Original Article

AN EVALUATION OF HAZARD ANALYSIS AND PERSONAL PROTECTIVE EQUIPMENT IN MITIGATING MARITIME ACCIDENTS IN TANZANIA

Joseph Baraka Mtemvu and Samuel Tunde Adebayo

Department of Maritime Studies Dar es Salaam Maritime Institute 19 Sokoine Drive, Dar es Salaam P.O. Box 6727, Dar es Salaam, Tanzania
DOI: https://doi.org/10.5281/zenodo.17046078

Abstract: The maritime sector in Tanzania, particularly along the Dar es Salaam–Zanzibar route, continues to face significant safety challenges despite the widespread use of personal protective equipment (PPE) and hazard analysis protocols. This study investigates the effectiveness of PPE application and hazard identification within this context, employing a Human Factors Engineering approach to examine crew behaviors and risk perceptions that contribute to marine incidents. Findings reveal that improper use and selection of PPE, influenced by factors such as comfort, training, environmental conditions, and communication gaps, significantly undermine safety measures. Notably, workers often remained exposed to hazards despite wearing PPE due to inadequate hazard recognition, while the absence of PPE during extreme conditions like heat stress led to increased accident rates. The study highlights a critical gap in the maritime safety framework where overemphasis on PPE and hazard analysis alone fails to address the complex human and operational factors at play. Consequently, the research advocates for an integrated safety strategy that balances technological, regulatory, and human-centered interventions. Effective PPE usage, combined with comprehensive training and improved hazard awareness, is essential for reducing maritime accidents and ensuring the long-term sustainability of Tanzania's marine transport industry.

Keywords: Maritime Safety, Personal Protective Equipment, Human Factors, Hazard Analysis, Tanzania Marine Sector

1 Introduction

The maritime industry in Tanzania, particularly the vessel operations from Da es Salaam to Zanzibar, encounters significant challenges in ensuring the safety of its workforce and preventing potential accidents (Bowo and Furusho, 2018). Despite the wide adoption of PPE and ongoing hazard analysis, there are persistent gaps in the effective implementation of these safety measures, resulting in continued maritime accidents and serious threats to those involved in maritime activities. These accidents not only risk lives but also wield significant financial impacts and can tarnish the reputation of the maritime industry. Chen and Demachi (2021a) proposed the

Original Article

approach that can identify hazards of improper use of PPE with high precision (94.47%) and recall rate (83.20%) in construction sites with real-time performance (15.62 FPS on average). Hazard analysis serves as a systematic approach to identify potential dangers and implement measures to prevent accidents, while PPE acts as a crucial barrier between workers and hazardous elements, providing a last line of defense when other controls fail to eliminate risks.

The evolution of PPE has seen it become an integral part of safety proto- cols across various sectors, including maritime activities. Personal protective equipment (PPE) reduces workplace injuries and illnesses by providing protection for various body systems, but it cannot replace engineering controls and must be maintained for effective protection (Garrigou et al, 2020).

Personal Protective Equipment (PPE) usage on board ships can reduce accidents, but proper usage is crucial for preventing accidents particularly those involving hazardous chemicals, the correct selection and use of PPE by emergency personnel are paramount (Husna et al, 2020). Near-miss reports from oil tanker ships reveal that proper housekeeping, equipment failure, and PPE usage are key to reducing near-misses and improving safety management (Hasanspahic´ et al, 2022) .The use of PPE is influenced by a variety of factors including individual perceptions of hazards, demographic factors, barriers to usage, comfort, training, environmental conditions, and the need for effective communication and training to ensure proper use in emergencies (Rabajczyk and Wolan´ski, 2023; A et al, 2023) .

The maritime sector's safety measures, relying on Personal Protective Equipment (PPE) and hazard analysis, have shown shortcomings in preventing incidents. Instances of workers being exposed to chemicals despite PPE due to inadequate hazard identification (Rabajczyk and Wolan´ski, 2023) and accidents from not wearing PPE in extreme conditions like heat stress highlight the gaps. Moreover, incidents occurred due to unsuitable PPE selection for high hazard levels (Youssef et al, 2023).To enhance safety, a comprehensive assessment considering specific hazards, environmental conditions, and potential worker exposure levels during maritime accidents, especially those involving hazardous chemicals, is crucial (Zampeta and Chondrokoukis, 2022) . This approach can address the deficiencies observed and improve the effectiveness of PPE in safeguarding maritime workers.

There is an urgent need to prioritize the correct selection of equipment, adequate training, and efficient emergency response procedures. Additionally, the public's reaction to chemical accidents, especially their methods of sheltering, needs to be improved to prevent further casualties.

This study aims to evaluate the current state of hazard analysis and the usage of personal protective equipment in the Tanzanian maritime industry, with a particular focus on the vessel operations between Da es Salaam and Zanzibar. By acknowledging the existing gaps and identifying areas for improvement, the study seeks to effectively prevent maritime accidents while ensuring the safety and well-being of personnel on board. This will be achieved by assessing and analyzing crew behavior using Human Factors Engineering to determine the most hazards associated with maritime accidents due to poor use of personal protective equipment.

This study has five parts: *Introduction*: This study discusses how PPE prevents maritime accidents in Tanzania. *Literature review*: PPE studies in maritime activities are examined: *Methodology: The* study's methodology includes participant selection, data collection, and statistical techniques like regression analysis, ANOVA, and IBM-SPSS. *Results:* Provides datadriven insights on participant characteristics, marine hazards, their effects, and

Original Article

PPE importance. *Conclusion:* PPE is important, and this study suggests increasing safety measures. It also suggests further research.

1.1 Problem statement

Maritime industries are prone to significant hazards, leading to serious accidents that endanger personnel safety, assets, and the environment. Humans cause 80%–96% of maritime accidents worldwide (Zhao et al, 2023). African and East African marine accidents ranging from minor injuries to fatalities and small damages to catastrophic losses. From 2010 to 2019, Nigeria had 552 ship and boat capsizing or collision deaths in inland seas, averaging 55 per year. Despite Kenya Maritime Authority safety procedures, rivers surge in the rainy season, causing accidents. Southern Lake marine accidents in Tanzania kill 217 people per 100,000.

While safety regulations exist, gaps in effective safety management processes persist, emphasizing the need for improved safety culture, training, and compliance with procedure (Lin and Yau, 2023; Kasyk et al, 2023a). Studies on commercial fishing incidents highlight the importance of vessel stability, navigation decisions, and survival equipment policies in mitigating fatalities and preventing nonfatal injuries (Kincl et al, 2023). Enhancing the implementation of Personal Protective Equipment (PPE) and conducting thorough hazard analysis are crucial steps to address these gaps and enhance safety measures in maritime industries.

In the maritime sector of Tanzania, particularly in vessel operations between Dar es Salaam and Zanzibar, safety challenges persist due to inadequate implementation of safety measures despite the adoption of PPE and hazard analysis (Mbije, 2023). The study on marine accidents emphasizes the importance of understanding the causes and risks of maritime accidents to enhance shipping sustainability (Kasyk et al, 2023b). Furthermore, the Zanzibar seaweed industry faces profitability challenges, partly due to the absence of industry policies and strategies, which could also impact safety measures in maritime activities in the region (Burra and Ushadevi, 2022). To address these safety concerns, there is a need for improved safety culture, training, and awareness to prevent accidents and ensure the well-being of maritime personnel. Strengthening regulatory enforcement and promoting compliance with safety protocols are crucial steps to mitigate risks and enhance maritime safety in Tanzania's operations (Burra and Ushadevi, 2022).

This study aimed to assess and analyze the current state of hazard analysis and PPE utilization within the Tanzanian maritime industry, particularly focusing on vessel operations between Da es Salaam and Zanzibar. By identifying the existing gaps and potential areas for improvement, the study intends to devise strategies that can prevent maritime accidents and improve safety measures. The assessment involves the analysis of crew behavior using Human Factors Engineering to identify the most hazardous situations associated with maritime accidents due to inadequate use of PPE.

2 Literature Review

2.1 Hazard Analysis in Maritime Industries

Hazard analysis plays a crucial role in maritime industries, as highlighted in various studies. For instance, the authors of"A novel cyber-risk assessment method for ship systems" emphasize the significance of hazard identification and assessment in mitigating maritime risks and preventing accidents (Kasyk et al, 2023c) . They introduce a new approach, FMECAATT&CK, for evaluating cybersecurity risks in ship systems. Similarly, the study"Validation of risk analysis for ship collision in narrow waters by using fuzzy Bayesian networks approach"

Original Article

stresses the importance of risk analysis in maritime safety (Mole´, 2024) . It proposes a method for validating risk analysis outcomes, specifically focusing on ship collision risks in narrow waters. These research efforts underscore the critical need for robust hazard analysis and risk assessment methodologies to enhance safety measures in the maritime sector.

A range of hazard analysis techniques are employed in maritime risk assessment, including Quantitative Risk Assessment (QRA) methods, Probabilistic Safety Assessment (PSA), Computational Fluid Dynamics (CFD), Geographic Information Systems (GIS), Remote sensing technologies, Predictive analytics, Machine learning models, Human Factors Engineering, and Virtual Reality (VR) and Augmented Reality (AR) (Prilana et al, 2021; Arici et al, 2020; Goerlandt et al, 2019). These techniques are used to prevent collisions, grounding, and capsizing, and to assess crew behavior, human performance, and the utilization of Personal Protective Equipment (PPE). They also help in identifying high-risk areas, real-time monitoring, continuous risk assessment, and anticipating future incidents.

Table 1: Hazards Analysis Techniques in Maritime Risk Assessment

S/no	Techniques	Possible Maritime Accident	Source or Refer- ence
1	Quantitative Assessment methods	Risk Collisions, grounding, capsizing Safety	(QRA) (Prilana et al, 2021; Golestani et al, 2020)
2	Probabilistic Assessment (PSA)		(Prilana et al, 2021; Golestani et al, 2020)
3	Computational Fluid Dynamics (CFD)	Identifying high-	(Prilana et al, 2021)
4	Geographic Information Systems (GIS)	risk areas Real-time moni- toring	(Prilana et al, 2021; Ehlers et al, 2022
Techniques	Possible Maritime Accident		Source or Refer- ence
5	Remote Sensing Tech- nologies	Continuous risk assessment	(Prilana et al, 2021; Ehlers et al, 2022)
Predictive Analytics	Predicting future incidents		(Prilana et al, 2021; Golestani et al, 2020)
Machine Learning Models	Assessing utilization	PPE	(Prilana et al, 2021; Goerlandt et al, 2019) (Prilana et al, 2021; Golestani et al, 2020; Arici et al, 2020; A et al, 2023)
Human Factors Engi- neering	Analyzing behavior	crew	(Prilana et al, 2021; Golestani et al, 2020; Ehlers et al, 2022)
Virtual Reality (VR) and Augmented			

Original Article

Reality (AR)
Assessing human performance

2.2 Utilization of PPE in Maritime Operations

The application and efficacy of Personal Protective Equipment (PPE) in maritime operations is a topic that has been extensively covered in numerous studies and literature. One such study, conducted by Husna et al (2020), delved into the usage of PPE across a multitude of sectors. The results of this comprehensive study revealed that, while the use of PPE has become an accepted standard, there are still noticeable gaps in its effective implementation. These gaps are often a result of factors such as the improper selection of equipment and a lack of adequate training provided to the users of the PPE (Chen and Demachi, 2021a). The insights from this research are particularly relevant to the maritime industry in Tanzania. A deeper analysis of these challenges and deficiencies in the use of PPE can provide valuable information about the current state of the industry. This, in turn, can guide the development of more effective strategies for the implementation of PPE in the Tanzanian maritime industry, potentially leading to improvements in safety and accident prevention.

2.3 Human Factors Engineering in Maritime Accidents

The field of Human Factors Engineering (HFE) plays a crucial role in under- standing and preventing maritime accidents by focusing on the interactions between humans and their working environment. Various studies emphasize the significance of human factors in maritime safety, such as crew behavior and the use of Personal Protective Equipment (PPE) (A et al, 2023)

. Research has shown that behavioral factors, like crew members' adherence to safety protocols, are key contributors to accidents at sea. By utilizing HFE principles, researchers aim to identify and address hazardous situations in maritime operations, ultimately enhancing safety measures. This approach is essential for developing effective solutions to mitigate risks and improve overall safety in the maritime industry (Brcko et al, 2023).

2.4 Safety Measures in Tanzanian Maritime Industry

The Tanzanian maritime industry is a remarkably under-researched area, lending a unique and profound significance to this particular study. The scarcity of research specifically focusing on this industry in Tanzania renders our work not just novel, but an important contribution to the field. Despite the limited number of studies concentrating on the Tanzanian maritime industry, it is valuable to consider and draw insights from research conducted on analogous industries in differing regions. One such pertinent study, conducted by Mwendapole and Jin (2021) , explored the maritime industry in Tanzania includes Dar es Salaam, Tanga and Mtwara seaports This particular study provided substantial insights, predominantly revealing that the key to ensuring the successful implementation of safety measures lies in the provision of continuous training and the execution of regular safety audits. This finding can be used as a benchmark, offering a potentially effective approach to enhancing safety measures within the Tanzanian maritime industry.

2.5 Strategies for Improvement

A multitude of research studies have been conducted with the aim of proposing robust strategies for enhancing safety within the realm of maritime industries. One research paper of particular significance, authored by Wang et al (2020), advocated for an intricate, multi-faceted approach. This approach encompasses several strategic elements, starting with comprehensive training programs designed to equip workers with the necessary skills and

Original Article

knowledge to identify and mitigate risks. It goes on to include the implementation of regular safety audits, which are crucial for monitoring compliance with safety regulations and identifying areas of improvement. Furthermore, the study emphasizes the critical role of the proper selection and use of personal Protective Equipment (PPE), which serves as the last line of defense against occupational hazards. Not to be overlooked is the importance of effective hazard analysis, a preemptive measure that allows for the identification of potential risks before they materialize into incidents. The insights and recommendations from this study are not only valuable but will be instrumental in devising comprehensive and effective strategies to address the identified gaps within the Tanzanian maritime industry, improving safety measures, and ultimately safeguarding the lives of those working in this critical sector.

The study's conceptual framework measures the presence, use, maintenance, and storage of Personal Protective Equipment (PPE). It also evaluates competence in PPE training through metrics like demonstration, hygiene procedures, and replacement procedures. The study identifies hazards that can be minimized with effective use of PPE and training, including chemical, physical, electric, and mechanical hazards (Loibner et al, 2019). The study hypothesizes that effective use of these predictors can reduce maritime accidents. Chemical hazards include exposure to substances like cleaning sol- vents, detergents, fuel, welding fumes, paints, pesticides, and fumigants used onboard ships. Physical hazards include exposure to UV radiation, microwave electromagnetic fields from ship radar and communication equipment, vibration due to ship movement, and extreme weather conditions (Lucas et al, 2022; Chen and Demachi, 2021b). Electrical hazards involve risks related to electrical systems on vessels, such as burns, electrocution, arc flash, and electric shocks. Mechanical hazards refer to accidents caused by moving parts and dangerous surfaces, as well as falls, slips, trips, and twists.

The conceptual framework Figure 1 entails that independence variables of the study was measured based on presence of PPE, use of PPE, maintenance of PPE, storage of PPE. Another variable in the study was competence of training on PPE was measured with metrics such as demonstration, hygiene procedures, and replacement procedures. Finally, the study measured the haz- ard that can be minimized with the effective use of PPE and training such as chemical, physical, electric and mechanical hazards. It conceptualized that if these predictors are effectively used, achieve reduced maritime accidents in vessels (Loibner et al, 2019). Moreover, in this study, as portrayed in the conceptual framework, chemical hazards imply exposure to chemical substances such as cleaning solvents, detergents, fuel, welding fumes, paints, pesticides, and fumigants, which are routinely used on-board ships for operation maintenance purposes and chemical shipped cargo. physical hazards mean exposure to UV radiation, while working at deck, microwave electromagnetic field (MW-EMF) emitted by ship radar and communication equipment, vibration due to ship rolling, pitching at high seas, and extreme ambient situations such as heat, cold, squall winds, torrent rains (Lucas et al, 2022) .

Electrical hazards include potential dangers and risks related to electrical systems on vessels due to burns, electrocution, arc flash, electric shocks. Between 2011 to 2015 a total of 87 electric related accidents reported to AMSA (AMSA, 2016); while mechanical hazards mean maritime accidents that are caused by wit parts moving in controlled/uncontrolled manner and with dangerous surfaces as well as caused by falling, shipping, tripping and twisting. Accidents related to transport tasks, mobile works equipment or fall from height.

Original Article

3 Methods and materials used

In this study, Human Factors Engineering (HFE) principles were applied to analyze crew behavior regarding the provision, usage, maintenance, training, and enforcement mechanisms of Personal Protective Equipment (PPE) onboard ships. The research methodology encompassed various steps to systematically investigate these factors and their impact on maritime safety as indicated in Figure 2

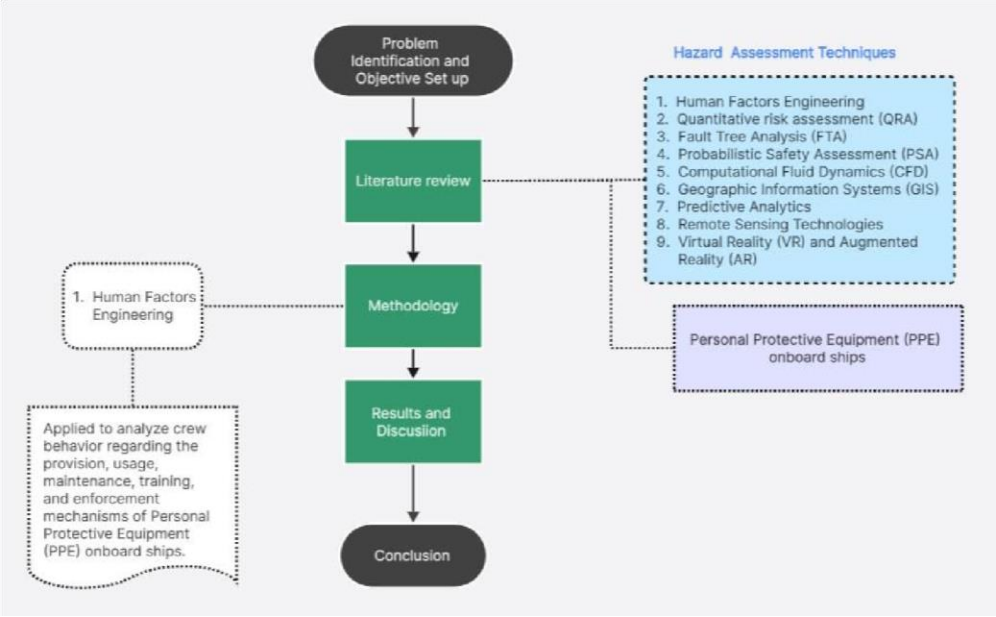

Fig. 2: Methodological steps (Own Source)

The research technique used in this study was carefully constructed to examine the intricate relationship between crew behavior and the use of personal Protective Equipment (PPE) on ships. The study aims to elucidate the frequencies of incidents and uncover causal linkages relevant to maritime safety by employing both descriptive and explanatory methodologies. This versatile approach facilitated a thorough analysis of crew conduct, covering several areas like the supply, utilization, upkeep, training, and enforcement mechanisms associated with personal protective equipment (PPE). The implementation of a case study methodology allowed for the classification of participants, while the cross-sectional study design helped the gathering of data within the limitations of time, ensuring a comprehensive examination of the research inquiries at hand.

The study examined the manual and mechanical operations on ships in Dar es Salaam and Zanzibar, with a specific focus on maritime activities. It acknowledged the importance of seafarers' activities in these regions. By focusing on these particular geographical places, the research intended to understand the intricacies of crew behavior within a specific nautical set- ting. The study sample consisted of 313 sailors from the engine room and deck departments, who were meticulously selected by the Zanzibar Maritime Authority. The intentional choice of participants ensured that the sample encompassed a wide variety of experiences and perspectives, which is essential for the accuracy and applicability of the study results.

The study collected data using questionnaires, in-depth interviews, observations, and documentary evaluations. The research triangulated these data collection approaches to improve its comprehensiveness and dependability. To verify data reliability and validity, Cronbach's alpha was employed and experienced researchers refined data

Original Article

gathering devices. Interviews and observations were properly documented and coded for transcription and analysis. ANOVA, regression coefficients, and IBM-SPSS were used to rigorously analyze quantitative and qualitative data, allowing the study to draw strong conclusions about crew behavior and maritime safety.

The study employed regression analysis to examine the associations between dependent and independent variables. The derived equations facilitated a more profound comprehension of the variables that affect crew conduct and its consequences on marine safety.

$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + e$ (1)

B0is the intercept term, indicating the value of the dependent variable when all independent variables are zero. β_1, β_2, *and* $\beta 3$*and* $\beta_4$are the regression coefficients associated with each independent variable x_1, x_2, x_3 and x_4, respectively. These coefficients measure the change in the dependent variable for a one-unit change in each independent variable while holding other independent variables constant.x_1, x_2, x_3, ,and x_4 represent different types of hazards onboard ships, such as chemical, physical, electrical, and mechanical hazards. *e* is the error term, accounting for factors other than the independent variables that may influence the dependent variable.

The study utilized regression analysis to evaluate the correlations between variables such as provision, usage, maintenance, training, and enforcement methods of personal protective equipment (PPE), and their impact on minimizing maritime accidents. These equations were useful tools for forecasting results and guiding initiatives aimed at enhancing safety measures on board ships.

4 Results and Discussion

This part provides an exposition of the study's discoveries, examination, and discourse. The text presents the key discoveries obtained from the participants' answers gathered through the use of questionnaires, in-depth interviews, and observations. The study focused on sailors working in marine transport lines in Dar es Salaam, located in the Indian Ocean, and Zanzibar Island, Tanzania. The section is divided into two main parts: the first part consists of the biographies of the respondents who were sampled in the study, while the second part focuses on presenting the findings related to the three specific objectives of the study. These objectives include identifying the most common hazards associated with maritime accidents caused by the improper use of personal protective equipment in maritime transport lines.

4.1 Demographic Characteristics of the Respondents

According to the survey results in Figure 3, the bulk of the respondents, specifically 72 individuals (69%), were between the ages of 30 and 49. This was followed by 16 individuals (15%) who were between the ages of 50 and 59, and 8 individuals (8%) who were between the ages of 18 and 29. Additionally, 8 individuals (8%) were 60 years old or older. This indicates that the study utilized respondents who were mature and capable of comprehending the issues posed to them and providing pertinent responses. Furthermore, the research indicates that a significant number of maritime professionals have a preference for working at sea during their younger years rather than in their later years.

Original Article

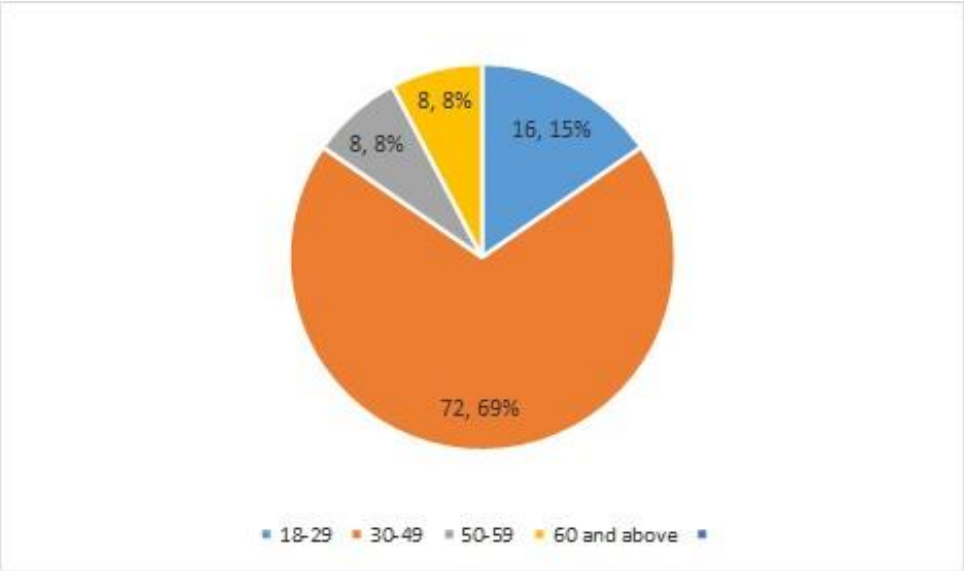

Fig. 3: Demographic age of respondents

4.1.1 Gender of the Respondents

The Figure 4 illustrates that males accounted for 88 individuals, or 85% of the total, while females accounted for 16 individuals, representing 15%. This suggests that men have a greater presence and influence in the field of maritime professions compared to women. This condition is particularly evident in African countries.

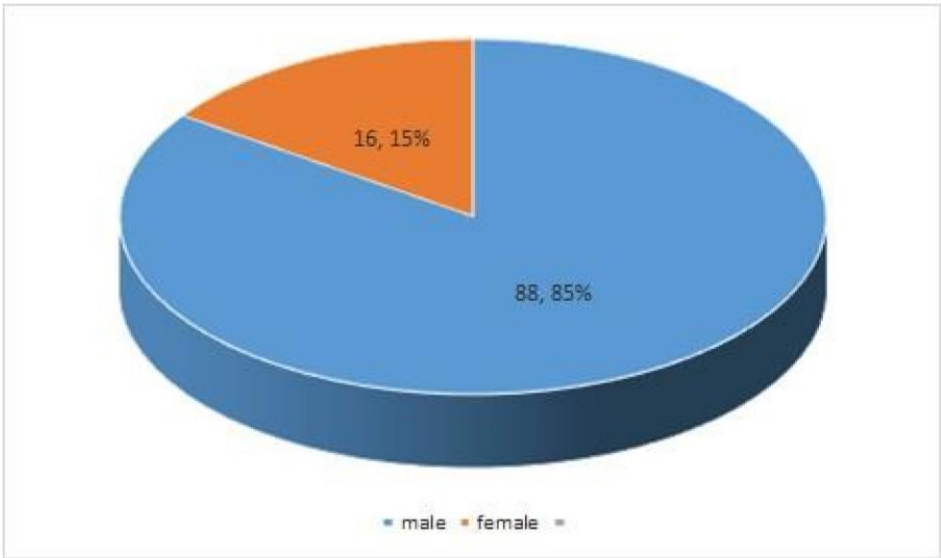

Fig. 4: Gender of Respondednts

4.1.2 Respondents' Level of Education

The data presented in Figure 5 indicates that the largest proportion of respondents, accounting for 40 (40.4%) of the total, held certificates. This was followed by diploma holders, who made up 24 (23.3%) of the total respondents. Primary education holders and bachelor degree holders each accounted for 16 (15.4%) and 16 (13.2%) of the respondents, respectively. This indicates that the study included participants who were capable of

Original Article

comprehending the intended significance of the questionnaire and providing appropriate responses. In addition, the findings suggest that a significant number of marine professionals prioritize certificates over formal schooling. It is worth noting that there are relatively few individuals with bachelor's degrees, and none of them possess a master's degree.

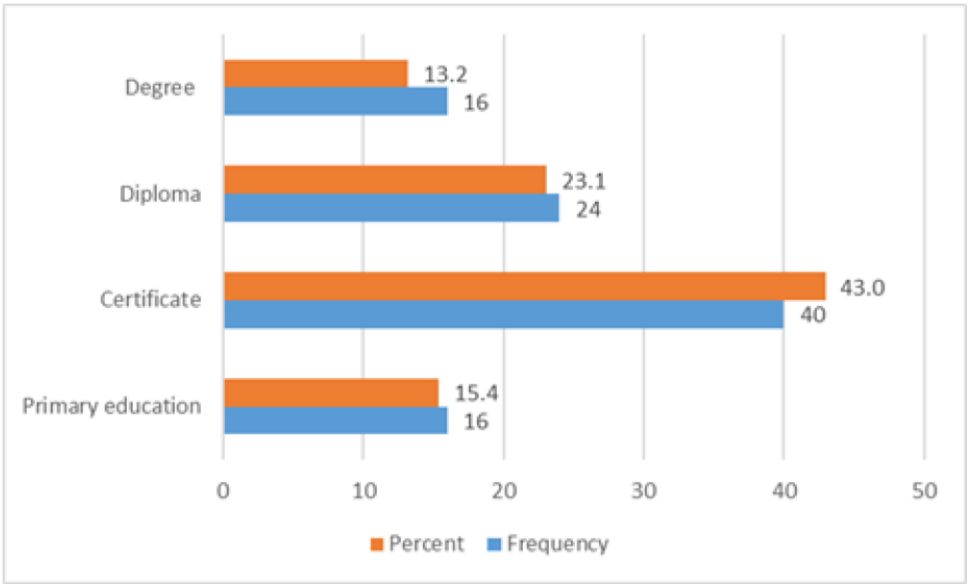

Fig. 5: Level of education of the respondents

4.1.3 Respondents' Membership and Certification by Maritime Organizations

According to Table 2 , the data shows that a large proportion of the respondents, specifically 80 individuals (76.9%), possessed certifications from different maritime organizations such as CLIT, TASU, MNOAT, and Fisheries Associations. On the other hand, 24 individuals (23.1%) out of the total respondents did not have any certifications. This indicates that the study primarily included respondents who were professionals in maritime activities, so effectively addressing the primary objectives of the study. The limited number of certified marine experts should not be disregarded, as this implies the presence of uncertified marine inhabitants who may contribute to mishaps.

4.1.4 Respondents' Witnessed Accidents

According to Figure 6 , the data shows that a significant majority of the respondents, specifically 96 individuals (92.3%), reported witnessing marine incidents as a result of inadequate use of Personal Protective Equipment

Table 2: Membership and Certification by Maritime Organizations

	Frequency	Percent	Valid Percent
Yes	80	76.9	79.6
No	24	23.1	23.1
Total	104	100.0	100.0

(PPE). Conversely, just 8 respondents (7.7%) stated that they had not witnessed any maritime accidents caused by improper use of PPE. The results suggest that inadequate utilization of personal protective equipment (PPE)

Original Article

has a significant influence on the frequency of maritime accidents. Therefore, it is crucial to prioritize the use of PPE in order to mitigate maritime accidents.

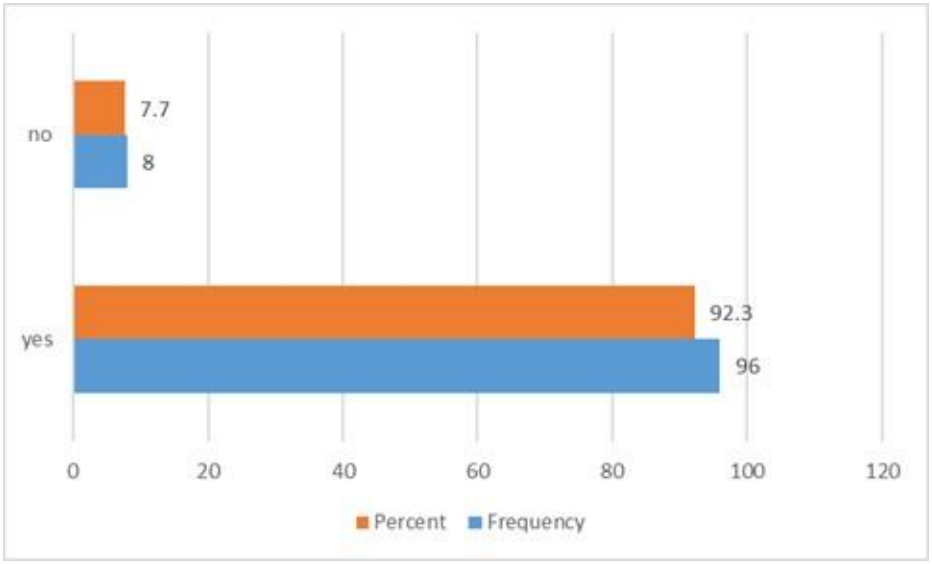

Fig. 6: Respondents' Witnessed Accidents

4.2 Regression on Hazard Management with the Use of PPE

Accidents at sea can be avoided by properly managing personal protective equipment (PPE), as illustrated in this section. It is indicated that the degree of significance in effectively avoiding dangers in maritime activities at sea by utilizing personal protective equipment (PPE), statistical significance in predictive of the model, and significance level of each independent variable are the predictors of the occurrence of maritime accidents.

Table 3: Model Summary on Hazards Management

R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.487[a]	.237 .206	1.144

where *a* . Predictors: (Constant), PPE are not effectively applied in protecting physical hazards in our vessels, PPE are not well used to protect against chemical hazards in our vessels, Electronic hazards are not well managed for with PPE in our vessels, PPE are not well applied to protect mechanical hazard in our vessels

The data shown in Table 3 provides an overview of maritime hazards management in the shipping sector. It focuses on the use of personal protective equipment (PPE) and its impact on the occurrence of marine accidents. Out of the various marine mishaps that have taken place, the independent fac- tors associated with maritime risks can account for 49% of the incidences. An explanation for the remaining 51% can be provided by other elements. These findings offer a restricted explanation for the incidence of maritime accidents, which might be ascribed to additional factors including the suitability of personal protective equipment (PPE) and the adequacy of training for PPE.

Original Article

4.2.1 ANOVA Test on Maritime Hazards Management on Alteration of Architectural Drawing of Construction Projects.

This section demonstrates the considerable level of the model's ability to anticipate maritime hazardous operations on the occurrence of maritime accidents in the shipping industry. The significant level of maritime risks that have an impact on the occurrence of maritime accidents is displayed in Table 4 . The data revealed that the significant level was 0.000. Therefore, the model is statistically significant in terms of its ability to predict the amount to which maritime hazards, including chemical hazards, mechanical hazards, electrical hazards, and physical hazards, have an impact on the occurrence of maritime accidents in the ship- ping industry, particularly at the local level. The significance of putting an emphasis on the management of marine hazards pertaining to shipping operations is demonstrated by this outcome. l hazards impact the maritime accidents occurrences in shipping industry especially at local level. This result signifies the essentiality of stressing management of maritime hazards in shipping operations.

Table 4: ANOVA test

Model	Sum of Squares	Df	mean Square	F	Sig.
Regression	40.202	4	10.050	7.675	.00[b]
Residual	129.644	99	1.310		
Total	169.846	103			

where *b* . Predictors: (Constant), PPE are not effectively applied in protecting physical hazards in our vessels, PPE are not well used to protect chemical hazards in our vessels, Electronic hazards are not well managed for with PPE in our vessels, PPE are not well applied to protect mechanical hazard in our vessels

4.2.2 Predictive Ability of Maritime Hazards Impact on Maritime Accidents Occurrences This section presents a multiple regression analysis that examines the relevance of variables related to marine risks in relation to the occurrence of maritime accidents. The analysis is based on the responses to specific statements provided by the study participants, in line with the study's third aim. Participants were instructed to assess the statements on a scale ranging from strongly disagree to strongly agree, regarding the prevalence of PPE usage in their work station for managing marine hazards during work performance. The following claims indicate that PPE is not properly used to manage electronic, mechanical, chemical, and physical dangers.

Table 5: Predictive Ability Maritime Hazards Impact on Maritime Accidents Occurrences

Unstandardized Coeffcients		**Standardized Coeffi- cients**	**t**	**Sig.**
B		**Std, Error**	**Beta**	
(Constant)	1.472	.785	1.875	.074

Original Article

Electronic hazards are not well managed for with PPE in our vessels	.230	.050	.523	.002
	.120			
PPE are not well applied to protect mechanical hazard in our vessels	.342	-.116		.002
	.378		1.104	
PPE are not well used to protect chemical hazards in our vessels	.158	.536	5.233	.000
	.827			
PPE are not effectively applied in protecting physical hazards in our vessels	.141	.072	-.715	.016
	.101			

Table 5 shows that multiple regression analysis of maritime hazards predictors' impact on maritime accidents occurrences in shipping industries. Findings are based on the study objective three which include independent predictors such as: electronic hazards are not managed effectively using PPE, mechanical hazards are not managed effectively using PPE, chemical hazards are not managed effectively using PPE and physical hazards are not managed effectively using PPE.

The findings from the Table 5 depict that, maritime hazards predictors on maritime accidents occurrences all predictors were strong with having significance level of 0.002, 0.022, 0.00, and 0.016 consecutively. Thus, the model was statistically significant in predicting the extent maritime accidents occurrences

Using the information in Table 5, the following equation can be derived:

$$Y = 1.742 + 0.120X_1 - 0.378X_2 + 0.872X_3 - 0.101X_4 \quad (2)$$

Where as

Y= Client related factors on alteration of architectural drawings,

X_1= Electronic hazards are not well managed for with PPE in our vessels X_2= PPE are not well applied to protect mechanical hazard in our vessels X_3= PPE are not well used to protect chemical hazards in our vessels

X_4= PPE are not effectively applied in protecting physical hazards in our vessels

The Equation (2) indicates that increasing the management of electronic hazards by using personal protective equipment (PPE) leads to a decrease of 0.120 units in maritime accidents. Similarly, increasing the management of mechanical hazards with the use of PPE at sea results in a decrease of

0.378 units in maritime accidents. Furthermore, increasing the management of chemical hazards with the use of PPE causes a decrease of 0.278 units in maritime accidents, particularly at the local level. Conversely, decreasing the management of physical hazards with the use of PPE leads to an increase of 0.723 units in maritime accidents at sea.

Original Article

If all variables, such as electronic hazards, mechanical hazards, chemical hazards, and physical hazards, are not effectively managed using personal protective equipment (PPE), the number of maritime accidents could decrease by 1.742 units. This rationale provides a basis for considering that characteristics related to the management of maritime risks are essential determinants for mitigating maritime accidents at sea.

The study revealed the significant impact of maritime risks management on reducing maritime accidents in maritime transportation. The study examined the factors that influence the management of maritime risks in order to reduce maritime accidents. The results showed that the level of maritime hazards management has a substantial impact on the reduction of maritime accidents. The study results, based on a sample of seafarers from several local transportation lines between Dar es Salaam and Zanzibar, revealed a significant influence on the frequency of maritime accidents in the maritime business.

During the interview with six selected participants in a Focus Group Discussion, it was observed that ”*the main cause of alterations in architectural drawings was the designers themselves. The institution, on the other hand, fulfilled its role by providing funds promptly, making timely decisions, consulting with technical staff, and maintaining a consistent project scope. Although there were some changes made to the architectural designs, they had a small influence on the budget, time, and did not compromise the quality”.*

Muhamad and Mohammad (2018) argues that their research provide sup- port for this study’s client, however it may result in alterations that are not comparable to those caused by contractors and design-related issues. Contractors and designers may neglect certain principles in building projects, which can have a negative impact on the client. This occurs when changes in the project scope are discovered by the client, but were not communicated to them earlier.

Furthermore, the results of this study by Shoar and Chileshe (2021) are corroborated by recognizing that clients may be responsible for modifying architectural drawings as the intended project may become obsolete before completion. This study aligns with the findings of a previous study, as it discovered that approximately 25% of architectural designs were altered in construction projects.

5 Conclusions

This study concludes that” Hazard Analysis and the Role of Personal Protective Equipment in Preventing Maritime Accidents in Tanzania,” was to evaluate the efficacy of personal protective equipment (PPE) in mitigating marine accidents. More precisely, the study aimed to assess the effectiveness of personal protective equipment (PPE) training, the sufficiency of PPE supply on ships, and the identification of risks related to insufficient PPE utilization. The findings provided valuable insights into the impact of Personal Protective Equipment (PPE) on maritime safety. The provision of appropriate personal protective equipment (PPE) on vessels has been identified as a crucial element in preventing accidents, highlighting the importance of ensuring an adequate supply of PPE onboard. Moreover, the implementation of competency training for marine personnel in the application of personal protective equipment (PPE) demonstrated encouraging outcomes in the prevention of accidents, underscoring the significance of comprehensive training programs. Furthermore, the inadequate utilization of personal protective equipment (PPE), which encompasses the improper handling of electronic, mechanical, chemical, and physical dangers, has been identified as a significant factor in marine accidents.

Original Article

In its conclusion, this study emphasizes the crucial need of Personal Protective Equipment (PPE) in improving maritime safety in Tanzania. In order to enhance safety protocols, it is advised that marine corporations give priority to extensive safety instruction for their staff, guarantee adherence to global rules, and promote employee involvement in safety projects. Furthermore, future investigations should examine the presence and ease of access to personal protective equipment (PPE) in the marine industry. Additionally, the study's range should be expanded to encompass other bodies of water outside of Dar es Salaam, such as lakes and rivers. The objective of these initiatives is to pro- mote safety protocols and decrease the occurrence of maritime incidents in Tanzania.

6 Recommendations

i. The study recommends that training of workers in safety and health which covers identification of hazards and measures to mitigate the hazards is very important for improving the overall safety and health of workers in workplaces. This will in turn raise the level of PPEs awareness among the maritime workers.

ii. The study recommends that maritime companies in Tanzania to adhere international regulations, set internal guidelines and policies and ensure that they are known by the employees and are fulfilled. There also need for continuous safety training programs to promote an understanding on the significance of use of PPE.

iii. There should be employees` engagement, not only in the implementation of safety and health practices but also in the formulation of the same. The involvement of employees in the whole process makes them feel accountable for the same and easy the implementation process. iv. Tanzania Shipping Agency Corporation (TASAC), the Tanzania Port Authority (TPA), the Zanzibar Maritime Authority (ZMA), must ensure all ship and boat operators adhere to SOLAS conventions issued by International Marine Organization (IMO) before being given the certificate to ferry passengers across Indian Ocean

References

A NT, ALBK, S NT, et al. (2023). Features of the manifestation of the "human factor" and its negative impact on the safety of navigation. *Operation of Maritime Transport, 0*(4), 36–46. https://doi.org/10.34046/aumsuomt105/7

Arici, S. S., Akyuz, E., & Arslan, O. (2020). Application of fuzzy bow-tie risk analysis to maritime transportation: The case of ship collision during the STS operation. *Ocean Engineering, 217,* 107960. https://doi.org/10.1016/j.oceaneng.2020.107960

Bowo, L. P., & Furusho, M. (2018). A comparison of the common causes of maritime accidents in Canada, Indonesia, Japan, Australia, and England. In *Advances in Human Error, Reliability, Resilience, and Performance*. https://doi.org/10.1007/978-3-319-94391-6_24

Brcko, T., Pavic, I., Misc, J., et al. (2023). Investigating the human factor in maritime accidents: A focus on compass-related incidents. *Transactions on Maritime Science, 12*(2). https://doi.org/10.7225/toms.v12.n02.w01

Original Article

Burra, N. J., & Ushadevi, K. N. (2022). Porter's five forces analysis of Zanzibar's seaweed industry. *Asian Journal of Agricultural and Environmental Science*, 40, 185–196. https://doi.org/10.9734/ajaees/2022/v40i111700

Chen, S., & Demachi, K. (2021a). Towards on-site hazards identification of improper use of personal protective equipment using deep learning-based geometric relationships and hierarchical scene graph. *Automation in Construction, 125*, 103619. https://doi.org/10.1016/j.autcon.2021.103619

Chen, S., & Demachi, K. (2021b). Towards on-site hazards identification of improper use of personal protective equipment using deep learning-based geometric relationships and hierarchical scene graph. *Automation in Construction, 125*, 103619. https://doi.org/10.1016/j.autcon.2021.103619

Ehlers, T., Portier, M., & Thoma, D. (2022). Automation of maritime shipping for more safety and environmental protection. *Automatisierungstechnik, 70*, 406–410. https://doi.org/10.1515/auto-2022-0003

Garrigou, A., Laurent, C., Berthet, A., et al. (2020). Critical review of the role of PPE in the prevention of risks related to agricultural pesticide use. *Safety Science*. https://doi.org/10.1016/j.ssci.2019.104527

Goerlandt, F., Innes-Jones, G., Owen, D., et al. (2019). Enhancing human performance in ship operations by modifying global design factors at the design stage. *Reliability Engineering and System Safety*. [Full citation details may be needed]

Golestani, N., Abbassi, R., Garaniya, V., et al. (2020). Human reliability assessment for complex physical operations in harsh operating conditions. *Process Safety and Environmental Protection, 140*, 1–13. https://doi.org/10.1016/j.psep.2020.04.026

Hasanspahic, N., Vujicic, S., Kristic, M., et al. (2022). Improving safety management through analysis of near-miss reports—A tanker ship case study. *Sustainability*. https://doi.org/10.3390/su14031094

Husna, I., Azise, A., & Sarifuddin. (2020). The use of personal protective equipment for reducing accidental risk on board. In *Proceedings* (pp. 147–150). https://doi.org/10.2991/aer.k.200220.031

Kasyk, L., Wolnowska, A. E., Pleskacz, K., et al. (2023a). The analysis of social and situational systems as components of human errors resulting in navigational accidents. *Applied Sciences, 13*(11), 6780. https://doi.org/10.3390/app13116780

Kasyk, L., Wolnowska, A. E., Pleskacz, K., et al. (2023b). The analysis of social and situational systems as components of human errors resulting in navigational accidents. *Applied Sciences, 13*(11), 6780. https://doi.org/10.3390/app13116780

Original Article

Kincl, L., Doza, S., Nahorniak, J., et al. (2023). Commercial fishing fatalities and injuries described by linked vessel incidents. *Journal of Agromedicine*. https://doi.org/10.1080/1059924X.2023.2229827

Lin, W. C., & Yau, H. Y. (2023). Construct maritime safety culture to reduce risk occurrence through implementation of balanced scorecard. *Journal of Ship Production and Design, 39*(4), 188–193. https://doi.org/10.5957/JSPD.12210033

Loibner, M., Hagauer, S., Schwantzer, G., et al. (2019). Limiting factors for wearing personal protective equipment (PPE) in a health care environment evaluated in a randomized study. *PLoS ONE, 14*. https://doi.org/10.1371/journal.pone.0210775

Lucas, D., Corman, V., Jensen, O., et al. (2022). Maritime workers and their global health: Need to improve scientific knowledge and prevention. *Journal of Global Health, 12*. https://doi.org/10.7189/jogh.12.03031

Mbije, N. E. (2023). Tanzanian coral reef in peril: Are we fighting a losing battle? *New Perspectives in Geoscience and Environmental Science, 8*, 68–88. https://doi.org/10.9734/bpi/npgees/v8/8053F

Molé, D. M. (2024). Submarine or surface vessel accident. In *Encyclopedia of Maritime Safety*. https://doi.org/10.1016/B978-0323-80932-0.00183-X

Muhamad, N., & Mohammad, M. F. (2018). Impact of design changes in construction projects. *Malaysian Journal of Sustainable Environment*. https://doi.org/10.24191/myse.v4i1.5603

Mwendapole, M., & Jin, Z. (2021). Seaport governance framework in Tanzania: Challenges and strategies. In *Proceedings of the 2021 12th International Conference on E-business, Management and Economics*. https://doi.org/10.1145/3481127.3481139

Prilana, R. E., Bowo, L. P., & Furusho, M. (2021). A hybrid methodology for human reliability assessment in maritime cargo accidents. *IOP Conference Series: Materials Science and Engineering, 1052*(1), 012037. https://doi.org/10.1088/1757-899X/1052/1/012037

Rabajczyk, A., & Wolański, R. (2023). Analysis of the issue of special clothing in the operation of fire protection units. *Safety & Fire Technology, 61*(1). https://doi.org/10.12845/sft.61.1.2023.4

Shoar, S., & Chileshe, N. (2021). Exploring the causes of design changes in building construction projects: An interpretive structural modeling approach. *Sustainability*. https://doi.org/10.3390/su13179578

Wang, S., Yin, J., & Khan, R. (2020). The multi-state maritime transportation system risk assessment and safety analysis. *Sustainability, 12*, 5728. https://doi.org/10.3390/su12145728

Original Article

Youssef, E. A., Sayed, S. F. E., & Abdelkader, S. (2023). Maritime accidents analysis using maritime human factors and analysis model. *Maritime Research and Technology, 2*(1), 44–60. https://doi.org/10.21622/MRT.2023.02.1.047

Zampeta, V., & Chondrokoukis, G. (2022). An empirical analysis for the determination of risk factors of work-related accidents in the maritime transportation sector. *Risks, 10*(12), 231. https://doi.org/10.3390/risks10120231

Zhao, C., Zhang, W., Chen, C., et al. (2023). Recognition of unsafe onboard mooring and unmooring operation behavior based on improved YOLO-v4 algorithm. *Journal of Marine Science and Engineering, 11*(2), 291. https://doi.org/10.3390/jmse11020291