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Noise-Induced fatigue in maritime work environments: A cross-sectional study of occupational exposure among seafaring personnel in Indonesia

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ABSTRACT

Objective: The study aims to examine the relationship between occupational noise exposure and the levels of physical, mental, and emotional fatigue among speedboat crew members.

Methods: A cross-sectional study was conducted among speedboat crew members in Tarakan, North Kalimantan, Indonesia on November 2024. This study involves two categories of ship personnel as samples, namely, crew members and captains were 87 crews were enrolled in this study. We calculated using Spearman's rho models to analysed the data.

Results: The study found that occupational noise levels on speedboats ranged from 77.9 to 100.9 dB(A), with one vessel exceeding the safe exposure threshold. The level of fatigue among the respondents is mostly in the low category (69% – 74.7%). Occupational noise aboard speedboats is a significant contributor to physical ($r = .715$, $p = .040$) and mental fatigue ($r = .839$, $p = .022$).

Conclusion: The results of the statistical test indicate that, besides the main research variable, other confounding variables correlate with the fatigue levels of the crew, such as age, educational background, and working period. While overall fatigue levels were low, the study highlights the need to address noise exposure and other correlated factors to safeguard seafarers well-being.

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Introduction

Indonesia is an archipelagic nation with over 17,000 islands, mostly linked by maritime transit networks. A common kind of maritime transportation is the fast passenger

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vessel, generally referred to as a speedboat. The use of speedboats facilitates rapid transportation for the population between areas. Tarakan, located in North Kalimantan, serves as a key maritime hub linking numerous coastal communities. Tarakan, is recognized as a central transit city that significantly contributes to economic activity, the exchange of products and services, and the advancement of development in the North Kalimantan area. North Kalimantan, being one of the youngest provinces in Indonesia, has a singular airport situated at Tarakan, which functions as the primary link between this province and other provinces, as well as important cities throughout Indonesia. Consequently, the role of Tarakan City is crucial in the regional transportation and logistics framework. Daily, about 50 speedboats depart from the Tarakan speedboat station, facilitating at least seven routes that link Tarakan City with many districts and other areas in North Kalimantan. Shipping is the most effective and economical means of transportation; nonetheless, it has harmful environmental impacts [1].

Occupational noise is a considerable issue in the marine sector, especially for ship crew members, who are often subjected to elevated noise levels while performing their responsibilities. Studies indicate that noise levels aboard vessels often surpass suggested limits, resulting in many detrimental health impacts, such as hearing impairment, sleep disruptions, depression, anxiety, stress, and elevated fatigue, which may compromise both safety and productivity [1,2]. On board physical characteristics, including noise, temperature, and vibration, are acknowledged as significant contributors to work-related fatigue. Studies indicate that these environmental variables often surpass permissible limits, leading to heightened fatigue and decreased productivity among ship crew members [3,4].

According to the IMO guideline for safeguarding humans from detrimental noise pressure levels on ships, the allowable noise exposure is 85 dB(A) in work areas, 75 dB(A) in the engine control room, 65 dB(A) in the command and navigation area, and 60 dB(A) in toilets. The cumulative exposure limit must not be above 80 dB(A) during a 24-hour period [5]. In Indonesia, there are currently no clear rules governing the maximum noise exposure restrictions in the maritime workplace. The applicable laws continue to reference the general standards established by the Ministry of Manpower of the Republic of Indonesia, which stipulate a noise exposure limit of 85 dB(A) for an eight-hour workday. The maximum noise limit may be modified for reduced exposure times. For an exposure duration of four hours, the permissible noise level is 88 dB(A); for two hours, it is 91 dB(A); and for one hour, it must not surpass 94 dB(A) [6].

Investigations of noise exposure, particularly within the marine industry in Indonesia, were uncommon. Numerous studies indicate that noise levels on different kinds of vessels often surpass the established threshold limits. Noise level measurements indicate 78–98 dB(A) on ferries [7], 97.57 dB(A) on fishing boats [8], and a range of 75–100 dB(A) on cargo ships [9]. Meanwhile, noise levels on speedboats were measured at 101.96 dB(A) [10]. Assessment findings for traditional boats reveal that around 79.5% surpass permissible noise levels [11]. Should this circumstance remain daily, it will result in fatigue for the crew.

While studies indicate that noise often surpasses limits on various vessels, including speedboats in Indonesia, there is a limited body of research within the Indonesian maritime industry that specifically examines the multi-dimensional effects of this exposure on

physical, mental, and emotional fatigue. Addressing this gap is essential for developing evidence-based occupational health interventions for seafarers and speedboat operators.

Work fatigue, in the context of maritime operations, is not merely a state of physical tiredness but encompasses a broader spectrum of experiences, including physical tiredness, mental exhaustion, and emotional depletion. To comprehensively assess this complex phenomenon, this study employs the three-dimensional work fatigue inventory (3D-WFI). The 3D-WFI, with its focus on physical fatigue, mental fatigue, and emotional fatigue, provides a nuanced understanding of the fatigue experience among ship crews. By utilizing this instrument, we aim to investigate the relationship between occupational noise exposure and the specific dimensions of work fatigue, thereby contributing to a more comprehensive understanding of the factors affecting the well-being and performance of maritime professionals.

Material and methods

Study design and participants

This study was observational research employing a cross-sectional design, conducted in November 2024. A total of 87 passenger speedboat crew members participated as research subjects, selected using an accidental sampling approach based on availability at the Port of Tarakan, North Kalimantan Province, Indonesia during the study period. Eligible participants comprised both captains and crew members who had worked at least one year, routinely conducted daily round-trip operations. The crew worked every day without scheduled days off, typically operating two round-trip routes per day (departures and returns). Each route required approximately one to two and half hours of travel time in one direction, depending on weather and distance. Between trips, crew members generally had a rest period of about three to four hours while waiting for the next departure schedule. Throughout these journeys, personnel were continuously exposed to engine noise, the intensity of which differed by location on the vessel whether on the open deck, in the rear section near the engines, or inside the captain's cabin. Individuals were excluded if they were unavailable during data collection, declined to provide written informed consent, crew members on temporary duty, those on sick leave, or those unable to complete the questionnaire.

Instruments

The three dimensional work fatigue inventory questionnaire

The Three-Dimensional Work Fatigue Inventory (3D-WFI) is an instrument designed to measure work-related fatigue across three primary dimensions: physical, mental, and emotional fatigue. The physical fatigue dimension reflects bodily exhaustion resulting from intense work activities, characterized by symptoms such as physical weakness, lack of energy, or reduced physical strength. Mental fatigue refers to cognitive weariness, marked by difficulties in concentration, frequent distraction, and feelings of boredom or diminished motivation to think. Emotional fatigue, on the other hand, describes affective strain, including feelings of frustration, irritability, or emotional overwhelm due to work-related stressors [12].

The instrument comprises 18 items, with each dimension represented by six statements, and responses are recorded using a 5-point Likert scale (1 = never to 5 = every day) with range score between 6 and 30 each dimension. Higher scores indicate greater levels of fatigue in the corresponding dimension [13]. The classification of fatigue levels based on total scores for each dimension is presented in Table 1. Prior to the study, the instrument was translated and culturally adapted via back-translation. A validity and reliability test were conducted on the questionnaire using a pilot group of maritime workers (30 samples) who had same characteristics as a main participant this study to ensure validity and relevance for the Indonesian maritime context. The results demonstrated that all items were valid, with correlation coefficients exceeding the critical r-value. Additionally, the instrument showed a high level of reliability, as indicated by a Cronbach's alpha coefficient of 0.767, suggesting strong internal consistency.

Occupational noise assessment

Occupational noise measurements were conducted on six different speedboats operating on various routes. These vessels typically accommodate 40–85 passengers and are constructed primarily from fiberglass materials, designed for medium-range voyages covering distances of approximately 43–158 kilometers. Each vessel is equipped with engines ranging from 400 to 1000 horsepower, with capacity and power adjusted according to operational range and vessel type. Speedboats in this setting are generally classified into two cabin types: closed and open. Closed-type speedboats, used for

Table 1. Demographic and occupational characteristic of respondents ($n = 87$)

Variables	*n* (%)
Age (years)	87 (100)
Mean / Min-Max	30.68 / 19–63
SD	11.06
Educational background	
Elementary school	3 (3.4)
Secondary school	4 (4.6)
High school	72 (82.8)
Undergraduate student	8 (9.2)
Job position	
Skipper	24 (27.6)
Crew	63 (72.4)
Working period (years)	87 (100)
Mean / Min-Max	5.05 / 1–24
SD	4.73
Daily work duration (hour)	87 (100)
Mean / Min-Max	4.22 / 3–6
SD	0.94
Work fatigue	
Physical	
Low (≤ 17)	65 (74.7)
Moderate (18–24)	12 (13.8)
High (≥ 25)	10 (11.5)
Mental	
Low (≤ 16)	60 (69)
Moderate (17–23)	20 (23)
High (≥ 24)	7 (8)
Emotional	
Low (≤15)	62 (71.3)
Moderate (16–24)	21 (24.1)
High (≥25)	4 (4.6)

longer routes, feature enclosed cabins with amenities such as air conditioning and televisions, which help to reduce internal noise exposure through partial sound insulation. In contrast, open-type speedboats, typically used for shorter routes, lack cabin enclosures adjacent to the engine, resulting in both crew and passengers being directly exposed to higher noise levels during voyages.

The researcher employed a personal noise dosimeter, specifically the Svantek SV 104 model (Warsaw, Poland), to capture real-time noise exposure levels. Noise dosimeters were calibrated daily according to ISO 9612:2009 standards prior to measurement to ensure accuracy. The noise measurements were conducted by the corresponding author (KF) following generally accepted practices for personal noise dosimetry, in accordance with the ISO standard using the Full Day Measurement (FDM) technique. The device was positioned on the shoulder of the crew member and remained in place throughout the entire voyage, starting when the speedboat departed and ending upon arrival at the destination port. In general, the measurement focused on four key acoustic parameters expressed in decibels (dB(A)): equivalent continuous sound level (Leq), minimum sound level (Lmin), maximum sound level (Lmax), and peak sound pressure level (LCpeak). Measurement results were interpreted against the Indonesian Ministry of Manpower regulation No. 5 of 2018 stipulating a limit of 85 dB(A) for an eight-hour workday, with corresponding limits for shorter durations (e.g. 94 dB(A) for one hour, 91 dB(A) for two hours, and 88 dB(A) for four hours).

Data collection process

A structured data collection form was utilized to record demographic and occupational data (age, sex, education, job position, work duration, work experience) and the results of the 3D-WFI and noise dosimeters. The data collection was primarily performed by KF. Data quality was maintained through direct supervision during questionnaire completion, double-entry verification of all collected data, and the use of calibrated equipment.

Statistical analysis

First, descriptive statistics were used to analyze the respondents' characteristic. Normality assumptions for occupational noise and work fatigue scores were assessed using the Kolmogorov – Smirnov and Shapiro – Wilk tests. As all variables exhibited non-parametric characteristics ($p < .001$). Spearman's rho was selected, which is appropriate for non-normally distributed data and does not presuppose linearity or homoscedasticity to analyze correlation between occupational noise and fatigue. All statistical analyses were performed using SPSS version 22, and the significance level was define as $p < 0.05$.

Results

Descriptive analysis was used to determine the crew members' demographic profile, including 87 respondents in the research. The mean age of participants was 30.68 years, with a range from 19 to 63 years, and all participants were male. A significant proportion of respondents had a high school education (82.8%), with crew member being the

Table 2. Normality tests of for occupational noise and fatigue scores

	Kolmogorov-Smirnov			Shapiro-Wilks		
Parameter	Statistic	dF	*p*-value	Statistic	dF	*p*-value
Occupational Noise	.357	87	<.001	.723	87	<.001
Work Fatigue						
Physical	.136	87	<.001	.919	87	<.001
Mental	.143	87	<.001	.939	87	<.001
Emotional	.133	87	<.001	.920	87	<.001

predominant employment position (72.4%). The mean work experience was 5.05 years, and the daily working length was 4.22 h. Concerning work fatigue, the majority of participants indicated low levels across all dimensions: 74.7% for physical fatigue, 69% for mental fatigue, and 71.3% for emotional fatigue. A tiny fraction exhibited significant weariness in any category. Table 1 provides a comprehensive overview.

The results of normality assessments for occupational noise exposure and work fatigue dimensions, using the Kolmogorov – Smirnov and Shapiro – Wilk tests, are shown in Table 2. All variables exhibited statistically significant *p*-values ($p < .001$), indicating that none of the data adhered to a normal distribution. Due to the non-parametric characteristics of the data, the following correlation studies used Spearman's rho, a rank-based correlation coefficient that does not presuppose normality.

Table 3 highlights the occupational noise levels documented on six distinct speedboats at various intervals. The equivalent continuous noise levels (Leq) varied from 77.9 dB(A) to 100.9 dB(A). The maximum peak noise level (LCpeak) was measured at 132.5 dB(A) aboard Speedboat 5, indicating a risk of hazardous noise exposure for personnel. Notably, Speedboat 3's Leq (100.9 dB(A)) surpassed the Indonesian limit of 94 dB(A) for a one-hour exposure.

Finally, Table 4 breaks down the Spearman's rank correlation outcomes across diverse independent variables and the three categories of job fatigue. Occupational noise had a significant correlation with physical fatigue ($r = .715$, $p = .040$) and mental fatigue ($r = .839$, $p = .022$), indicating strong and very strong correlations between noise exposure and both

Table 3. Occupational noise levels documented on six passenger boats

Source	Distance	Time measurement	Leq[a] (dB(A))	Lmin[b] (dB(A))	Lmax[c] (dB(A))	LCpeak[d] (dB(C))
Speedboat 1	± 68.87 km (42.80 mil)	09.49–11.19 (1 h 30 m)	79.9	55.8	104.7	121.0
Speedboat 2	± 43.20 km (26.85 mil)	12.18–14.14 (56 m)	78.8	57.7	85.3	117.4
Speedboat 3	± 128.97 km (80.14 mil)	13.58–15.17 (1 h 19 m)	100.9	65.0	112.4	127.0
Speedboat 4	± 121.64 km (75.58 mil)	07.05–08.15 (1 h 10 m)	80.4	49.0	91.0	123.3
Speedboat 5	± 134.91 km (83.83 mil)	13.20–15.52 (2 h 32 m)	89.1	55.5	117.4	132.5
Speedboat 6	± 158.38 km (98.41 mil)	08.22–11.08 (2 h 46 m)	77.9	62.8	87.8	109.8

[a]Equivalent Continuous Sound Level.
[b]Minimum Sound Level.
[c]Maximum Sound Level.
[d]Peak Sound Pressure Level.

Table 4. Spearman's rho correlations (r) between occupational noise, demographic variables, and three dimensions of work fatigue

	Physical fatigue		Mental fatigue		Emotional fatigue	
Variables	r[a]	*p*	r[a]	*p*	r[a]	*p*
Age	.280	.009**	.265	.013*	.250	.020*
Sex[b]	n/a	n/a	n/a	n/a	n/a	n/a
Educational background	.221	.040*	.125	.247	.223	.038*
Job position	−.145	.181	−.179	.097	−.182	.091
Working period	.330	.002**	.283	.008**	.263	.014*
Daily work duration	−.010	.927	.059	.589	.084	.437
Occupational noise	.715	.040*	.839	.022*	.573	.0.61

[a]$r \leq 0.19$ very weak, $0.20 \leq r \leq 0.39$ weak, $0.40 \leq r \leq 0.59$ moderate, $0.60 \leq r \leq 0.79$ strong, $0.80 \leq r \leq 1.00$ very strong.
[b]n/a: Not applicable, as all participants were male.
*p-value < 0.05, **p-value < 0.01.

fatigue symptoms. A moderate connection with emotional exhaustion was noted (r = .573); however, this link not statistical significance ($p = .061$). Moreover, age and working period of employment were correlated with all three aspects of fatigue, but those variables exhibited lower, though significant, associations with physical, mental, and emotional fatigue. The Spearman's rho analysis indicated a significant association between occupational noise exposure and both physical and mental fatigue in the study population.

Discussion

This study indicated that the majority of speedboat crew members experienced low levels of physical, mental, and emotional fatigue. However, occupational noise exposure among the measured speedboats reached high levels, with some exceeding the national exposure limits. Occupational noise was significantly associated with physical and mental fatigue, but not emotional fatigue. Age and length of employment showed significant but weaker correlations with all fatigue dimensions. These findings suggest that excessive occupational noise plays an important role in the development of work-related fatigue among speedboat crew members.

The passenger vessels are speedboats that typically carry 40–85 passengers for medium-range routes. These boats vary in design, with both open and closed cabin types influencing the level of noise exposure. Closed-cabin speedboats, often used for longer routes, provide partial sound insulation, whereas open-type vessels expose crew and passengers more directly to engine noise during operation. This investigation included monitoring occupational noise levels by placing the equipment on the shoulders of the ship personnel. Nonetheless, during the voyage, the crew's locations may fluctuate, influencing the fluctuation in occupational noise exposure experienced. They may be located on the ship's deck, in the rear next to the engine, or within the cabin beside the captain.

Presently, laws concerning noise threshold values for ships remain generic and fail to particularly address high-speed watercraft like speedboats. The regulations concerning occupational noise limitations often pertain to the categorization of rooms aboard the ship, as outlined by the International Maritime Organization (IMO) norms [5]. Nevertheless, modifications to the noise threshold may be implemented according to the length

of exposure. If the workforce fails to use hearing protection during work, the permissible noise level is capped at 85 dB(A) for an eight-hour period. Conversely, with the use of hearing protection, the permissible noise threshold may be raised to a maximum of 120 dB(A) for the same duration of employment [14].

This survey revealed that no crew members used hearing protection equipment while working. Consequently, the occupational noise threshold pertains to the daily exposure time without auditory protection. The speedboat does two round trips daily; hence, the occupational noise threshold is established according to the exposure duration of a single trip. The established noise limitations are 94 dB(A) for a one-hour duration, 91 dB(A) for two hours, and 88 dB(A) for four hours [6]. The measurement findings indicate that only speedboat number three surpassed the threshold values, with an equivalent noise level (Leq) of 100.9 dB(A). At this decibel level, crew exposure should not surpass 15 min to minimize the risk of auditory damage. The elevated noise levels coincided with periods of rough sea conditions, including strong waves and rainfall, which may have contributed to higher background noise during the measurements. This situation compelled the crew, typically stationed on the deck, to relocate inside the cabin to aid the captain in monitoring the water conditions. The recorded noises originate not just from the ship's engine but also from exterior sources, including severe rain, enormous waves, and the shouts of distressed passengers. Meanwhile, in the tests taken on another speedboat, the predominant occupational noise level was mostly attributed to the main engine sound. This is attributable to the very constant weather conditions throughout the measurement procedure, resulting in little interference from external noise sources.

The occupational noise measurement in this research was done singularly in one direction along the same travel route, therefore failing to reflect the noise distribution on the opposing path comprehensively. Nevertheless, while the vessel type and sailing path remain the same, the researchers contend that the occupational noise levels generated do not exhibit substantial variations. Conversely, if another type of speedboat, particularly one with varying capacity and engine specs, is used on the same route, the resultant occupational noise level is likely to fluctuate. Despite the observed noise levels often being within the threshold, the crew members remain in constant exposure. Prolonged exposure may result in health consequences [1]. This study analyzed the health consequences of noise exposure, specifically job fatigue.

Fatigue among sailors is attributable to several factors and is a significant occupational issue on numerous current vessels. Significant job responsibilities and extended working hours, often associated with 2-watch systems, may lead to exhaustion. Crews experience increased fatigue and weariness due to extended working hours, particularly with frequent port turnaround periods [15]. The speedboat crew's principal responsibility is to follow the skipper during the voyage. In addition to navigation responsibilities, they are tasked with assuring the operational readiness of the speedboat, which includes assessing the engine condition and other auxiliary functions such as the television, air conditioning, and the cleaning of the vessel as part of the commercial service. The speedboat crew operates for three to six hours daily, averaging 4.22 h of labor. Observations throughout the study indicated that crew members of the speedboats parked at Tarakan Harbor had a break interval of four to six hours before the next departure. This interval was used for resting. This aligns with data indicating that a majority of crew members suffer little physical tiredness (74.7%).

The crew exhibits a low degree of mental tiredness, with 69% of responders indicating mild degrees of exhaustion. This situation may be attributed to the fact that crew members are often persons familiar with maritime work patterns and have completed a rigorous screening procedure, both physically and intellectually. Individuals with lower mental adaptability often leave this field prematurely, resulting in the retention of individuals with superior mental resilience. The data indicates that most crew members have over five years of experience, with some possessing up to 24 years of service. The ship's constant routines and work structure mitigate cognitive stress [16], since the activities are well-defined and largely insulated from extraneous disruptions. An ordered work environment mitigates the danger of mental weariness. The crew's social support is significant since a strong sense of solidarity develops over the service duration [17]. This is apparent via favorable social interactions, such as communal laughing or leisurely activities conducted during intervals between tasks. Moreover, the operational framework enabling crew members to return home to their families post-duty contributes to the preservation of social equilibrium and the reinforcement of familial emotional connections. Research indicates that mariners maintaining consistent communication with their families exhibit less anxiety and loneliness, which are essential factors contributing to mental exhaustion [18].

In line with these findings, harmonious interpersonal relationships with colleagues and the availability of internet access to communicate with family have proven to significantly contribute to helping sailors manage stress and maintain emotional well-being [19,20]. A high level of work autonomy and a positive social climate on board are also correlated with lower levels of chronic fatigue [19]. The relatively low levels of emotional fatigue observed among participants may be influenced by several contextual factors suggested in previous studies. Literature indicates that crew stability and supportive managerial practices can foster a positive work environment, enhancing workers' sense of control and reducing emotional strain. This is consistent with observations of strong solidarity and camaraderie among the crew in this study. Furthermore, although sleep quality was not explicitly measured, the relatively short daily working hours and presence of breaks between activities may facilitate recovery and reduce emotional fatigue. Previous studies have also emphasized that adequate rest and effective sleep management strategies play a crucial role in maintaining lower emotional fatigue levels [19,21].

The statistical analysis revealed that, among the three dimensions of fatigue physical, mental, and emotional only physical and mental fatigue demonstrated a statistically significant association with occupational noise exposure on the speedboat in this study. While only one vessel was documented to exceed the established noise threshold, it is plausible that crew members on other boats were exposed to noise levels approaching the threshold for prolonged periods. Individual variability in auditory sensitivity and responsiveness to noise may lead to differential physiological and psychological effects [22], thereby contributing to the emergence of statistically significant correlations.

Fatigue is not solely influenced by the intensity of noise at a single point in time but also by the duration of exposure. Long-term exposure to noise, even if it is slightly below the threshold value, still has the potential to trigger fatigue or mild cumulative stress. This condition can be statistically identified, especially if the instruments and data used have adequate sensitivity levels. Several studies also show that exposure to noise occurring repeatedly over the long term, despite the relatively short duration in each session, can significantly contribute to increased fatigue levels [23–25]. In addition,

indirectly, confounding factors such as age and length of service also have an impact on the fatigue experienced by the crew. The correlation between working hours and mental health issues remains inadequately defined; nonetheless, it is presumed that occupational pressures, including extended working hours, may adversely affect workers' psychological and physical well-being [26].

This study has several notable strengths. It focuses on a rarely studied occupational group (speedboat crew members) who are at potential risk of noise-related fatigue due to their unique working environment. The use of personal noise dosimetry represents a methodological strength, as it is the most suitable approach for capturing individual noise exposure levels during actual work activities. In addition, the use of the Three-Dimensional Work Fatigue Inventory (3D-WFI), which has been tested for validity and reliability among the study sample, enhances the robustness of the fatigue assessment and offers a useful tool for future research in Indonesia.

However, certain limitations should be acknowledged. The cross-sectional design restricts the ability to infer causal relationships or long-term effects. The relatively small sample size (N = 87) may limit generalizability. Furthermore, the analysis did not adjust for several potential confounders, such as sleep quality, body mass index (BMI), and specific health conditions. Noise exposure was measured at a single location on one crew member's shoulder which may not fully represent exposure variability across different crew roles. Additionally, the noise measurements were conducted along a one-way route, which may not capture full daily exposure variations.

Conclusion

This study highlights that occupational noise exposure aboard speedboats is significantly associated with physical and mental fatigue among crew members. Although most measured noise levels were within regulatory thresholds, at least one vessel recorded noise levels exceeding safe limits, emphasizing the potential for hazardous exposure in specific conditions. The analysis revealed significant positive correlations between occupational noise exposure and both physical and mental fatigue. Specifically, the correlation with physical fatigue was strong, and that with mental fatigue was very strong, suggesting a consistent relationship between increased noise levels and higher fatigue scores. Although only one vessel exceeded the recommended noise threshold, the overall fatigue levels reported by participants were relatively low. This may be associated with favorable working conditions, including shorter daily working hours, regular breaks, and strong social support among crew members, which could help mitigate the effects of noise exposure on fatigue.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Data availability statement

The datasets utilized and examined in this study can be obtained from the corresponding author upon reasonable request.

Authors' contributions

KF, and JG conceived the idea. KF, collected, analysed data, and original drafted the manuscript under the supervision of LM, MLM, and JG. All the authors have read and approved the final manuscript.

Ethical approval

The ethics committee of the medical faculty at Mulawarman University Samarinda approved this research (number: 140/KEPK-FK/VII/2024). We secured informed consent from all participants before data collection, with each subject providing written agreement to indicate their desire to participate in the research.

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