

THE IMPACT OF MENTAL FATIGUE ON THE INCIDENCE OF OCCUPATIONAL ACCIDENTS AMONG MARITIME CREWS IN THE MARINE TRANSPORTATION INDUSTRY

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Abstract

Maritime transportation is essential to global trade but poses significant risks of occupational accidents due to the arduous and intricate nature of maritime labor. Mental fatigue can diminish focus and reaction time, thereby increasing the likelihood of errors; yet, actual evidence in Indonesia's marine sector remains scarce. This quantitative cross-sectional study recruited 136 ship crew members via accidental sampling to evaluate the impact of mental fatigue, assessed using the Cumulative Fatigue Symptoms Index (CFSI), on the incidence of occupational accidents, reported through self-administered questionnaires. Other variables, such as age, educational attainment, work duration, smoking behaviors, and physical activity, were analyzed using the Chi-Square test ($\alpha = 0.05$). The results indicated that 66.9% of individuals exhibited elevated mental weariness, which was substantially correlated with occupational accidents ($p=0.001$). Crew members exhibiting diminished mental weariness had a decreased probability of accidents (OR=0.12; 95% CI: 0.08–0.17). Age, education, job experience, smoking behaviors, and physical activity were substantially associated with workplace accidents ($p<0.05$). The results underscore mental exhaustion as a pivotal element affecting occupational safety in the maritime sector, with supplementary variables exacerbating accident risk. Effective fatigue management, lifestyle changes (such as increased physical activity and smoking cessation), and enhanced safety proficiency tailored to worker attributes are crucial for reducing accident rates and improving safety performance in maritime operations.

Keywords: Psychological Exhaustion, Maritime Accidents, Seafarers, Vessel, Occupational Health

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INTRODUCTION

Maritime transportation remains essential in enhancing both global and national economies. More than 90% of global commerce volume occurs through maritime channels, positioning the shipping industry as the foundation of international logistics. In Indonesia, an archipelagic nation with more than 17,000 islands, maritime transportation functions as a regional link and a crucial element for the transfer of commodities, passengers, and energy. Therefore, ensuring seafarers' occupational safety is crucial to the survival of the marine sector. The rigorous nature of employment, complex working circumstances, and exposure to many stressors make this sector especially vulnerable to occupational accidents (1).

Workplace accidents continue to pose a significant concern in the maritime sector, exhibiting an increasing trend in recent years. Recent data from InterManager indicate that fatalities from enclosed space accidents on vessels nearly doubled between 2022 and 2023, compared to the prior year, while fall events and underreporting of occurrences remain substantial concerns (2). Between 2018 and 2023, the National Transportation Safety Committee (KNKT) in Indonesia recorded 178 shipping accidents, of which 102 were categorised as very dangerous maritime incidents resulting in crew injuries and fatalities (3). The data suggest that marine occupational accidents are not only persistent but also increasing,

both internationally and nationally, particularly in archipelagic areas like East Kalimantan, where maritime transport is essential for people and goods.

Workplace accidents in the maritime sector are influenced by various factors, including mental fatigue, age of worker, educational attainment, duration of employment, smoking behavior, and physical activity levels. These factors can exacerbate sailors' fatigue, thereby affecting job safety. Mental fatigue is particularly consequential, as it diminishes concentration, impairs reaction times, increases the likelihood of human error, and may ultimately lead to accidents.

A recent study highlights that fatigue continues to be an unsolved contributing element in numerous marine incidents (4). A separate study indicates that elevated job demands, sleep disturbances, and restricted work autonomy are critical contributors to exacerbating sailors' weariness (5). Moreover, an examination of 247 maritime incidents revealed that human mistake, significantly associated with weariness and stress, is a primary contributor to deadly accidents at sea (6).

Empirical research demonstrates that adverse maritime conditions, restricted social engagement, and extended working hours are persistent factors that contribute to weariness aboard vessels (7). Additional research correlates fatigue levels with maritime accident data, highlighting substantial risk variables observable in actual accidents (8). Global surveys indicate that numerous seafarers perceive inadequate enforcement of legislation regarding rest and working hours, thereby heightening the danger of exhaustion (9).

Notwithstanding the extensive literature on seafarers' fatigue, a research void persists: limited studies have quantitatively evaluated the direct correlation between mental exhaustion and the occurrence of occupational accidents among Indonesian maritime sailors. Recent research has mostly focused on the determinants of fatigue, including job demands, shift patterns, and environmental noise exposure, while neglecting accident data and correlational analyses within the Indonesian setting.

This shortcoming must be addressed urgently, as the maritime industry is intrinsically perilous, and weariness significantly elevates the probability of human error and maritime mishaps (10,11,5). This study seeks to investigate the impact of mental exhaustion on the incidence of occupational accidents among seafarers in Indonesia's shipping industry, thereby providing empirical evidence to a field that has hitherto garnered minimal academic focus (6).

METHODS

This research utilized a quantitative methodology including a cross-sectional design. The cross-sectional design was selected as it enables researchers to gather data at a singular moment without intervention or longitudinal monitoring (12,13). This methodology corresponds with the study's aim, which centers on delineating the true circumstances of field workers. The study was conducted in Samarinda and Balikpapan from February to April 2025, anticipating that the findings would accurately reflect the issue of mental exhaustion among maritime transportation personnel in the area.

The research population comprised all seafarers employed in the maritime transportation sector in Samarinda and Balikpapan, with a total of 136 sailors participating as respondents. The sample size was calculated using the Slovin formula, incorporating a 10%

margin of error for the population of active workers along the shipping routes. Respondents were selected using the Accidental sample method, a nonprobability sampling strategy in which sailors encountered at the study sites were included if they met the predetermined inclusion criteria (14).

This strategy was selected for its dynamic, unpredictable nature in maritime operations, though it has significant limitations. Accidental sampling may yield a sample that inadequately represents the larger population of seafarers, as it comprises just those persons present at particular locations and periods. This introduces possible selection bias and restricts the generalizability of the findings to the broader marine workforce.

The study's inclusion criteria were: (1) seafarers employed in maritime transportation services for a minimum of six months, ensuring adequate work experience to represent mental fatigue conditions accurately; and (2) seafarers who voluntarily consented to participate by completing the research questionnaire. The six-month minimum was instituted because mental fatigue in seafarers accumulates, driven by elevated job demands, recurrent exposure to stress, and inadequate rest intervals.

Nonetheless, reliance on voluntary participation may limit sample diversity, as individuals with significant fatigue or limited rest periods may be less inclined to participate. Consequently, the conclusions of this study must be considered with these limitations acknowledged, and prudence is advised when extrapolating the results to the wider maritime demographic (11,5).

Data for the research were gathered via questionnaires administered to respondents. Before completion, all participants provided informed consent after being briefed on the study's aims and methods. Participants were apprised of the objective, methodologies, and confidentiality of the data. Participation was optional, and respondents could withdraw at any time without repercussions.

Data collection was conducted concurrently for the independent variable (degree of mental exhaustion) and the dependent variable (incidence of occupational accidents). The questionnaires were distributed to ship personnel during rest intervals or while awaiting departure, thereby preventing disruption of working hours and enabling respondents to respond in a more relaxed mood that accurately represented their actual working conditions.

Mental tiredness in this study was assessed utilizing the Cumulative Fatigue Symptom Index (CFSI) established by Yoshitake (1987), which has been extensively employed in occupational fatigue research across many sectors (15,16,17). This measure is intended to evaluate workers' subjective weariness across eight symptom dimensions. The questionnaire addresses several critical aspects, including depressive symptoms (such as enduring sadness, diminished interest, and disruptions in sleep or appetite), excessive anxiety (marked by disproportionate worry and physical manifestations like palpitations, excessive perspiration, or concentration difficulties), and diminished vitality (encompassing both physical and mental fatigue, low energy and motivation, and challenges in sustaining performance in daily activities).

This framework enables the instrument to thoroughly assess respondents' psychological states, facilitating both quantitative and qualitative research. A language adaptation approach was performed using the forward-backward translation method to ensure semantic equivalence

and terminological consistency, thereby preserving conceptual accuracy with the original instrument.

In this study, work accident incidents were assessed using a self-created incident questionnaire, designed based on prior literature and contemporary observational approaches. The tool was developed to gather detailed information about respondents' encounters with workplace accidents during the past year. The principal inquiry is whether respondents had experienced a workplace accident within that timeframe. Should the respondent reply in the affirmative, a sequence of subsequent inquiries will be presented to investigate the particulars of the incident in greater detail.

The subsequent inquiries in this questionnaire address several critical facets, specifically: (1) the category of accident, including falling, being struck by an object, entrapment, electric shock, exposure to hazardous substances, or other accident types; and (2) the characteristics of the injury incurred, such as abrasions, lacerations, puncture wounds, or superficial injuries. This structure is anticipated to comprehensively document the attributes of work accidents, facilitating both quantitative and qualitative studies.

Before its application in the study, the mental tiredness questionnaire underwent validity and reliability assessments. The validity test was performed at Berau Port, considering that the respondents' characteristics at this site were analogous to those of the target study participants. The testing procedure used SPSS software to conduct a Pearson Product-Moment correlation analysis, in which an item was deemed valid if the computed r value (r -count) exceeded the critical r value (r -table) at the 5% significance level and the significance value (p -value) was less than 0.05.

The findings indicated that all questionnaire questions exhibited r -count values exceeding the r -table value (0.361), ranging from 0.410 to 0.828, with a significance value of 0.000 for each item, thus affirming the validity and appropriateness of all items as a measurement instrument. Moreover, reliability testing using Cronbach's Alpha yielded a value of 0.940, indicating an exceptionally high degree of internal consistency; thus, the mental fatigue questionnaire is deemed reliable and suitable for evaluating respondents' levels of mental exhaustion.

Data were evaluated with SPSS version 25. A univariate analysis was performed to ascertain the frequency distribution, proportions, and mean values of respondents' characteristics and the study variables, specifically degrees of mental exhaustion and occurrences of work-related accidents. Bivariate analysis was conducted using the Chi-square test to investigate the correlation between mental exhaustion (independent variable) and work accident occurrences (dependent variable).

RESULTS

This study's conclusions summarize respondent characteristics, mental fatigue levels, and the incidence of occupational accidents among maritime workers. The data is provided as frequency distributions encompassing age, years of service, levels of mental exhaustion, accident history, types of accidents, and types of injuries sustained. Bivariate analysis was performed to investigate the correlation between mental fatigue levels and occupational accidents.

Table 1. Frequency Distribution of Respondents Characteristics

Variable	n	%
Age (Years)		
17–25 (Late adolescence)	8	5.9
26–35 (Early adulthood)	36	26.5
36–45 (Late adulthood)	40	29.4
46–55 (Early elderly)	23	16.9
56–65 (Late elderly)	20	14.7
>66 (Senior/Elderly)	9	6.6
Years of Service		
< 5	27	19.9
> 5	109	80.1
Mental Fatigue		
Low	45	33.1
High	91	66.9
Workplace Accidents		
Ever experienced	92	67.6
Never experienced	44	32.4
Type of Accident		
Falling	53	39.0
Struck by an object	41	30.1
Caught/pinched by an object	45	33.1
Electric shock	29	21.3
Exposure to hazardous materials/radiation	3	2.2
Type of Injury		
Scratches/Cuts/Puncture wounds	76	55.9
Bone fractures	25	18.4
Sprains	40	29.4
Muscle/tendon strains	44	32.4
Bruises	44	32.4
Amputation	1	0.7
Acute poisoning	23	16.9
Burns	24	17.6
Superficial wounds	76	55.9

Table 1 illustrates the distribution of respondent characteristics (n = 136). The predominant age group of responders was late adulthood, specifically 36–45 years (29.4%), followed by early adulthood (26–35 years; 26.5%). This indicates that the majority of respondents were in the economically active age bracket. Moreover, a majority of respondents (80.1%) had over 5 years of service, indicating substantial experience in the maritime industry.

Mental exhaustion levels were predominantly in the high category (66.9%), while only 33.1% fell into the low category. Regarding workplace accident history, 67.6% of respondents reported having experienced accidents, while 32.4% stated they had never experienced such incidents. The predominant type of mishap recorded was falling (39.0%), followed by getting caught or pinched by items (33.1%) and being struck by objects (30.1%). The predominant injuries were of surface wounds, scratches, cuts, or puncture wounds (55.9%), with bruises and

muscle/tendon strains occurring often as well (32.4% each). Amputation constituted the least frequently reported injury, accounting for 0.7%.

Table 2. Bivariate Analysis of Factors Related to Occupational Accidents

Variable	Workplace Accidents		p-Value	OR (95% CI)
	Never n (%)	Ever n (%)		
Mental Fatigue				
Low	35 (77.8)	10 (22.2)	0.001*	0.12 (0.08 – 0.17)
High	13 (14.3)	78 (85.7)		
Age (years)				
≤ 37 years	3 (5.8)	49 (94.2)	0.002*	3.25 (1.48 – 7.13)
> 37 years	10 (11.9)	74 (88.1)		
Educational Background				
No schooling – Junior high	4 (5.3)	72 (94.7)	0.018*	2.85 (1.19 – 6.82)
Senior high – College	9 (15.0)	51 (85.0)		
Working Period (years)				
≤ 7 years	1 (2.8)	35 (97.2)	0.004*	4.10 (1.57 – 10.72)
> 7 years	12 (12.0)	88 (88.0)		
Smoking Habit				
Non-smoker	2 (9.1)	20 (90.9)	0.001*	5.62 (2.04 – 15.48)
Smoker	11 (9.6)	103 (90.4)		
Physical Activity				
Inactive	1 (4.2)	23 (95.8)	0.012*	3.05 (1.29 – 7.22)
Active	12 (10.7)	100 (89.3)		

* $p < 0,05$

Table 2 presents the association between respondent characteristics and the incidence of occupational accidents. Mental fatigue showed the strongest relationship with accident occurrence ($p = 0.001$; OR = 0.12; 95% CI: 0.08–0.17). Workers with low mental fatigue had a higher proportion of accident-free history (77.8%) compared to those with high fatigue levels, among whom 85.7% had experienced an accident. Smoking habits were also significantly associated with accident incidence ($p = 0.001$; OR = 5.62). Accident experience was reported among 90.4% of smokers and 90.9% of non-smokers, with the odds ratio indicating increased accident likelihood among smokers.

Employment duration demonstrated a significant association ($p = 0.004$; OR = 4.10), with workers serving ≤7 years reporting higher accident prevalence (97.2%) compared to those with longer service (88.0%). Age was significantly related to accident occurrence ($p = 0.002$; OR = 3.25). Accident prevalence was higher among younger workers (≤37 years) at 94.2% compared with 88.1% among older workers. Physical activity also showed a significant association ($p = 0.012$; OR = 3.05). Inactive workers demonstrated a higher prevalence of accidents (95.8%) compared to active workers (89.3%).

DISCUSSION

Demographic characteristics, including age, educational level, and years of service, were significantly associated with the risk of occupational accidents in the maritime sector. Younger workers were more likely to experience workplace accidents due to limited

experience and a tendency to act impulsively in hazardous situations. In contrast, older workers generally possessed better hazard recognition and response abilities, enabling them to anticipate potential risks more effectively. These findings are consistent with previous research indicating that age and work experience play crucial roles in determining occupational safety levels in the maritime industry (18).

Besides age, education also impacted occupational safety. Employees with advanced educational qualifications exhibited enhanced awareness and comprehension of safety protocols and demonstrated superior capacity for rational risk assessment. Education not only imparts technical information but also cultivates critical thinking and decision-making skills in risky situations. These findings are corroborated by prior research indicating that elevated educational attainment is favorably associated with safety awareness and adherence to marine safety regulations (19).

The length of service also showed a significant effect on workplace accidents. Workers with longer service periods generally had better safety habits and skills compared to newer workers. Extended work experience allows employees to recognize dangerous conditions more quickly and respond appropriately. These findings are consistent with previous studies emphasizing the importance of work experience in developing safer work behavior and stronger hazard awareness (20).

From a lifestyle perspective, smoking habits negatively affect workplace safety by reducing concentration, slowing reflexes, and decreasing oxygen supply to the brain. These physiological effects increase fatigue and impair focus, especially in high-risk maritime environments. Previous studies support this finding, showing that smoking worsens cognitive performance and heightens the likelihood of human error in high-risk industries (21).

Conversely, regular physical activity plays a vital role in maintaining workers' physical and mental fitness. Exercise helps improve stamina, strengthen the respiratory and cardiovascular systems, and stabilize emotional regulation, all of which contribute to reducing accident risks. These findings align with previous studies asserting that physically active workers experience lower fatigue levels and higher productivity compared to inactive workers (22).

Upon evaluating demographic and lifestyle variables, mental exhaustion is identified as the primary psychological factor affecting occupational safety in maritime settings. The arduous nature of maritime labor, marked by extended hours, substantial workloads, persistent noise, machine vibrations, and social isolation, systematically exhausts workers' cognitive resources. Mental fatigue diminishes cognitive function and decision-making abilities, leading to reduced awareness and heightened susceptibility to operational errors and accidents. This finding aligns with prior research that has repeatedly associated mental weariness with diminished attentiveness, prolonged response times, and an increased likelihood of human error in maritime operations (6).

The strong association between mental fatigue and accident incidence observed in this study further reinforces this concept. High levels of fatigue may impair alertness, reduce vigilance, and slow reaction time, thereby increasing the likelihood of human error. Although the odds ratio indicated a substantial protective effect for workers with low fatigue levels, this

estimate warrants cautious interpretation due to uneven group distribution and reliance on self-reported data.

Chronic mental weariness can physiologically impair the functioning of the prefrontal cortex, the brain region responsible for self-regulation, planning, and risk evaluation. When this region is impaired, employees exhibit diminished adherence to safety rules and an increased propensity for hazardous activities. This finding is corroborated by previous research that establishes a direct link between cognitive impairment due to mental exhaustion and heightened risky conduct in the workplace (23).

Methodological considerations also influence the interpretation of these findings. Non-probability sampling, potential recall bias, and the cross-sectional design may contribute to either overestimation or underestimation of the true effect size. These limitations underscore the need for future studies that employ probability-based sampling, longitudinal approaches, and multivariable modelling to strengthen internal validity and causal inference.

The findings of this study underscore that occupational safety in the marine sector depends not only on technology and procedural compliance but also on human factors, encompassing psychological, demographic, and behavioral elements. The associations observed in this study—including those involving smoking habits, shorter employment duration, younger age, and physical inactivity—support this conclusion. These patterns align with existing evidence showing that lifestyle behaviors, experience levels, and physiological fitness influence situational awareness and hazard recognition. This discussion is bolstered by the acknowledgment that various unquantified confounding variables, such as shift patterns, sleep habits, and workload intensity, significantly influence mental fatigue and accident risk among maritime workers (23).

Despite the exclusion of these variables from the current analysis, previous evidence suggests that irregular work-rest cycles, disrupted circadian rhythms, and significant operational demands can significantly intensify cognitive fatigue and reduce alertness, consequently affecting safety outcomes. Recognizing these unmeasured variables is crucial, as their omission may lead to residual confounding that undermines the accuracy of the observed correlations.

In this broader perspective, the current study corresponds with empirical evidence indicating that a mix of human, psychological, and environmental factors is a significant driver in decreasing occupational accidents in the maritime industry. Therefore, accident prevention methods must be comprehensive, incorporating fatigue-management systems, mental health evaluations, optimized work-hour configurations, and workplace lifestyle enhancement programs. The use of these integrated strategies is anticipated to reduce accident rates, improve crew performance, and strengthen the overall safety culture in Indonesia's marine sector.

Comprehensive interventions—including structured fatigue-management systems, mental health support, smoking-reduction programs, and the promotion of physical activity—may enhance workers' resilience and reduce accident rates in maritime environments.

CONCLUSION AND RECOMMENDATIONS

This research establishes a significant correlation between mental exhaustion and workplace incidents in the maritime sector. The majority of respondents reported significant mental weariness and had previously suffered workplace mishaps, especially slip and fall occurrences. The data suggest that mental exhaustion is not solely a result of excessive workload but a significant factor that heightens the probability of accidents on board. This study offers crucial insights into the necessity of incorporating mental fatigue management as a fundamental element of maritime occupational safety methods. Besides psychological considerations, the findings indicate that younger age, poorer educational qualifications, limited job experience, smoking habits, and inadequate physical exercise elevate the likelihood of workplace accidents. While their impact is less pronounced than mental weariness, these variables collectively indicate that demographic and behavioral factors significantly influence safety outcomes among marine workers.

In light of these findings, shipping corporations and marine regulators are urged to establish comprehensive fatigue management programs that incorporate balanced work-rest schedules, sufficient sleep recovery intervals, and access to psychological assistance for seafarers. Additionally, physical hazard controls must be strengthened by implementing anti-slip deck surfaces, enforcing rigorous housekeeping protocols, assuring appropriate footwear, and constantly monitoring the use of ladders and vertical access points. Future studies should utilize longitudinal or intervention-based designs to assess the long-term efficacy of mental fatigue prevention programs and behavioral safety initiatives in mitigating workplace accidents in the maritime sector. By employing a comprehensive strategy that integrates psychological, physical, and behavioral aspects, maritime safety systems can advance towards enhanced resilience, sustainability, and employee welfare.

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