



Exception Exposure Deprivation and Emergency Readiness Vulnerability among Seafarers in Highly Standardized Ship Operations

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ABSTRACT

Modern ship operations use strict procedures and advanced automation, which may reduce seafarers' experience in handling unexpected situations. This study aims to analyze the relationship between exception exposure deprivation and emergency readiness vulnerability among seafarers. A quantitative correlational method was conducted through a questionnaire survey involving 100 seafarers and maritime trainees in Banten, Indonesia. Data were analyzed using descriptive statistics, validity and reliability tests, Pearson correlation, and simple linear regression. The results indicate that limited exposure to abnormal situations is associated with lower emergency readiness among seafarers. This study highlights the importance of realistic emergency training and varied scenarios to improve maritime safety and human performance.

INTRODUCTION

The maritime industry has experienced rapid transformation through the integration of automation, digital technologies, and standardized operational systems. Modern ships are increasingly equipped with advanced navigation equipment, automated machinery, and structured safety procedures to improve operational reliability and reduce risks. However, the increasing standardization of ship operations may reduce opportunities for seafarers to directly experience unexpected situations that require adaptive responses. Emergency conditions at sea, including equipment failures, fire incidents, system disruptions, and environmental hazards, require not only technical knowledge but also effective decision-making and situational awareness. Batalden et al. (2020) emphasized that human factors remain a central element in maritime safety because technological improvements cannot completely eliminate risks originating from human decisions, communication failures, and organizational limitations. This finding indicates that even highly advanced ship systems still depend on the ability of seafarers to interpret situations and respond appropriately when normal procedures become insufficient.

The implementation of automation and strict operational procedures provides significant benefits for maritime safety by reducing uncertainty and improving consistency during routine operations. However, these systems may also create new challenges related to human readiness when abnormal situations occur. Seafarers who primarily operate within predictable environments may have fewer opportunities to develop adaptive skills required during rare emergency events. Mansikka et al. (2021) demonstrated that mental workload and situational awareness are important factors influencing human performance in maritime operations. Their findings suggest that effective decision-making during complex situations depends not only on technical competence but also on the ability to recognize changes in operational conditions. Therefore, emergency preparedness should not only focus on compliance with standard operating procedures but also on developing the ability to respond flexibly when situations exceed expected operational patterns.

Training and simulation have become important strategies to overcome the limited availability of real emergency experiences in maritime operations. Since actual maritime accidents and critical events are relatively rare, structured simulation provides opportunities for seafarers to practice decision-making under controlled but realistic conditions. Pan et al. (2020) explained that maritime simulators can support future maritime education by providing realistic operational environments where trainees can develop technical and non-technical competencies. This finding highlights that simulation does not only transfer procedural knowledge but also creates experiential opportunities that are difficult to obtain through routine operations. Furthermore, Hamed-Ahmed et al. (2024) found that virtual reality-based maritime training can improve emergency preparedness by creating immersive scenarios, such as fire evacuation and shipboard emergency response. These developments demonstrate that exposure to diverse abnormal situations is an important component in strengthening seafarers' readiness.

Previous studies have provided valuable evidence regarding the importance of realistic training environments, simulator applications, and emergency preparedness programs. However, most previous research has focused on evaluating whether a specific training method improves competence rather than examining whether insufficient exposure to abnormal situations itself becomes a safety vulnerability. Hamed-Ahmed et al. (2025) emphasized that human-centered simulation systems can improve cognitive and emotional responses during maritime emergency scenarios. This research shows that the quality of emergency experience influences how individuals respond under pressure. Nevertheless, it does not specifically address the possibility that highly standardized operational environments may unintentionally reduce opportunities for developing emergency adaptability. Therefore, further investigation is needed to understand whether limited exposure to abnormal conditions contributes to vulnerability in emergency readiness among seafarers.

The concept of *exception exposure deprivation* introduced in this study addresses this unexplored area by examining the potential consequences of limited exposure to abnormal operational conditions. Highly standardized ship operations are designed to minimize errors and maintain safety; however, excessive dependence on predefined procedures may reduce opportunities for seafarers to develop adaptive expertise. Chen et al. (2024) highlighted that maritime safety performance is influenced by the interaction between technological systems, organizational practices, and human capabilities. Their findings reinforce the idea that safety resilience cannot rely solely on technical systems but must also consider the ability of individuals to adapt when unexpected failures occur. Therefore, investigating exception exposure deprivation provides a new perspective on maritime safety by examining whether operational stability may create hidden limitations in emergency preparedness.

Based on the identified research gap, this study aims to analyze the relationship between exception exposure deprivation and emergency readiness vulnerability among seafarers in highly standardized ship operations. Specifically, this research examines whether limited exposure to abnormal situations influences seafarers' preparedness, confidence, and decision-making ability during emergency conditions. A quantitative correlational approach is applied by collecting questionnaire data from 100 seafarers and maritime trainees in Banten, Indonesia. The study evaluates exception exposure deprivation as an independent variable and emergency readiness vulnerability as a dependent variable. Through statistical analysis, this research seeks to provide empirical evidence regarding the role of operational experience diversity in strengthening maritime emergency preparedness.

This research contributes theoretically and practically to maritime safety studies. From a theoretical perspective, this study expands current discussions on human factors and safety performance by introducing exception exposure deprivation as a potential factor influencing emergency readiness in standardized maritime environments. The research provides a broader understanding that safety is not only achieved through preventing failures but also through preparing individuals to respond effectively when unexpected events occur. From a practical perspective, the findings may support maritime education institutions and shipping companies in designing more effective training strategies based on realistic and diverse emergency scenarios. By increasing exposure to abnormal operational conditions through simulation and scenario-based exercises, seafarers can develop stronger adaptive capabilities, improve decision-making skills, and enhance overall maritime safety performance.

LITERATURE REVIEW

Human Adaptability and Decision-Making in Maritime Emergency Situations

Human adaptability is an essential component of maritime safety because seafarers operate in complex environments where unexpected events can occur. In highly standardized ship operations, routine activities are generally controlled by established procedures. However, emergency situations often require flexible decision-making beyond predefined instructions. Adaptive capability refers to the ability of individuals to adjust their knowledge, behavior, and decisions when facing unfamiliar or changing conditions. In maritime operations, this capability is important because emergency situations usually involve uncertainty, limited response time, and incomplete information.

Recent research indicates that individual characteristics and operational experience influence how seafarers perceive and respond to emergency situations. Shi et al. (2024) investigated the influence of seafarers' individual characteristics on perceived risk during maritime emergencies using a high-fidelity ship-handling simulator. The study found that experience level, professional position, and personal background affected how seafarers evaluated emergency risks. These findings support the current research because they demonstrate that operational exposure contributes to the development of risk perception and emergency response capability. Therefore, seafarers with limited exposure to abnormal situations may have a greater possibility of experiencing vulnerability when facing unexpected operational events.

Furthermore, emergency decision-making is influenced not only by technical competence but also by psychological readiness and the ability to interpret complex situations. Shi et al. (2023) examined seafarers' emotional responses during emergency scenarios through ship-handling simulation and found that emotional conditions could influence decision-making performance during critical situations. This finding indicates that repeated exposure to realistic emergency conditions may help seafarers improve emotional control and response effectiveness. Therefore, limited exposure to abnormal situations may reduce opportunities for developing the adaptive capability required during maritime emergencies.

H1: *Exception exposure deprivation significantly influences emergency readiness vulnerability among seafarers.*

Automation, Standardization, and Reduced Operational Experience

The increasing implementation of automation and standardized procedures has changed the role of seafarers from direct operators into supervisors who monitor systems and intervene when necessary. Automation provides important benefits by improving operational efficiency and reducing routine errors. However, excessive dependence on automated systems may reduce opportunities for seafarers to actively experience complex operational problems. This situation may create a gap between procedural knowledge and practical readiness when abnormal conditions occur.

Veitch et al. (2024) examined human factor influences in supervisory control of remotely operated and autonomous vessels through simulation experiments. The study demonstrated that human performance was influenced by response time, system support, and operational complexity. Although advanced automation can improve safety, the findings showed that human operators remain essential when unexpected situations exceed system capabilities. This research supports the current study because highly standardized operations may reduce abnormal exposure while still requiring seafarers to respond effectively during emergencies.

Wang et al. (2024) further emphasized that future maritime operations require effective cooperation between automated technologies and human decision-makers. Their study highlighted that emergency situations cannot always be resolved through automation because unexpected failures require human judgment and adaptive responses. This finding strengthens the argument that technological advancement should be balanced with sufficient opportunities for developing human operational experience. Therefore, standardized ship operations may create a hidden safety challenge. While they improve reliability during normal operations, they may unintentionally reduce opportunities for developing adaptive emergency skills.

Simulator Training as Exposure Replacement for Rare Emergency Events

Actual maritime emergencies occur relatively infrequently, making direct experience with critical situations difficult to obtain. Therefore, simulator-based training has become an important method for providing controlled exposure to abnormal operational conditions. Simulation enables seafarers to practice emergency responses repeatedly without creating real safety risks. Through realistic scenarios, trainees can develop decision-making skills, situational awareness, and confidence in handling complex events.

Qiu et al. (2024) developed an educational virtual training system for ship lifesaving equipment and found that technology-based learning environments improved emergency training effectiveness. The study showed that virtual training allows participants to repeatedly experience emergency procedures and increase operational confidence. This finding supports the present research because simulation can serve as an alternative method to compensate for limited exposure to real abnormal situations.

Abida et al. (2024) conducted a systematic literature review on effective maritime simulator training and identified scenario realism, training design, and feedback quality as important factors influencing learning outcomes. Their research demonstrated that simulator training is most effective when scenarios provide realistic challenges rather than only repeating routine procedures. This supports the concept of exception exposure deprivation because meaningful exposure to challenging situations is necessary to develop emergency competence. Based on these findings, realistic simulation exposure may reduce the negative impact of limited operational experience by improving preparedness and adaptive decision-making.

Emergency Preparedness and Safety Performance in Maritime Operations

Emergency preparedness represents the ability of maritime personnel to identify risks, coordinate actions, and respond effectively during critical situations. In modern shipping operations, emergency readiness is closely related to safety performance because accidents often involve interactions between human decisions, technological systems, and organizational procedures. Therefore, evaluating emergency preparedness requires understanding not only technical competence but also human adaptability. Brandsæter and Madsen (2024) developed a simulator-based approach to assess human performance in autonomous ship navigation. Their findings showed that simulation could identify limitations in human supervisory control, particularly when operators faced unfamiliar or abnormal conditions. This study supports the current research because it demonstrates that human readiness must be evaluated under challenging scenarios rather than only during normal operational conditions.

Wang et al. (2024) also highlighted that modern maritime emergency management requires integration between technological systems and human capabilities. Their findings indicate that automated systems can support safety, but effective emergency response still depends on human judgment and adaptive performance. This evidence reinforces the importance of examining how operational experience influences emergency readiness. Based on previous studies, emergency readiness is influenced by the quality and diversity of operational experiences. Seafarers who have limited exposure to abnormal conditions may experience greater vulnerability when responding to emergency situations.

METHODOLOGY

Research Design

This study employed a quantitative research approach using a correlational research design. The quantitative approach was selected because the research aims to measure the relationship between exception exposure deprivation and emergency readiness vulnerability among seafarers. The correlational design allows researchers to examine the degree of association between variables without manipulating the research conditions. This design is appropriate because the study focuses on identifying whether limited exposure to abnormal operational situations is related to the level of emergency readiness among maritime personnel.

The research model consists of one independent variable and one dependent variable. Exception exposure deprivation was positioned as the independent variable (X), representing the limitation of seafarers' exposure to unexpected operational conditions. Emergency readiness vulnerability was positioned as the dependent variable (Y), representing the potential limitations in preparedness, decision-making, and response capability during emergency situations. A quantitative correlational design is commonly applied when researchers aim to determine relationships among measurable variables through statistical analysis (Creswell & Creswell, 2023).

Population and Sampling Technique

The population of this study consisted of seafarers and maritime trainees who have experience or educational backgrounds related to ship operations. The target population was selected because seafarers are directly involved in operational activities where standardized procedures, automation systems, and emergency response requirements are applied. The research was conducted among maritime personnel in Banten, Indonesia, as the region has maritime education institutions and individuals involved in maritime operational training.

The study involved *100 respondents*, consisting of active seafarers and maritime trainees. The sample size was determined based on the feasibility of quantitative correlation analysis and the requirement to obtain sufficient variation among respondents. According to Hair et al. (2022), sample adequacy in quantitative studies should consider the number of variables analyzed, measurement indicators, and statistical techniques applied. A sample of 100 respondents is considered acceptable for preliminary correlational analysis involving simple regression models.

The sampling technique used was *non-probability purposive sampling*. This technique was selected because respondents were required to meet specific characteristics related to maritime operational experience. The inclusion criteria were:

1. Respondents have maritime education, training, or operational experience.
2. Respondents understand basic ship operation and emergency procedures.
3. Respondents are willing to participate voluntarily.
4. Respondents have experience participating in maritime safety training or emergency drills.

Purposive sampling is appropriate when researchers need participants with specific knowledge or experience relevant to the research objectives (Campbell et al., 2020).

Data Collection Instrument

Data were collected using a structured questionnaire distributed to selected respondents. The questionnaire consisted of two main sections. The first section measured *exception exposure deprivation*, including indicators related to limited experience with abnormal situations, frequency of emergency scenario exposure, and variation of operational experiences. The second section measured *emergency readiness vulnerability*, including indicators related to emergency confidence, decision-making ability, situational awareness, and perceived preparedness.

The questionnaire items were developed based on previous studies related to maritime human factors, emergency preparedness, and simulator-based maritime training. Items were adapted to fit the research context of highly standardized ship operations. All statements were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Before data analysis, the questionnaire was tested to ensure measurement quality. A validity test was conducted using Pearson product-moment correlation to determine whether each item accurately measured the intended construct. Reliability testing was conducted using Cronbach's alpha coefficient, where values above 0.70 indicate acceptable internal consistency (Taber, 2020).

Research Procedure

The research procedure was conducted through several stages. The first stage involved identifying the research problem based on the increasing standardization and automation of maritime operations and its potential influence on emergency preparedness. The second stage involved developing research instruments based on relevant maritime safety and human factor literature.

The third stage involved distributing questionnaires to selected respondents who met the predetermined criteria. Respondents were informed about the purpose of the research and participation was conducted voluntarily. After collecting responses, the data were reviewed to ensure completeness and accuracy before statistical analysis. The final stage involved analyzing the collected data and interpreting the relationship between exception exposure deprivation and emergency readiness vulnerability. The findings were then evaluated to determine whether limited exposure to abnormal situations contributes to reduced emergency readiness among seafarers.

Data Analysis

The collected data were analyzed using statistical methods with the support of statistical software such as *IBM SPSS Statistics*. The analysis was conducted through several stages.

First, descriptive statistics were used to describe respondent characteristics and the distribution of responses for each research variable. This analysis provided an overview of the level of exception exposure deprivation and emergency readiness vulnerability among respondents.

Second, validity and reliability tests were performed to evaluate the quality of the questionnaire instrument. Pearson correlation analysis was applied to examine item validity, while Cronbach's alpha was used to assess internal consistency.

Third, Pearson correlation analysis was conducted to determine the strength and direction of the relationship between exception exposure deprivation and emergency readiness vulnerability. Finally, simple linear regression analysis was performed to examine the predictive influence of exception exposure deprivation on emergency readiness vulnerability. The regression model used in this study was:

$$Y = \alpha + \beta X + e$$

Where:

Y = Emergency Readiness Vulnerability

X = Exception Exposure Deprivation

α = Constant value

β = Regression coefficient

e = Error term

The analysis results were used to determine whether limited exposure to abnormal situations significantly influences emergency readiness among seafarers.

RESEARCH RESULT

Respondent Characteristics

This study involved 100 respondents consisting of active seafarers and maritime trainees in Banten, Indonesia. The analysis of respondent characteristics was conducted to identify the background of participants related to maritime experience, operational involvement, and emergency training exposure. These characteristics provide important information because differences in operational experience may influence how individuals perceive abnormal situations and their ability to respond during emergencies. The variation among respondents allows the study to examine emergency readiness from different levels of maritime exposure.

Table 1. Characteristics of Respondents

Characteristics	Category	Frequency (n)	Percentage (%)
Respondent Status	Active Seafarers	58	58
	Maritime Trainees	42	42
Maritime Experience	Less than 3 years	39	39
	3–5 years	36	36
	More than 5 years	25	25
Emergency Training Exposure	Regular emergency drills	67	67
	Limited emergency drills	33	33

Table 1 shows that the respondents consisted of 58 active seafarers and 42 maritime trainees. Most respondents had maritime experience of less than three years (39%), followed by respondents with 3–5 years of experience (36%). This indicates that the majority of participants were still developing operational experience and adaptive capabilities in maritime environments. Furthermore, 67% of respondents had regularly participated in emergency drills, while 33% had limited exposure to emergency training activities. These findings indicate that although emergency training exposure exists, direct experience with abnormal operational situations may still vary among seafarers.

Descriptive Analysis of Exception Exposure Deprivation

Exception exposure deprivation was analyzed to determine the extent to which respondents experienced limitations in encountering abnormal operational situations. This variable represents the reduced opportunity for seafarers to experience conditions beyond routine procedures. The measurement focused on several aspects, including exposure to unexpected events, variation of emergency scenarios, and experience in handling situations outside normal operations.

Table 2. Descriptive Statistics of Exception Exposure Deprivation

Indicators	Mean	Standard Deviation	Interpretation
Limited exposure to abnormal operational situations	3.52	0.74	Moderate
Limited variation of emergency scenarios	3.45	0.71	Moderate
Rare experience beyond standard procedures	3.39	0.76	Moderate
Limited opportunity for adaptive decision-making	3.44	0.70	Moderate
Overall Score	3.45	0.72	Moderate

Table 2 demonstrates that the overall mean score of exception exposure deprivation was 3.45, indicating a moderate level of limited exposure to abnormal operational conditions. The highest mean value was found in the indicator related to limited exposure to abnormal situations (3.52), suggesting that respondents experienced fewer opportunities to directly encounter unexpected operational events. The lowest score was observed in experience beyond standard procedures (3.39), indicating that some respondents still had opportunities to face operational variations. These results show that highly standardized ship operations may provide consistency during normal conditions but may reduce opportunities for developing adaptive experience.

The finding supports the conceptual assumption of this study that limited exposure to abnormal situations represents a potential human factor challenge in maritime safety. The results indicate that seafarers may have sufficient procedural knowledge but fewer opportunities to strengthen decision-making skills in unpredictable conditions.

Descriptive Analysis of Emergency Readiness Vulnerability

Emergency readiness vulnerability was measured to identify the extent of limitations experienced by respondents when facing emergency conditions. This variable reflects several aspects, including confidence, decision-making ability, situational awareness, and response capability during unfamiliar situations. Understanding this variable is important because emergency conditions often require rapid adaptation beyond routine operational procedures.

Table 3. Descriptive Statistics of Emergency Readiness Vulnerability

Indicators	Mean	Standard Deviation	Interpretation
Confidence during emergency situations	3.20	0.73	Moderate
Decision-making under pressure	3.15	0.69	Moderate
Response capability in unfamiliar situations	3.11	0.75	Moderate
Situational awareness during emergencies	3.26	0.68	Moderate
Overall Score	3.18	0.71	Moderate

Table 3 shows that emergency readiness vulnerability obtained an overall mean score of 3.18. The highest score was found in situational awareness during emergencies (3.26), indicating that respondents generally understood the importance of monitoring conditions during critical events. Meanwhile, the lowest score was observed in response capability during unfamiliar situations (3.11), suggesting that respondents experienced greater challenges when facing conditions outside their previous experience. These results indicate that emergency readiness is not only influenced by knowledge of procedures but also by exposure to varied operational situations. The findings strengthen the argument that limited experience with abnormal situations may influence the ability of seafarers to respond effectively during emergencies.

Validity and Reliability Analysis

Before conducting hypothesis testing, the research instrument was evaluated to ensure that all measurement items were valid and reliable. Validity testing was conducted to determine whether each questionnaire item represented the intended construct. Reliability testing was performed to examine the consistency of measurement items used in this study.

Table 4. Validity and Reliability Test Results

Variable	Number of Items	Validity Range	Cronbach's Alpha	Result
Exception Exposure Deprivation	8	0.452–0.786	0.861	Valid and Reliable
Emergency Readiness Vulnerability	8	0.438–0.794	0.879	Valid and Reliable

Table 4 indicates that all questionnaire items achieved acceptable validity values. The correlation range for both variables exceeded the minimum acceptable level, demonstrating that each item was capable of measuring its respective construct. The reliability analysis showed Cronbach's alpha values above 0.80 for both variables, indicating strong internal consistency. Therefore, the measurement instrument was considered appropriate for further statistical analysis. The reliability findings confirm that the variables used in this study can consistently represent exception exposure deprivation and emergency readiness vulnerability among seafarers.

Relationship Between Exception Exposure Deprivation and Emergency Readiness Vulnerability

Pearson correlation analysis was conducted to examine the relationship between exception exposure deprivation and emergency readiness vulnerability. This analysis was performed to determine whether limited exposure to abnormal operational situations was associated with increased vulnerability during emergency conditions.

Table 5. Pearson Correlation Analysis Between Research Variables

Relationship	Correlation Coefficient (r)	Significance (p-value)	Interpretation
Exception Exposure Deprivation → Emergency Readiness Vulnerability	0.638	<0.001	Significant Positive Relationship

Table 5 shows a significant positive relationship between exception exposure deprivation and emergency readiness vulnerability ($r = 0.638$, $p < 0.001$). The positive correlation indicates that higher levels of limited exposure to abnormal situations are associated with higher emergency readiness vulnerability. This means that respondents who experienced fewer opportunities to encounter unexpected operational events tended to report greater limitations in emergency preparedness. The result demonstrates that operational exposure diversity plays an important role in strengthening adaptive capabilities among seafarers. Based on this finding, the hypothesis proposed in this study is supported H1: Exception Exposure Deprivation significantly influences Emergency Readiness Vulnerability among seafarers.

Regression Analysis and Hypothesis Testing

Simple linear regression analysis was conducted to determine the predictive influence of exception exposure deprivation on emergency readiness vulnerability. This analysis aimed to identify whether exception exposure deprivation could explain changes in emergency readiness vulnerability among respondents.

Table 6. Simple Linear Regression Analysis

Predictor Variable	Beta (β)	t-value	Significance
Exception Exposure Deprivation	0.638	8.15	<0.001

Table 7. Regression Model Summary

R	R Square (R^2)	Adjusted R Square
0.638	0.407	0.401

Table 6 demonstrates that exception exposure deprivation significantly predicts emergency readiness vulnerability with a positive regression coefficient ($\beta = 0.638$, $p < 0.001$). This indicates that increasing limitations in abnormal situation exposure are followed by increasing vulnerability in emergency readiness. Table 7 shows that exception exposure deprivation explains 40.7% of the variation in emergency readiness vulnerability. The remaining variation may be influenced by other factors such as training quality, individual experience, organizational support, and psychological readiness. These findings confirm that limited exposure to abnormal operational situations is an important factor affecting emergency preparedness among seafarers.

The results of this study demonstrate that exception exposure deprivation significantly influences emergency readiness vulnerability among seafarers operating in highly standardized ship environments. The findings show that standardization and automation may improve operational reliability during normal conditions, but limited exposure to abnormal situations can become a potential weakness in emergency preparedness. Unlike previous studies that mainly focus on accident prevention, simulator effectiveness, or safety training outcomes, this study highlights the importance of considering the absence of abnormal exposure as a human factor risk.

The novelty of this research lies in introducing *exception exposure deprivation* as a potential hidden vulnerability factor in maritime safety. The study provides a new perspective that safety improvement should not only focus on reducing operational failures but also on increasing opportunities for seafarers to develop adaptive responses through diverse emergency scenarios. These findings suggest that maritime education institutions and shipping organizations should design training programs that provide realistic and varied emergency experiences to strengthen decision-making capability and emergency readiness.

DISCUSSION

The findings of this study demonstrate that exception exposure deprivation significantly influences emergency readiness vulnerability among seafarers operating in highly standardized ship environments. The positive relationship between these variables indicates that limited opportunities to experience abnormal operational conditions may reduce the ability of seafarers to respond effectively during emergency situations. This finding can be explained through the concept of adaptive expertise, where individuals develop stronger problem-solving abilities when they encounter diverse and challenging situations. According to Myllylä et al. (2022), maritime competence is not only developed through formal procedures but also through accumulated operational experiences that allow individuals to adjust their actions under uncertain conditions. Therefore, the current study extends previous safety perspectives by showing that the absence of abnormal exposure may become a potential vulnerability factor rather than merely a lack of training opportunity.

The relationship identified in this study is consistent with previous research emphasizing the importance of experiential learning in safety-critical industries. Hystad and Eid (2021) found that safety performance among maritime personnel is strongly influenced by psychological preparedness, operational awareness, and previous experience with challenging situations. Their study supports the current finding because both studies highlight that emergency competence cannot be developed solely through routine operational activities. However, the present research differs from previous studies because it does not focus on the effect of training programs or individual characteristics but examines the potential negative consequence of insufficient exposure to abnormal events. This difference provides a new perspective by suggesting that highly reliable operational systems may unintentionally reduce opportunities for developing adaptive emergency capabilities.

The findings also contribute to discussions regarding the role of standardization and automation in maritime safety. Standard operating procedures are essential for maintaining consistency and reducing operational errors, but excessive dependence on predefined responses may create limitations when seafarers encounter situations outside normal patterns. According to Wróbel et al. (2023), increasing automation in maritime operations requires stronger human adaptability because operators may face rare but complex situations where automated systems provide limited assistance. This previous research supports the current study because both emphasize that human capability remains essential despite technological development. Nevertheless,

the current study provides additional insight by identifying limited abnormal exposure as a possible mechanism through which standardized environments influence emergency readiness vulnerability.

The results further indicate that emergency preparedness should be strengthened through training approaches that provide meaningful exposure to diverse scenarios rather than focusing only on procedural repetition. Similar findings were reported by Pritchard et al. (2022), who demonstrated that realistic scenario-based training improves decision-making performance and confidence among professionals working in high-risk environments. The similarity between these studies lies in the recognition that practical exposure contributes to improved emergency response capability. However, while previous research mainly evaluated the effectiveness of training interventions, this study focuses on the underlying condition that creates the need for such interventions, namely insufficient exposure to abnormal situations. This distinction highlights the novelty of the current research because it shifts attention from improving training outcomes toward identifying hidden weaknesses within standardized operational systems.

Although this study provides important contributions, several limitations should be considered. First, the research used a quantitative correlational design with respondents from Banten, Indonesia, which may limit the generalization of findings to seafarers from different maritime regions and operational environments. Second, the study relied on self-reported questionnaire data, meaning that respondents' perceptions may not completely represent their actual emergency performance. Future research should consider combining survey methods with simulator-based experiments, behavioral observations, or longitudinal studies to examine how exposure diversity influences real emergency decision-making over time. Despite these limitations, the study contributes a new theoretical perspective by introducing exception exposure deprivation as a human factor variable that should be considered in maritime safety management.

CONCLUSIONS AND RECOMMENDATIONS

This study concludes that exception exposure deprivation significantly influences emergency readiness vulnerability among seafarers in highly standardized ship operations. Based on the analysis of 100 respondents, exception exposure deprivation showed a significant positive relationship with emergency readiness vulnerability ($r = 0.638$, $p < 0.001$). The regression analysis further confirmed that exception exposure deprivation significantly predicts emergency readiness vulnerability ($\beta = 0.638$, $p < 0.001$) and explains 40.7% of the variance in emergency readiness vulnerability ($R^2 = 0.407$). These findings indicate that limited exposure to abnormal operational situations may reduce seafarers' preparedness, particularly in responding to unfamiliar emergency conditions and making decisions under pressure. Therefore, maritime education institutions and shipping organizations are recommended to provide more diverse emergency scenarios and realistic training environments to strengthen adaptive capabilities and improve maritime safety performance.

ADVANCED RESEARCH

This study has several limitations. The research used a quantitative correlational approach with 100 seafarers and maritime trainees in Banten, Indonesia, which may limit the generalization of findings to other maritime populations. Future research is recommended to involve larger samples, different maritime regions, and additional methods such as simulator-based experiments or observational studies to further examine how abnormal situation exposure affects emergency response performance.

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