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The Effect of Crew Skills and Safety Training on Man Overboard Handling with Occupational Safety as a Mediating Variable

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Abstract: Man Overboard (MOB) remains one of the most fatal maritime accidents, yet its prevention is often examined only through technical factors. The research gap lies in the limited empirical study positioning occupational safety as a mediating mechanism linking human capital investment to MOB handling capability in the offshore vessel sector. This study aims to analyze the effect of crew skills and safety training on MOB handling, both directly and through occupational safety as a mediating variable. A quantitative approach with path analysis was applied to 43 crew members of PT Asean Cableship, selected through convenience sampling, using a five-point Likert questionnaire processed with SPSS. The results show that crew skills and safety training positively and significantly affect occupational safety, Crew skills, safety training and occupational safety also positively and significantly affect MOB handling, Occupational safety partially mediates both relationships, The novelty of this study lies in positioning occupational safety as an intervening mechanism in the offshore cable-ship context.

Keyword: Crew Skills, Safety Training, Occupational Safety, Man Overboard.

INTRODUCTION

The incident of a person falling into the water, technically referred to as Man Overboard (MOB), is one form of maritime accident arising from natural influences, technical constraints, and human behavioral variables (Widodo & Saleh, 2022). Environmental factors include storms and high waves, technical factors include ship collisions, fires, and sinking, while the human dimension is rooted in negligence and low personnel vigilance. Conditions such as insufficient caution in areas outside the accommodation during high waves, undisciplined behavior near railings, and loss of concentration while crossing slippery decks are significant human-related causes of MOB incidents.

The National Transportation Safety Committee of the Republic of Indonesia recorded 235 shipping accident cases from 2003 to 2023, with 1,826 fatalities and 661 injuries (Komite Nasional Keselamatan Transportasi, 2023). Although the statistical incidence of MOB is smaller compared to other maritime emergencies, its fatality rate is very high because rescue efforts face limitations in time, weather conditions, and the competence of responders (Marine Accident Investigation Branch, 2015). The accuracy of ship maneuvering selection is also a

crucial factor for accurately returning the ship's position to the location where the victim fell (Formela et al., 2015), while crew members are required to understand the ship's characteristics and the physical forces affecting its movement (Subandrijo, 2014).

From a regulatory perspective, Article 86 paragraph (2) and Article 87 paragraph (1) of Law Number 13 of 2003 on Manpower, together with Law Number 1 of 1970 on Occupational Safety, require companies to establish occupational safety and health programmed, provide personal protective equipment, and provide training on its use. At the international level, the Standards of Training, Certification and Watchkeeping (STCW) 1978, along with the 2010 Manila Amendments, require safety refresher training on a five-year cycle, while the International Safety Management Code requires companies to establish emergency preparedness procedures and train all relevant personnel. This regulatory framework positions skills and training as normative obligations but has not yet explained the psychological and organizational mechanisms that link them to safety outcomes in the field.

Several previous studies have examined this issue, but most stop at direct relationships and use qualitative approaches. Indra Bagus and Cahya Fajar (2023) found three main problems on the MV Zaleha Fitrat: minimal officer supervision during safety drills, low crew understanding of procedures for handling persons overboard, and insufficient mastery of safety equipment. Narwastu (2023) highlighted the importance of passenger compliance with safety instructions in supporting MOB prevention. Kusumartono et al. (2020), through rescue turn maneuver trials on a radar simulator, found that trainees' responses during emergencies often did not match the maneuver manual, particularly in the early stages. Sonlay (2023) reported that victim handling on the MV Lauser was not fully in accordance with procedures, resulting in suboptimal evacuation.

On the other hand, Sitorus et al. (2024) and Prasetyo et al. (2022) have used quantitative approaches and demonstrated links between safety equipment maintenance, self-rescue skills, and crew performance. However, neither study explicitly tested occupational safety as an intervening variable. Thus, the research gap that emerges is the absence of an empirical model that simultaneously tests the mediating role of occupational safety in the relationship between crew skills, safety training, and MOB handling, particularly in the offshore vessel sector, which has operational characteristics different from passenger ships or general merchant vessels.

This research is grounded in Human Capital Theory as proposed by Becker (1964), which views knowledge, skills, experience, and training as a form of organizational investment in human resources, rather than merely a cost. Such investment enhances individuals' ability to carry out work effectively, efficiently, and safely, thereby reducing the risk of occupational accidents. In the shipping industry, this investment is realized through safety training, emergency drills, and the enhancement of crew members' technical skills. The higher the skills and the more effective the training provided, the better the implementation of occupational safety on board, which in turn improves readiness to face MOB events.

The novelty (state of the art) of this research lies in two aspects. Contextually, the research was conducted at PT Asean Cableship, a Singapore-flagged offshore towing and supply vessel management company operating in marine construction and petroleum exploration activities — a context that has not been widely studied in Indonesian maritime safety literature. Conceptually, this research positions occupational safety as a mediating variable that bridges the effect of skills and training on MOB handling, thus not stopping at direct relationships as in previous research.

Based on the above description, the research objectives are does crew skill affect occupational safety, does safety training affect occupational safety, does occupational safety affect Man Overboard handling, does crew skill affect Man Overboard handling, both directly and through occupational safety as a mediating variable and does safety training affect Man Overboard handling, both directly and through occupational safety as a mediating variable.

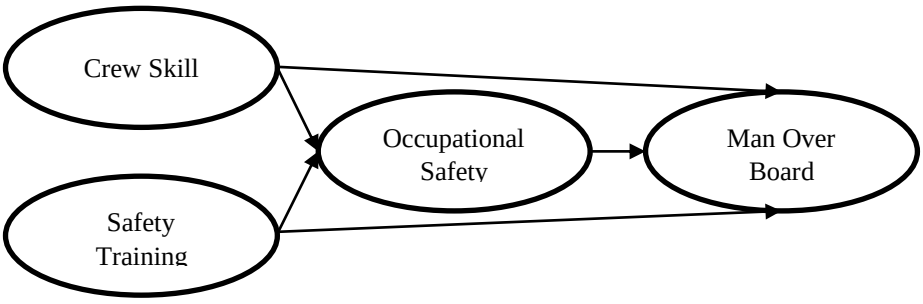
METHOD

Cableship, a Singapore-flagged offshore towing and supply vessel management company involved in offshore construction, maritime exploration, and petroleum activities. The type of data used is primary data obtained directly from respondents through a structured questionnaire.

The research population consisted of 45 crew members of PT Asean Cableship, distributed across several vessels. Sample size was determined using the Slovin formula with a five percent margin of error, yielding a minimum sample size of 41 respondents. Sampling was conducted using the convenience sampling technique, based on availability and ease of reaching sample elements, given that crew members were on different sailing schedules. A total of 43 questionnaires were returned and met the completeness criteria, thereby exceeding the required minimum sample size.

The research instrument was a questionnaire distributed via Google Form, measured using a five-point Likert scale, ranging from strongly disagree (value one) to strongly agree (value five). The crew skill variable was measured through four indicators: skill in handling MOB, performance of duties and responsibilities, discipline, and skill in using safety equipment. The safety training variable was measured through two indicators: MOB rescue drills and mastery of MOB rescue procedures/muster lists. The occupational safety variable was measured through three indicators: sense of safety at work, teamwork, and procedures for using safety equipment. The MOB handling variable was measured through two indicators: handling of accidents on board and ship maneuvering.

Data analysis techniques included descriptive analysis to map respondent characteristics and response distribution, validity and reliability tests to assess instrument feasibility, and path analysis to test direct and indirect relationships between variables. Path analysis is a development of multiple linear regression that allows tracing the effect of independent variables on dependent variables both directly and through mediating variables. The structural model estimated is expressed in two equations. The first structural equation is KK = ρzx1KAK + ρzx2PK + ρzЄ1, while the second structural equation is MOB = ρyx1KAK + ρyx2PK + ρyzKK + ρyЄ2, where KAK denotes crew skill, PK denotes safety training, KK denotes occupational safety, and MOB denotes Man Overboard handling. Hypothesis testing was conducted using the t-test, with the decision criterion of rejecting the null hypothesis if the significance value is less than 0.05. Data processing used SPSS software. The conceptual framework of the research is presented in Figure 1.



Source: Research Results

Figure 1. Conceptual Framework

RESULTS AND DISCUSSION

Results

Respondent Characteristics

The study respondents consisted of 43 crew members of PT Asean Cableship. Based on position, respondents comprised 3 masters, 3 chief officers, 14 engine department personnel, 16 deck department personnel, 4 galley personnel, and 3 interpreters. This composition shows

that many respondents came from the deck department, the unit that interacts most with the ship's open areas and is therefore most exposed to MOB risk. Based on education level, 8 respondents had vocational high school (SMK/STM) education, 25 respondents had diploma education, and 10 respondents had bachelor's degree education, indicating that many crew members had an adequate maritime vocational education background. Based on age, 4 respondents were under 30 years old, 21 respondents were 31 to 40 years old, and 18 respondents were over 40 years old, indicating that most crew members were within a productive age range with accumulated work experience.

Descriptive Analysis

Descriptive analysis shows that for the crew skill variable, the discipline indicator received the highest positive response, with 27 respondents stating agree and 10 respondents stating strongly agree. However, the MOB handling skill indicator received the weakest response, with 2 respondents disagreeing and 16 respondents only stating moderately agree. This finding indicates a gap between formal discipline and mastery of specific technical skills for MOB handling.

For the safety training variable, the MOB rescue drill indicator received a good response, with 24 respondents stating agree and 9 respondents stating strongly agree. Conversely, the indicator for mastery of MOB rescue procedures/muster lists showed lower results, with 12 respondents only stating moderately agree and 4 respondents stating strongly agree. This shows that drill implementation has run well, but understanding of formal role division in the muster list still needs to be strengthened.

For the occupational safety variable, the teamwork indicator received the most positive response, with 21 respondents stating agree and 15 respondents stating strongly agree. For the MOB handling variable, the indicator for handling accidents on board received the best response, with 22 respondents stating agree and 16 respondents stating strongly agree, while the ship maneuvering indicator showed the weakest results, with 19 respondents only stating moderately agree. This pattern is consistent with the findings of Kusumartono et al. (2020), who found that mastery of rescue maneuvers is the aspect most difficult for crew members to master.

Validity and Reliability Tests

Validity testing showed that all indicators had correlation coefficients above the critical value, so all statement items were declared valid and suitable for use as measurement instruments. Validity coefficients ranged from 0.391 to 0.852, with the highest coefficient on the sense-of-safety-at-work indicator and the lowest coefficient on the task and responsibility performance indicator. The reliability test results are presented in Table 1.

Table 1. Reliability Test Results

Variable	Cronbach's Alpha	Conclusion
Crew Skill	0.728	Reliable
Safety Training	0.739	Reliable
Occupational Safety	0.722	Reliable
Man Overboard Handling	0.705	Reliable

Source: Data Processing Results (2026)

All variables had Cronbach's Alpha values above 0.60 as per the criteria proposed by Sekaran and Bougie (2020), so the research instrument was declared reliable and consistent in measuring the intended constructs.

First Structural Path Analysis Results

The first structure tested the effect of crew skill and safety training on occupational safety. The model produced a coefficient of determination of 0.464 with an F-test significance value of 0.005, so the model was declared fit. This value means that 46.4 percent of the variation in occupational safety can be explained by crew skill and safety training, while the remaining 53.6 percent is explained by other factors outside the model. The path coefficient test results are presented in Table 2.

Table 2. First Structural Path Analysis Results

Relationship Between Variables	Path Coefficient	t-value	Sig.	Decision
Crew Skill → Occupational Safety	0.406	2.550	0.015	H1 accepted
Safety Training → Occupational Safety	0.326	1.789	0.035	H2 accepted

Source: Data Processing Results (2026)

Second Structural Path Analysis Results

The second structure tested the effect of crew skill, safety training, and occupational safety on MOB handling. The model produced a coefficient of determination of 0.424 with an F-test significance value of 0.000, so the model was declared fit. This value means that 42.4 percent of the variation in MOB handling can be explained by the three variables in the model, while the remaining 57.6 percent is explained by other factors. The test results are presented in Table 3.

Table 3. Second Structural Path Analysis Results

Relationship Between Variables	Path Coefficient	t-value	Sig.	Decision
Crew Skill → MOB Handling	0.375	2.224	0.026	Significant
Safety Training → MOB Handling	0.417	2.475	0.038	Significant
Occupational Safety → MOB Handling	0.440	3.173	0.003	Significant

Source: Data Processing Results (2026)

Indirect Effect Test Results

Indirect effects were calculated by multiplying the path coefficients on both mediation segments. The calculation results, along with their comparison to direct effects, are presented in Table 4.

Table 4. Indirect Effects

Path	Indirect Effect	Mediation Type
Crew Skill → Occupational Safety → MOB Handling	0.406 × 0.440 = 0.179	Partial mediation
Safety Training → Occupational Safety → MOB Handling	0.326 × 0.440 = 0.143	Partial mediation

Source: Data Processing Results (2026)

Because both the direct and indirect effects are significant and in the same direction, occupational safety is proven to act as a partial mediator (complementary partial mediation) on both paths. Thus, the fourth and fifth hypotheses are accepted.

Discussion

Effect of Crew Skill on Occupational Safety

The results show that crew skill has a positive and significant effect on occupational safety, with a path coefficient of 0.406. This finding means that every increase in crew members' mastery of technical skills is followed by an improvement in the quality of occupational safety implementation on board. Crew members who master safety procedures and equipment are not only able to act appropriately but also have greater risk awareness, making them more likely to consistently comply with operational standards.

This finding is consistent with Indra Bagus and Cahya Fajar (2023), who found that crew members' limited understanding of MOB procedures slows down the rescue process, and that the solution lies in implementing drills, familiarization, socialization of emergency procedures, and adding first-aid literature. Within the framework of Human Capital Theory (Becker, 1964), skill is a form of human capital accumulated through experience and learning, and this accumulation produces outcomes in the form of safer work behavior.

Effect of Safety Training on Occupational Safety

Safety training was shown to have a positive and significant effect on occupational safety, with a path coefficient of 0.326. The implementation of MOB rescue drills and mastery of muster list procedures build collective readiness that reduces the likelihood of errors in operating safety equipment. Training functions not merely as compliance with STCW and ISM Code regulatory obligations, but as a mechanism for establishing safe work routines.

This result is consistent with Kusumartono et al. (2020), who found that insufficient training leads to errors that endanger MOB victims' safety, particularly in the early stages of rescue maneuvers. It should be noted that the training coefficient is smaller than the skill coefficient in the first structure. This indicates that formal training alone is not sufficient unless internalized into skills embedded in the individual, consistent with the descriptive analysis results showing weaker mastery of muster list procedures compared to drill implementation.

Effect of Occupational Safety on Man Overboard Handling

Occupational safety has a positive and significant effect on MOB handling, with a path coefficient of 0.440, the largest coefficient in the model. This finding shows that a good occupational safety climate — reflected in a sense of safety at work, quality of teamwork, and mastery of safety equipment usage procedures — is the strongest determinant of crew readiness to face MOB events.

This result is consistent with Sonlay (2023), who emphasized the importance of clarity in crew duties and responsibilities during MOB events, as regulated in the ISM Code-based safety management system manual. The dominance of the teamwork indicator in the descriptive analysis reinforces this interpretation, given that MOB rescue is a collective operation dependent on coordination between positions as listed in the muster list.

Effect of Crew Skill on Man Overboard Handling through Occupational Safety

Crew skill affects MOB handling both directly, with a coefficient of 0.375, and indirectly through occupational safety, with a coefficient of 0.179, resulting in a total effect of 0.554. Because both paths are significant, occupational safety acts as a partial mediator. This means that skill works through two mechanisms simultaneously: directly through technical proficiency in executing rescue procedures, and indirectly through the formation of a safety climate that supports such execution.

This finding extends the results of Prasetyo et al. (2022), who stated that basic safety skills are mandatory for everyone working on board and that safety at sea depends on equipment readiness. This research shows that such readiness is not merely technical but also organizational, through the occupational safety variable.

Effect of Safety Training on Man Overboard Handling through Occupational Safety

Safety training affects MOB handling both directly, with a coefficient of 0.417, and indirectly through occupational safety, with a coefficient of 0.143, resulting in a total effect of 0.560. A pattern of partial mediation was again found on this path. Interestingly, the direct effect of training on MOB handling is greater than the direct effect of skill, even though in the first structure training had a smaller coefficient. This can be understood because MOB training

is highly specific to emergency situations, so its impact is more directly felt in readiness to face incidents compared with daily safety climate.

This finding is consistent with Sitorus et al. (2024), who stated that adequate training and education on safety equipment maintenance can increase crew awareness and compliance with established procedures.

CONCLUSION

Conclusion

This research concludes that crew skill and safety training both have a positive and significant effect on occupational safety at PT Asean Cableship, with a combined contribution of 46.4 percent. Furthermore, crew skill, safety training, and occupational safety jointly have a positive and significant effect on Man Overboard handling, with a contribution of 42.4 percent, where occupational safety is the strongest determinant with a path coefficient of 0.440.

Occupational safety is proven to partially mediate the effect of both crew skill and safety training on Man Overboard handling. Thus, improving MOB handling capability cannot be achieved solely by adding training hours or skill certification, but must be accompanied by strengthening the occupational safety climate, which includes a sense of safety, teamwork, and mastery of safety equipment use. This finding contributes to the development of maritime safety management by positioning occupational safety as a process variable, not merely an outcome variable.

Limitations

This research has several limitations. First, the research was conducted at only one offshore vessel management company with 43 respondents, so the results cannot yet be generalized to the entire shipping sector or other operational areas. Second, the research used only three explanatory variables, while other factors such as work fatigue, captain's leadership, organizational safety culture, and operational weather conditions may also potentially affect MOB handling readiness. Third, the convenience sampling technique used did not give every population member an equal chance of being selected, so sample representativeness needs to be interpreted with caution. Fourth, variable measurement relied on respondents' self-perception through a questionnaire, so it does not yet reflect actual MOB handling performance and does not capture long-term changes.

Recommendations

For future research, it is recommended to expand the research object to several shipping companies, increase the sample size, and add other relevant variables such as safety culture, work fatigue, and safety leadership. The use of a more robust analytical method, such as Partial Least Squares-based Structural Equation Modelling with a bootstrapping procedure, is also recommended to more accurately test the significance of indirect effects, along with a longitudinal approach to capture changes in safety readiness over time.

For PT Asean Cableship's management, the descriptive analysis results indicate three priority areas requiring attention: the continued presence of crew members not yet skilled in handling MOB, weak understanding of rescue procedures/muster lists, and low mastery of ship maneuvering. The company is advised to establish a more detailed and scheduled drill implementation policy on board, strengthen the socialization of the muster list so each crew member specifically understands their role, and conduct simulator-based rescue maneuver training for deck officers. Strengthening the occupational safety climate through close officer supervision during drills is also needed, given that this variable has the greatest influence in the model.

Author Contributions

The first author was responsible for research conceptualisation, data collection, data analysis, and manuscript preparation. The second author contributed to the formulation of the theoretical framework, interpretation of results, and critical review and revision of the manuscript. All authors have read and approved the final version of the article submitted for publication.

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