultural influences, and the impact of weariness on crew coordination. Another important area of focus for the study is organizational variables, including safety culture, regulatory compliance, and decisions

regarding training and resource allocation. The study aims to provide a comprehensive understanding of the human factors contributing to marine accidents by examining these three interrelated areas, offering insightful information to enhance safety protocols in the maritime sector.

As new technologies and automation continue to transform the maritime sector, it is also crucial to reassess their impact on human performance and decision-making. Given the dynamic nature of the maritime environment and the challenges associated with integrating cutting-edge technologies, the existing literature gap is even more pronounced.

By employing a human-centered approach to examine the various facets of human factors in maritime accidents, the study aims to bridge this gap. By doing so, the study will make a significant contribution to the existing research data, inform safety regulations and policies, and ultimately enhance maritime safety.
The proposed study aligns with several of the United Nations' Sustainable Development Goals (SDGs). Firstly, improving marine safety will reduce the frequency of maritime incidents, which in turn will minimize injuries and fatalities among seafarers, thereby directly contributing to Goal 3: Good Health and Well-being (Fernandez, 2020).

The study also pertains to Goal 9: Infrastructure, Industry, and Innovation. To strengthen the overall infrastructure of the marine sector and promote innovation in safety measures and technologies that enhance the efficiency and reliability of maritime operations, research is focusing on human aspects of maritime accidents (Wang et al., 2020).

Considering fewer maritime accidents help to preserve marine ecosystems, the research also promotes Goal 14: Life Below Water. Sea accidents can affect marine life and biodiversity by causing oil spills and other environmental risks. To mitigate these hazards and ensure the sustainable use of oceans, a human-centered approach to marine safety is crucial (Zhang et al., 2019).

In summary, the study highlights the importance of integrating sustainability principles into marine safety measures, benefiting both people and the environment. It is both academically significant and aligned with key Sustainable Development Goals (SDGs).

Theoretical Underpinnings

The study's foundation is the Swiss Cheese Model, a well-established theory in safety engineering and human factors developed by James Reason. The purpose of the model is to illustrate how a series of minor mistakes or failures can accumulate to cause accidents. Systems and failure-prevention measures are depicted in this approach as layers of slices that resemble Swiss cheese slices. According to Reason et al. (2006), each slice represents a defense against failure, and the holes in the slices stand for the defenses' shortcomings or vulnerabilities.

In the Swiss Cheese Model, the layers of slices represent the various defenses against failure in a system. These defenses include safety protocols, technology, human factors considerations, and organizational processes. Each slice is a barrier to prevent failures from progressing to an accident. However, holes in these slices symbolize vulnerabilities in the defenses.

Applying the Swiss Cheese Model to maritime accidents involves identifying the specific slices or layers within the maritime system. For example, slices may represent navigation protocols, communication procedures, equipment reliability, crew training, and other safety measures. The holes in these slices can then be linked to specific weaknesses or lapses in those areas.

Objectives

This study aimed to investigate the experience level of maritime crew members and the human errors that lead to accidents in order to enhance our understanding of the factors influencing safety in maritime operations.
Specifically, this study sought to answer the following questions:1) most common human factors that contribute to maritime accidents onboard in terms of cognitive, social, and organizational; 2) the level of severity of these human factors that contribute to maritime accidents onboard; 3) the significant difference in the common human factors that contribute to maritime accidents onboard as to age, years of experience, type of maritime vessel, and type of maritime

vessel; 4) significant difference in the level of severity that contributes to maritime accidents onboard according to age, years of experience, type of maritime vessel, and type of maritime vessel; and 5) the preventive measures and strategies could address the maritime accidents associated with human factors.

Methodology:

The study covers three parts: (1) Purpose of the Study and Research Design, (2) Method, (3) Statistical Treatment of Data, and (4) Ethical Consideration

Purpose of the Study

The purpose of this study is to investigate the level of experience among maritime crew members and the human errors that contribute to accidents, and to clarify the key factors that influence safety in maritime operations. Specifically, this study aims to identify the most common human factors contributing to maritime accidents onboard, categorized into cognitive, social, and organizational domains, and assess the severity of these factors.

The study also aims to investigate how these human factors vary in demographic and operational variables, such as age, years of experience, and type of maritime vessel. Additionally, it examines whether the severity of human factors varies significantly when categorized by these same variables. Ultimately, the study seeks to identify preventive measures and strategies that can mitigate maritime accidents caused by human error.

Research Design

Based on the purpose of the study, an explanatory sequential design was employed, a mixed-methods research approach that begins with the collection and analysis of quantitative data followed by qualitative data to further explain the initial findings(Toyon, 2021).
For the quantitative part, a descriptive-comparative research design was utilized through the use of surveys. This design provides a systematic framework for studying scientific problems by integrating both descriptive and comparative methodologies (Indu & Vidhukumar, 2019). It is widely applied across various fields, including education, where it is used to analyze and compare systems, policies, and outcomes (Egetenmeyer, 2020).

Meanwhile, for the qualitative part, a narrative research design was employed through in-depth interviews. This method involves collecting detailed, chronological accounts from respondents to gain deeper insights into their experiences (Faizin, 2020). The sample size for this phase is flexible, typically ranging from one to twenty-five participants, with data collected through one to three interviews per participant or until data saturation is achieved (Adhikari, 2022).

Method

The respondents of the study were the 30 seafarers (15 on deck, 15 at the engine) for the quantitative investigation, and (5) five seafarers or informants were purposively selected from the quantitative sample for in-depth interviews.

The study utilizes two data sources such as a survey questionnaire and an interview.
A researcher-structured survey questionnaire on common human factors in maritime accidents was administered to 30 seafarers (15 on deck and 15 at the engine) participating in the quantitative phase. This survey collected data on the profiles of respondents, their experience levels, and the human errors that led to accidents.
The survey questionnaire consisted of an introduction, demographic information, and common human factors. In the introduction, it is emphasized that the participation and insights of the respondents are valuable for researching and improving safety measures in the maritime industry. In the demographic information section, it entails age, gender, years of experience in the maritime industry, and type of maritime vessel. Common human factors encompass statements categorized as cognitive, social, and organizational factors. A 5-point Likert scale was used to interpret the

responses to the items. The respondents choose from 1 to 5 alternative responses according to which applied to them.

The in-depth interview provides rich insights into participant's perspectives on the experiences related to human errors and accidents. The content of this in-depth interview consisted of questions focusing on the crucial role in preventing errors as associated with cognitive, social, and organizational factors and the interview protocol.

Statistical Treatment of Data

Appropriate descriptive, inferential, and thematic analyses were utilized in this research.

Descriptive Statistics
Mean and Standard Deviation were used to determine the most common human factors contributing to maritime accidents onboard and the level of severity of these factors

One-way analysis of Variance was used to determine the significant differences in the most common human factors that contribute to maritime accidents onboard and the level of severity of these factors when grouped according to respondents' age, years of experience, and type of maritime vessel.
Moreover, to determine the significant differences in the most common human factors that contribute to maritime accidents onboard and the level of severity of these factors when grouped according to the type of marine seafarer, t-test for independent samples was used.

The qualitative data from the in-depth interviews was carefully analyzed using a thematic analysis. The process involved identifying recurring themes and patterns that emerged from the participants' shared experiences. Through their stories, the study aimed to uncover the underlying challenges, decision-making processes, and situations that often lead to human errors in maritime operations.
By exploring their personal insights, the thematic analysis provided a deeper and more nuanced understanding of their perspectives, enriching the overall interpretation of the research questions.

Ethical Consideration

In accordance with Republic Act 10173, also known as the Data Privacy Act of 2012, no identities were mentioned for privacy and confidentiality reasons. In addition, the research findings were reported accurately, transparently, and without data manipulation to avoid misinterpretation. Lastly, access to the data was exclusive only to the researchers and data analysts.

Results and Discussion

The most common factors contributing to maritime accidents onboard are shown in Table 2. Fatigue among crew members (M=4.9, SD=0.4)) tops the most common human factors, and the least is memory lapses and forgetting important procedures (M=4.5, SD=0.4) in the area of cognitive factors. In terms of social factors, ineffective communication between crew members (M = 4.8, SD = 0.4) is the most common factor, while the least common is the lack of social support among crew members (M = 4.3, SD = 0.4). Lastly, among the organizational factors, the most common human factor is insufficient training and education of crew members (M = 4.6, SD = 0.4). In contrast, the least common is complex or unclear procedures (M = 4.4, SD = 0.3).

Table 2
Most Common Human Factors that Contribute to Maritime Accidents Onboard.

Rank	Human Factors	Mean	Interpretation	SD
	Cognitive Factors	*4.7*	*Strongly Agree*	*0.4*
1	Fatigue among crew members is a significant contributor to maritime accidents.	4.9	Strongly Agree	0.4

2	Lack of situational awareness is a common cause of accidents on board.	4.8	Strongly Agree	0.2
3	Poor decision-making skills among crew members often lead to maritime incidents.	4.6	Strongly Agree	0.4
4	Inattention and distraction among crew members are significant factors in maritime accidents.	4.5	Strongly Agree	0.4
4	Memory lapses and forgetting important procedures contribute to onboard accidents.	4.5	Strongly Agree	0.4
	Social Factors	*4.6*	*Strongly Agree*	*0.4*
1	Ineffective communication between crew members contributes significantly to onboard accidents.	4.8	Strongly Agree	0.4
2	Poor leadership and supervision are critical factors in the occurrence of maritime accidents.	4.7	Strongly Agree	0.4
3	Lack of teamwork and collaboration is a major factor in maritime accidents.	4.5	Strongly Agree	0.4
3	Interpersonal conflicts among crew members often lead to disruptions and accidents	4.5	Strongly Agree	0.3
5	Lack of social support among crew members can increase stress and contribute to accidents.	4.3	Strongly Agree	0.4
	Organizational Factors	*4.5*	*Strongly Agree*	*0.4*
1	Insufficient training and education of crew members are primary contributors to accidents onboard.	4.6	Strongly Agree	0.4
2	A weak safety culture within the organization significantly increases the risk of maritime accidents.	4.5	Strongly Agree	0.6
2	Inadequate maintenance and poor equipment conditions contribute to accidents onboard.	4.5	Strongly Agree	0.2
2	High workload and stress levels among crew members are common factors in maritime accidents.	4.5	Strongly Agree	0.5
5	Complex or unclear procedures increase the likelihood of maritime accidents.	4.4	Strongly Agree	0.3

Legend: 4.21 – 5.00 Strongly Agree, 3.41 – 4.20 Agree, 2.61 – 3.40 Neutral, 1.81 – 2.60 Disagree, 1.00 – 1.80 Strongly Disagree

The study's findings align closely with those of the key informants, particularly in highlighting the most common factors contributing to maritime accidents onboard. The insights gathered from the qualitative interviews provide a deeper understanding of the quantitative data presented in Table 1. The key informants' experiences and strategies resonate with the identified human, social, and organizational factors, showcasing a comprehensive picture of the challenges and preventive measures within the maritime industry.

The study identifies fatigue as the top human factor contributing to maritime accidents, and the key informants' responses underscore this issue. Key Informant 4, who emphasized the importance of physical and mental

preparation, highlights the need to address fatigue in order to ensure high-quality work and safety. Key Informant 1's emphasis on experience and Confidence in handling tasks also implicitly underscores the necessity of being well-rested and alert to perform effectively.

While memory lapses are rated as the least common cognitive factor, they are still significant. Key Informant 5's emphasis on continuous monitoring and risk assessment suggests that maintaining constant vigilance and adhering to procedures are crucial to mitigating this issue. The practice of conducting regular drills, as mentioned by Key Informant 1, helps reinforce procedural memory and preparedness, reducing the likelihood of forgetting important steps.

Ineffective communication is highlighted as a major social factor, aligning with the key informants' emphasis on teamwork and open communication. Key Informant 1's advocacy for gathering ideas and suggestions from others highlights the importance of effective communication in ensuring safety. Similarly, Key Informant 2's mention of safety consciousness and a proactive attitude highlights the importance of clear communication in preventing accidents.

While the lack of social support is rated as a lesser factor, it still plays a significant role in maritime safety. Key Informant 4's approach to self-care and preparation highlights the need for a supportive environment where crew members can rely on one another. This sense of camaraderie and mutual support can help mitigate stress and improve overall safety.

The top organizational factor, insufficient training, is echoed in the informants' responses. Key Informant 5's emphasis on training, practice, and guidance for new members highlights the critical role of proper education in ensuring safety. The importance of continuous learning and staying updated with best practices, as mentioned by Key Informant 2, further aligns with the need for comprehensive training programs.

Although complex procedures are the least cited organizational factor, they are still relevant. Key Informant 3's recollection of stopping a cargo operation due to stability concerns reflects the importance of clear and understandable procedures in decision-making. Key Informant 4's proactive approach to safety, involving anticipation and mitigation of hazards, suggests that simplifying and clarifying procedures can enhance safety and prevent errors.

The alignment between the study results and the key informants' responses demonstrates the multifaceted nature of maritime safety. The quantitative data provides a broad overview of common factors, while the qualitative insights offer detailed, experience-based strategies for addressing these challenges. By integrating these perspectives, the study presents a comprehensive understanding of how human, social, and organizational factors interact and influence maritime safety.

1. Human Factors and Experience

The high rating of fatigue as a contributing factor is supported by the key informants' emphasis on physical and mental readiness. Ensuring crew members are well-rested and alert is crucial for effective performance and safety.

The importance of experience in preventing memory lapses and handling procedures efficiently is evident from the informants' focus on continuous learning and hands-on practice.

2. Social Factors and Communication

Effective communication is vital for preventing accidents, as highlighted by both the quantitative data and the informants' responses. Encouraging open dialogue and teamwork can significantly enhance safety.

Providing social support and fostering a supportive environment can help mitigate stress and enhance overall well-being, ultimately contributing to improved performance and safety.

3. Organizational Factors and Training

Comprehensive training and education are crucial for equipping crew members with the necessary skills and knowledge to perform their duties safely and effectively. The informants' emphasis on training and continuous learning underscores this need.

Simplifying procedures and ensuring they are clear and understandable can aid in decision-making and reduce the risk of errors, as highlighted by the informants' proactive safety measures.

Level of Severity of These Human Factors that Contribute to Maritime Accidents Onboard

Table 3 presents the severity levels of human factors contributing to maritime accidents onboard. Among the cognitive factors, fatigue among crew members (M = 4.8, SD = 0.3) and lack of situational awareness (M = 4.8, SD = 0.2) have the highest level of severity, while memory lapses and forgetting important procedures (M = 4.1, SD = 0.3) are the lowest. In terms of social factors, ineffective communication between crew members (M = 4.8, SD = 0.3) is the most severe, while the lack of social support among crew members (M = 4.0, SD = 0.7) is the least severe.

Lastly, among the organizational factors, insufficient training and education of crew members (M = 4.6, SD = 0.5) have the highest level of severity, while complex or unclear procedures (M = 4.0, SD = 0.1) have the lowest.

Table 3

Level of Severity of These Human Factors that Contribute to Maritime Accidents Onboard.

Rank	Human Factors	Mean	Interpretation	SD
	Cognitive Factors	4.5	Very High Severity	0.4
1	Fatigue among crew members	4.8	Very High Severity	0.3
1	Lack of situational awareness	4.8	Very High Severity	0.2
3	Inattention and distraction among crew members	4.5	Very High Severity	0.5
4	Poor decision-making skills among crew members	4.3	Very High Severity	0.5
5	Memory lapses and forgetting important procedures	4.1	High Severity	0.3
	Social Factors	4.4	Very High Severity	0.5
1	Ineffective communication between crew members	4.8	Very High Severity	0.3
2	Poor leadership and supervision	4.7	Very High Severity	0.4
3	Interpersonal conflicts among crew members	4.5	Very High Severity	0.5
3	Lack of teamwork and collaboration	4.1	High Severity	0.6
5	Lack of social support among crew members	4.0	High Severity	0.7
	Organizational Factors	4.3	Very High Severity	0.4
1	Insufficient training and education of crew members	4.6	Very High Severity	0.5
2	A weak safety culture within the organization	4.5	Very High Severity	0.6
3	Inadequate maintenance and poor condition of equipment	4.1	High Severity	0.1
3	High workload and stress levels among crew members	4.1	High Severity	0.3
5	Complex or unclear procedures	4.0	High Severity	0.6

Legend: 4.21 – 5.00 Very High Severity,3.41 – 4.20 High Severity, 2.61 – 3.40 Moderate Severity, 1.81 – 2.60 Low Severity, 1.00 – 1.80 Very Low Severity

The study's results, as shown in Table 3, highlight the severity of various human factors contributing to maritime accidents. The qualitative responses from key informants provide valuable insights that align closely with these quantitative findings, offering a deeper understanding of the impact of cognitive, social, and organizational factors on maritime safety.

The study identifies fatigue as having one of the highest levels of severity among cognitive factors. Key informant responses highlight this issue, particularly in terms of its impact on the ability to perform tasks effectively and safely. Key Informant 4 emphasized the importance of physical and mental preparation, which directly addresses the issue of fatigue. By ensuring that crew members are well-rested and alert, the risk of accidents due to fatigue can be significantly reduced.

The informants' experiences support the high severity of lack of situational awareness. Key Informant 3's decision to stop cargo operations upon noticing the ship's rolling due to a low GM highlights the critical role of situational awareness in preventing accidents. This response demonstrates how experienced mariners leverage their situational awareness to make informed decisions, thereby mitigating risks.

Although memory lapses are rated as having the lowest severity among cognitive factors, they are still a significant concern. Key Informant 5's emphasis on continuous monitoring and regular drills suggests that reinforcing procedural memory is crucial for safety. These practices help ensure that crew members remember and follow important procedures, reducing the likelihood of errors.

Ineffective communication is highlighted as the most severe social factor, which aligns with the key informants' emphasis on the importance of clear and effective communication. Key Informant 1's suggestion to gather ideas and suggestions from others highlights the importance of maintaining open communication channels. Similarly, Key Informant 2's emphasis on safety consciousness and proactive attitudes underscores the crucial role of communication in maintaining vigilance and preventing accidents.

While the lack of social support is rated as having the lowest severity among social factors, it still impacts safety. Key Informant 4's approach to self-care and preparation highlights the importance of a supportive environment. Ensuring that crew members have social support can help mitigate stress and improve overall performance, contributing to a safer working environment.

The high severity of insufficient training and education is mirrored in the informants' responses. Key Informant 5's emphasis on training, practice, and guidance for new members underscores the crucial role of proper education in ensuring safety. Continuous learning and staying current with industry standards, as noted by Key Informant 2, are essential for equipping crew members with the necessary skills to handle maritime challenges effectively.

Complex or unclear procedures are rated as having the lowest severity among organizational factors, yet they remain relevant. Key Informant 3's proactive decision-making during cargo operations reflects the importance of clear and understandable procedures. Key Informant 4's approach to anticipating and addressing potential hazards suggests that simplifying procedures can enhance safety and reduce the risk of errors.

The alignment between the study results and the key informants' responses demonstrates a consistent understanding of the severity of human factors contributing to maritime accidents. The quantitative data provides a broad overview, while the qualitative insights offer detailed, experience-based strategies for addressing these challenges.

1. Cognitive Factors and Experience

The high severity of fatigue and lack of situational awareness are supported by the informants' emphasis on physical and mental readiness, as well as the critical role of situational awareness in decision-making.

The importance of experience in preventing memory lapses and ensuring procedural adherence is evident from the informants' focus on continuous learning and regular drills.

2. Social Factors and Communication

Effective communication is vital for preventing accidents, as highlighted by both the quantitative data and the informants' responses. Encouraging open dialogue and teamwork can significantly enhance safety.

Providing social support and fostering a supportive environment can help mitigate stress and enhance overall well-being, ultimately contributing to improved performance and safety.

3. Organizational Factors and Training

Comprehensive training and education are crucial for equipping crew members with the necessary skills and knowledge to perform their duties safely and effectively. The informants' emphasis on training and continuous learning underscores this need.

Simplifying procedures and ensuring they are clear and understandable can aid in decision-making and reduce the risk of errors, as highlighted by the informants' proactive safety measures.

Table 4

One-way Analysis of Variance (ANOVA) results of human factors that contribute to maritime accidents when classified according to their age, years of experience, and type of maritime vessel.

Variable	Sum of Squares	df	Mean Square	F	Sig.
Age					

Between Groups	0.924	2	.045	0.93	.750
Within Groups	0.346	27	.072		
Total	1.167	29			
Years of experience					
Between Groups	0.006	2	.010	0.12	.832
Within Groups	1.169	27	.039		
Total	1.175	29			
Type of maritime vessel					
Between Groups	0.131	2	.065	1.24	.354
Within Groups	1.044	27	.039		
Total	1.175	29			

p<0.05, significant

Table 5 presents the t-test results for independent samples on the human factors contributing to maritime accidents, classified by the type of marine seafarer. The results reveal that there is no significant difference in the human factors contributing to maritime accidents between deck (M = 4.5) and engine (M = 4.4) seafarers, t(28) = -0.16, p = .860.

Table 5

t-test for Independent Samples: Results of Human Factors Contributing to Maritime Accidents When Classified according to the type of marine Seafarerr.

Variable	**M**	**t-value**	**df**	**Sig. (2-tailed)**
Deck	4.5	-0.16	28	.860
Engine	4.4			

P<0.05, significant

The results of the study, as shown in Tables 4 and 5, indicate that there are no significant differences in the human factors contributing to maritime accidents when classified by age, years of experience, type of maritime vessel, or type of marine seafarer. This was determined through One-way Analysis of Variance (ANOVA) and T-tests for Independent Samples. The qualitative responses from key informants corroborate these findings, suggesting that the key issues affecting maritime safety are universally recognized across different demographic and role classifications within the maritime industry.

The absence of significant differences in human factors by age suggests that issues such as fatigue, situational awareness, and communication are pervasive across all age groups within the maritime workforce. The key informants' responses support this finding, as their experiences and strategies for preventing accidents are universally applicable across all age groups. For instance, Key Informant 4's emphasis on physical and mental preparation, as well as Key Informant 1's focus on continuous learning and experience, are relevant to seafarers of all ages. These strategies are essential for ensuring safety and apply to all age groups.

Similarly, the study found no significant differences in human factors based on the number of years of experience. This finding aligns with the key informants' responses, indicating that the challenges and preventive measures are consistent across different experience levels. For example, Key Informant 2's emphasis on staying updated with best practices and industry standards and Key Informant 5's focus on training and guidance for new members highlight the importance of continuous learning and adherence to safety protocols, regardless of the seafarer's experience level. These practices help ensure that both novice and veteran seafarers can effectively mitigate risks and prevent accidents.

The lack of significant differences in human factors by the type of maritime vessel suggests that the core safety issues are common across different vessel types. The key informants' responses indicate that the principles of safety, such as effective communication, situational awareness, and proper training, are universally applicable. Key Informant 3's proactive decision-making during cargo operations and Key Informant 4's proactive safety approach

highlight the importance of these universal safety measures. Regardless of the type of vessel, ensuring clear procedures, conducting regular drills, and fostering a culture of safety are critical to preventing accidents.

The t-test for Independent Samples reveals no significant difference in human factors between deck (M=4.5) and engine (M=4.4) seafarers. This finding is supported by the key informants' experiences, which suggest that the challenges and strategies for ensuring safety are similar across different roles within the maritime industry. Key Informant 1's and Key Informant 5's emphasis on training and preparedness, as well as Key Informant 2's focus on safety consciousness, indicate that both deck and engine seafarers face similar safety issues and must adopt comparable preventive measures. The uniformity of these strategies across different roles underscores the shared nature of the challenges faced by all seafarers.

The alignment between the study results and the key informants' responses demonstrates that the critical human factors contributing to maritime accidents are consistent across different demographic and role classifications. The quantitative data provides a broad overview, while the qualitative insights offer detailed, experience-based strategies for addressing these challenges.

1. Universality of Human Factors

The study reveals that human factors, including fatigue, situational awareness, and communication issues, are universally significant, regardless of age, experience, or vessel type. The key informants' emphasis on preparedness, continuous learning, and effective communication reinforces the importance of these factors.

2. Consistent Safety Strategies

The absence of significant differences in human factors based on demographics and roles suggests that the same safety strategies are effective across the board. The key informants' focus on training, situational awareness, and proactive safety measures highlights the universal applicability of these strategies.

3. Holistic Approach to Maritime Safety

The integration of qualitative and quantitative data highlights the importance of a holistic approach to maritime safety. By focusing on common human factors and implementing universal safety measures, the maritime industry can enhance overall safety and reduce the incidence of accidents.

Significant Difference in the Level of Severity that Contribute to Maritime Accidents Onboard According to Categories

There is no significant difference in the level of severity of human factors contributing to maritime accidents when classified by age, $F(2,27) = 0.23$, $p = .834$. There is also no significant difference in the level of severity when classified by years of experience ($F(2,27) = 0.08$, $p = .715$). Lastly, there was no significant difference in the level of severity when classified according to their type of maritime vessel, $F(2,27) = 1.64$, $p = .674$. These were analyzed using One-way Analysis of Variance (ANOVA) and presented in Table 6.

Table 6

One-way Analysis of Variance (ANOVA) results of the level of severity of human factors that contribute to maritime accidents when classified according to their age, years of experience, and type of maritime vessel.

Variable	Sum of Squares	df	Mean Square	F	Sig.
Age					
Between Groups	0.200	2	.003	0.24	.83
Within Groups	1.181	27	.018		
Total	1.037	29			
Years of experience					
Between Groups	0.006	2	.003	0.05	.71
Within Groups	1.169	27	.043		
Total	1.175	29			
Type of maritime vessel					

Between Groups	0.131	2	.065	1.64	.674
Within Groups	1.044	27	.039		
Total	1.175	29			

p>0.05, significant

The t-test for Independent Samples results in the level of severity of human factors contributing to maritime accidents when classified by the type of marine seafarer. It reveals that there is no significant difference in the level of severity of human factors that contribute to maritime accidents between deck (M=4.6) and engine (M=4.5) seafarers, t (28)=-0.27, p=.621.

Table 7

The t-test for Independent Samples results in the level of severity of human factors contributing to maritime accidents when classified by the type of marine seafarer.

Variable	**M**	**t-value**	**df**	**Sig. (2-tailed)**
Deck	4.6	-0.27	28	.621
Engine	4.5			

p>0.05, significant

The study's results, as shown in Tables 6 and 7, reveal no significant differences in the level of severity of human factors contributing to maritime accidents when classified by age, years of experience, type of maritime vessel, or type of marine seafarer. This was determined through One-way Analysis of Variance (ANOVA) and t-tests for Independent Samples. The qualitative responses from key informants further support these findings, suggesting a universal recognition of the severity of human factors across different demographic and professional classifications within the maritime industry.

The study reveals no significant difference in the severity of human factors contributing to maritime accidents when classified by age. This suggests that the perceived severity of factors such as fatigue, lack of situational awareness, and ineffective communication are consistent across all age groups within the maritime workforce. Key informants' responses echo this sentiment. For example, Key Informant 4's emphasis on physical and mental preparation underscores that fatigue and situational awareness are significant concerns for seafarers of all ages. Similarly, the need for continuous learning and experience, as emphasized by Key Informant 1, is relevant to ensuring safety regardless of age.

The absence of significant differences in the level of severity based on years of experience aligns with the informants' responses. This indicates that challenges such as fatigue, communication issues, and situational awareness are equally severe for both novice and veteran seafarers. Key Informant 2's emphasis on staying updated with best practices and Key Informant 5's focus on training and guidance for new members underscore the importance of addressing these issues consistently across different experience levels. The need for continuous improvement and adherence to safety protocols is crucial for preventing accidents, regardless of a seafarer's tenure.

The study also reveals no significant difference in the level of severity of human factors by the type of maritime vessel. This suggests that the core safety issues are similarly severe across different types of vessels. Key informants' experiences support this finding. For instance, Key Informant 3's decision-making during cargo operations reflects the importance of situational awareness and effective communication, regardless of the vessel type. Similarly, Key Informant 4's proactive safety approach, along with the emphasis on regular drills and clear procedures, highlights the need for universal safety measures across all types of maritime vessels.

The t-test for Independent Samples shows no significant difference in the level of severity of human factors between deck (M=4.6) and engine (M=4.5) seafarers. This finding is corroborated by the key informants' responses, indicating that the severity of issues like fatigue, situational awareness, and communication problems is perceived similarly by both deck and engine seafarers. Key Informant 1's and Key Informant 5's emphasis on training, preparedness, and effective communication highlights that these safety measures are crucial for all seafarers, regardless of their specific roles. The shared recognition of the severity of these issues underscores the need for consistent safety practices across various maritime roles.

The alignment between the study results and the key informants' responses demonstrates a consistent understanding of the severity of human factors contributing to maritime accidents across different demographic and professional classifications. The quantitative data provides a broad overview, while the qualitative insights offer detailed, experience-based strategies for addressing these challenges.

1. *The universality of Severity in Human Factors*

The study demonstrates that the severity of human factors, including fatigue, situational awareness, and communication issues, is universally recognized, regardless of age, experience, or vessel type. The key informants' emphasis on preparedness, continuous learning, and effective communication reinforces the importance of addressing these factors across the board.

2. *Consistent Safety Strategies*

The absence of significant differences in the severity of human factors based on demographics and roles suggests that the same safety strategies are effective across all demographics and roles. The key informants' emphasis on training, situational awareness, and proactive safety measures underscores the importance of consistently applying these strategies to mitigate risks and prevent accidents.

3. *Holistic Approach to Maritime Safety*

The integration of qualitative and quantitative data underscores the importance of a holistic approach to maritime safety. By focusing on common human factors and implementing universal safety measures, the maritime industry can improve overall safety and reduce the incidence of accidents. The key informants' experiences offer practical, experience-based insights that complement the statistical data, reinforcing the need for a comprehensive approach to maritime safety.

Conclusions

The study on human factors contributing to maritime accidents provides valuable insights into the critical safety challenges faced by the maritime industry. Through a combination of descriptive, inferential data, and thematic analyses, several key conclusions are advanced:

The research underscores that factors such as fatigue, lack of situational awareness, ineffective communication, and insufficient training are universally recognized as significant contributors to maritime accidents. These factors were consistently highlighted across both quantitative data analysis and qualitative insights from key informants.

The study found no significant differences in the occurrence or severity of human factors contributing to maritime accidents based on demographic factors, such as age and years of experience, or professional factors, including the type of maritime vessel and the type of marine seafarer. This study suggests that safety challenges are pervasive and equally impactful across different segments of the maritime workforce.

The uniform recognition of critical human factors underscores the importance of implementing consistent and comprehensive safety strategies across the maritime industry. Strategies should focus on mitigating fatigue through proper rest and scheduling practices, enhancing situational awareness through training and technology, improving communication protocols among crew members, and ensuring rigorous training and education programs.

By integrating quantitative data analysis with qualitative insights from key informants, the study provides a holistic understanding of safety issues in maritime operations. The qualitative data enriches the findings by offering practical, experience-based perspectives on the implementation and effectiveness of safety measures.

Acknowledgment

I would like to extend my heartfelt appreciation to my beloved Administrator, Engr. Roberto Neal S. Sobrejuanite, whose unwavering support and encouragement have been invaluable throughout this research.

My sincere gratitude goes to my research adviser, C/M John Erll Destacamento, PhD., for his expert guidance and mentorship.

I am also deeply grateful to Dr. Geneva Eler, Dean of the JBLFMU Graduate School, for her wisdom and leadership.

Special thanks to my co-teachers, Dr. Ruby Causing, Dr. Joecil Solidarios, Ms. Joanna Gudio, MAEd, C/M Alex Tan, and 2M Cesar Chin, for their time and effort in validating my survey forms and interview guide questions. Your insights and support have been integral to the success of this study. Thank you all for your contributions.

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