

The Relationship Between Cadets' Fatigue Levels and Human Error Potential In Navigational Watchkeeping

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Abstract

Fatigue is a factor that can affect a person's physical and cognitive abilities in carrying out tasks, potentially increasing the risk of human error. This condition is a significant concern for cadets engaged in watchkeeping activities that require precision, concentration, and decision-making skills. This study aims to determine the relationship between fatigue levels and the potential for human error among cadets on maritime navigational watch. This study used a quantitative approach with a correlational method. The population in this study was 263 cadets on maritime navigational watch, using proportionate stratified random sampling. Data were collected using a questionnaire and analyzed through validity, reliability, normality, and correlation tests. The results showed a significant relationship between cadet fatigue levels and the potential for human error during navigational watchkeeping. Based on the results, it can be concluded that fatigue is associated with human error, thus increasing the risk of errors in navigational decision-making during maritime watchkeeping. These findings indicate that discussions on navigational safety in maritime education environments need to consider human conditions, especially fatigue, as part of the safety system.

Keywords: Fatigue Levels, Navigational Watchkeeping, Cadets' Fatigue

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INTRODUCTION

Navigational Watchkeeping are a crucial function in maintaining maritime safety. According to Jonathan (Kapal, 2022), the Watch is a person or group of watch personnel who carry out watch duties on the bridge and are given tasks and responsibilities for the smooth operation of the ship. In the context of seafaring education, nautical cadets practicing watchkeeping, both in simulators and during sea practice, face various challenges such as cognitive stress, mental workload, and circadian rhythm disruption due to the rotating watchkeeping system. Maintaining sea watch services while a ship is underway requires high levels of focus, accurate interpretation of navigation data, a high degree of seamanship responsibility, and the skills of a navigator to make quick and accurate decisions.

During a voyage, a ship is operated by a crew on watch duty according to predetermined hours. According to Filemon (*No Title*, n.d.), before someone carries out watch duties, the ship's crew must prepare themselves physically and mentally adequately as well as have the knowledge and skills so that watch duties can be carried out well. An officer of the watch (OOW) has full responsibility for the safety of the ship and all crew members during sea watch hours, whether the ship is underway, at anchor, or berthed. In carrying out these duties, watch officers must comply with the provisions of the International Regulations for Preventing Collisions at Sea (COLREG 1972), established by the International Maritime Organization as the international standard for preventing ship collisions at sea. Various studies have shown that most shipping accidents are caused by human factors. This is supported by research conducted by (Maternov et al., 2023). From

2015 to 2022, 112 maritime accidents were chosen for causal factor investigation. Through the analysis of these accidents, 160 causal factors were identified. Among these factors, human failure was responsible for 95 occurrences, meteorological conditions contributed to 23 incidents, and 42 accidents were attributed to technical failures. A situation where unknown factors were at fault (now under ongoing investigation) occurred in 30 instances.

International organizations such as the International Maritime Organization and the International Chamber of Shipping also confirm that fatigue is a major contributing factor to human error in ship navigation operations. According to (Ilmiah & Indonesia, 2023), this condition is often caused by a lack of adequate rest time, leading to fatigue among crew members performing watchkeeping duties. In the long term, fatigue can reduce crew performance, resulting in less than optimal monitoring of the ship's surroundings.

According to (Ilmiah & Pendidikan, 2025), working conditions on board ships, such as excessive working hours, inadequate rest periods, excessive workloads, high stress levels, and demanding work environments, can cumulatively trigger fatigue in seafarers. These conditions can reduce alertness, concentration, and decision-making abilities, ultimately increasing the likelihood of human error, which can impact the safety of ship navigation. Furthermore, (Arslan & Er, 2007) states that fatigue is associated with poor sleep quality, negative environmental factors, high job demands, and high stress. Fatigue plays a significant role, especially in these slips and lapses. If fatigue is closely related to poor sleep quality, negative environmental factors, high job demands, and high stress levels, it can lead to operational errors such as slips and lapses in the execution of duties. If this condition persists, the risk of operational errors (human error) in ship navigation activities will increase.

In shipping practice, crew on watch must carry out their duties according to a predetermined schedule to prevent or minimize the risk of collisions, grounding, or other risks that could endanger the safety of the ship. Sophia (Di et al., 2023) added that all crews carrying out the handover of watchkeeping duties need to be supervised by the Captain so that all crews maintain discipline in carrying out the handover and are responsive to the risks of deviations from the handover of watchkeeping duties, so that the crew is more alert in carrying out the handover of watchkeeping duties before leaving the bridge. Therefore, watchkeeping activities must be carried out properly and responsibly to avoid various undesirable incidents due to fatigue during watchkeeping. According to (Mawardi, 2021), the officer on watch must ensure efficient supervision is maintained and ensure that conditions around the ship are safe before carrying out navigational watch duties.

Based on this background, this study aims to statistically analyze the relationship between the fatigue level of training cadets and the potential for human error during navigational watch duty. In carrying out navigational watch duty, fatigue is also inseparable from psychological factors and the cadets' ability to adapt to the demands of the work environment. (Cristopher & Devota, 2025) Stress plays a significant role in how well cadets adapt, so resilience and appropriate coping strategies are required. The shift from a controlled learning environment to a fast-paced onboard environment can be challenging, and many cadets struggle to adapt. The results of this study are expected to provide an empirical overview of the importance of fatigue management in improving navigational safety and serve as a consideration for maritime educational institutions in managing watchkeeping systems for cadets.

(Sánchez-beaskoetxea et al., 2021) generally states that 80% of all accidents at sea are the result of human error. In fact, it's probably more accurate to say that all accidents at sea are the result of human error because, no matter how much automation is introduced into the design or operation of a ship or its systems, there is always human input. Several factors influence human error during navigation system maintenance operations. These factors can be classified into two broad categories: internal and external factors. Internal factors can be further categorized as seafarer ability, mental state, and physical condition. External factors can also be further categorized as environmental and operational factors. Arief said (Arief & Hakim, 2025), The human error factor has been presented in the results of this study, consisting of indicators of skill, personnel, stress, and communication. The skill factor of crew on passenger ships is a mandatory competency that must be possessed to navigate on the high seas and in shipping lanes.

Fatigue while on duty on a ship can reduce crew effectiveness in navigation, including human error. (Jepsen et al., 2015) found that crew fatigue is largely influenced by workload and stress. Excessive workload often occurs during maintenance activities due to high job demands,

while too little workload can also cause problems due to lack of stimulation. Both of these extreme conditions can lead to human error. If crew members lose focus or become bored, the risk of errors increases. In the long term, excessive workload can lead to sleep deprivation and fatigue. Factors such as inexperience, staffing shortages, sleep deprivation, time pressure, task difficulty, and perceived danger also exacerbate the workload, making it difficult for crew members to stay focused and work safely.

Fatigue is significantly linked to an increased potential for human error in watch navigation. Physiologically, fatigue causes a decline in cognitive function. According to (Ain et al., 2025), cognitive impairments due to fatigue, including diminished decision-making abilities, slower reaction times, and decreased situational awareness, are identified as critical factors leading to navigation errors and equipment mishandling. Physically, fatigue results in reduced muscle activity, impaired proprioception, and overall motor performance decline, further exacerbating the risk of accidents. The mental health of seafarers is also significantly affected, with increased incidences of stress, anxiety, and depression linked to chronic fatigue. Research in the field of occupational safety shows that individuals experiencing fatigue are more likely to make human errors in navigation than individuals in good condition. According to (Albert, 2024), fatigue is a well-documented human factor that significantly affects the cognitive and physical capabilities of seafarers. Seafarers often work long hours with irregular sleep patterns, which impair their situational awareness, reaction times, and overall decision-making abilities. In the context of shipping, this can directly impact navigation safety. Thus, the higher the level of fatigue of cadets, the greater the potential for human error in navigational watch duty.

METHODS

This study uses a quantitative approach with a correlational method. The quantitative approach was used because the study aims to measure and analyze the relationship between work fatigue and human error through numerical data obtained from respondents. The collected data were then processed using statistical techniques to determine the level of relationship between the two variables. Through this approach, researchers can obtain an overview of the influence of the level of fatigue experienced by workers on the possibility of human error in carrying out work. The results of the study are expected to serve as a basis for efforts to prevent human error by managing the factors that cause work fatigue. According to (Itting, 2024), therefore, correlational research can only provide useful information to explain the relationship between the variables studied and provide a basis for further research.

The population in this study was all 263 Level IV cadets who participated in the study. The selection of Level IV cadets was based on the consideration that they have gained sufficient practical experience and on-duty activities to provide relevant information regarding fatigue and the potential for human error. The sampling technique used in this study was Proportional Stratified Random Sampling. Sampling was conducted randomly at each stratum, with a proportionate number of participants in each level, ensuring that each member of the population had an equal chance of being selected as a respondent. The sample size used in this study was approximately 160 respondents from Level IV cadets. In this study, data were collected using questionnaires and observations. The research instrument was designed to measure fatigue levels and potential human error among cadets undergoing sea practice.

Table 1. Operational Research Variables

Variable	Operational Definition	Indicator	Item	Scale
Fatigue level (X)	A condition of declining physical and mental abilities of cadets due to learning, practice and guard activities which can affect performance.	Cognitive	1, 2, 3, 4	Likert 1-5
		Physical	5, 6, 7, 8	Likert 1-5
		Behavior	9, 10, 11, 12	Likert 1-5
Human Error Potential	The possibility of errors being made by cadets in carrying out their duties is due to limited physical and mental abilities.	Cognitive	13, 14, 15	Likert 1-5

Variable	Operational Definition	Indicator	Item	Scale
(Y)				
		Perseption	16, 17, 18	Likert 1-5
		Action	19, 20, 21	Likert 1-5
		Communication	22, 23, 24	Likert 1-5
		Prosedur	25, 26, 27	Likert 1-5

Data analysis techniques are the process of processing data obtained from distributing questionnaires to respondents to answer the research problem formulation and test the research hypotheses. In this study, data analysis was conducted using the Statistical Package for Social Sciences (SPSS) program. Before use, the questionnaire was tested for validity and reliability. Next, a normality test, a product-moment correlation test, a Spearman correlation test, and finally a determination test were carried out.

RESULT AND DISCUSSION

Based on the validity test results, it is known that all statement items have a Corrected Item-Total Correlation value greater than 0.30. In Table 2, the lowest value is found in item X5 at 0.307 with a criterion greater than 0.30. While the highest value is found in Table 3, found in item Y5 at 0.963. Thus, all statement items in the Guard Fatigue and Human Error variables are declared valid and therefore suitable for use as research instruments.

Table 2. Validity test for guard fatigue variable

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
X1	38.00	92.414	.652	.831	.924
X2	38.33	94.989	.630	.904	.925
X3	38.13	87.085	.784	.820	.920
X4	38.10	91.403	.744	.891	.922
X5	36.67	93.885	.334	.742	.941
X6	38.20	95.062	.635	.852	.925
X7	38.27	92.064	.713	.893	.923
X8	38.03	93.826	.617	.957	.925
X9	38.13	91.223	.748	.956	.921
X10	38.23	92.185	.742	.929	.922
X11	38.10	94.921	.594	.746	.926
X12	38.43	93.220	.678	.916	.924
X13	38.33	91.954	.717	.939	.922
X14	38.37	90.447	.808	.977	.920
X15	38.33	93.885	.798	.903	.922

Table 3. Validity test for human error variable

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Y1	35.17	120.006	.777	.	.971
Y2	35.17	116.557	.928	.	.969
Y3	35.20	116.993	.903	.	.969
Y4	35.20	117.407	.880	.	.969
Y5	35.30	118.079	.941	.	.969

Y6	35.17	117.730	.956	.	.968
Y7	35.00	123.517	.601	.	.974
Y8	35.10	118.714	.778	.	.971
Y9	35.20	118.097	.884	.	.969
Y10	35.30	117.528	.880	.	.969
Y11	35.33	119.333	.825	.	.970
Y12	35.20	118.786	.769	.	.971
Y13	35.20	116.441	.893	.	.969
Y14	35.07	115.582	.633	.	.977
Y15	35.20	117.821	.949	.	.969

The analysis results show that the Cronbach's Alpha value for the guard fatigue variable, as shown in Table 4, is 0.929 with 15 items. This value is well above the minimum limit of 0.70, thus concluding that the research instrument has a very high level of reliability. Likewise, the Cronbach's Alpha value for the human error variable, as shown in Table 5, is 0.972. This indicates that all items in the questionnaire are able to provide consistent measurement results when used under the same conditions.

Table 4. Reability test for guard fatigue variable

Reliability Statistics

Cronbach's Alpha	Cronbach's Based on Standardized Items	Alpha on N of Items
.929	.937	15

Table 5. Reability test for human error variable

Reliability Statistics

Cronbach's Alpha	Cronbach's Based on Standardized Items	Alpha on N of Items
.972	.975	15

The results of the normality test in Table 6 show that the Guard Fatigue variable has a Kolmogorov-Smirnov significance value of 0.023, while the Human Error variable has a significance value of 0.000. Both values are less than 0.05. Therefore, it can be concluded that the research data is not normally distributed. Because the data does not meet the assumption of normality, an analysis of the relationship between variables was conducted using the Spearman rank correlation test, a nonparametric method for measuring the relationship between two variables.

Table 6. Tests of normality

Tests of Normality

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
KELELAHAN_JAGA	.077	160	.023	.974	160	.004
HUMAN_ERROR	.118	160	.000	.955	160	.000

a. Lilliefors Significance Correction

The relationship between watchman fatigue and human error was tested using the Spearman rank correlation test. In the table 7, the analysis showed a correlation coefficient (Spearman's rho) of 0.836 with a significance level of 0.000. Because the significance level is less than 0.05, H_0 is rejected and H_1 is accepted, indicating a significant relationship between watchman fatigue and human error. Furthermore, the correlation coefficient of 0.836 falls within the 0.80–1.00 range, indicating a very strong relationship between the two variables. A positive coefficient indicates a unidirectional relationship. This means that the higher the level of watchman fatigue experienced by crew members, the greater the likelihood of human error occurring during their duties.

Table 7. Spearman Rank Correlation Test

Correlations

			KELELAHAN_JAGA	HUMAN_ERROR
Spearman's rho	KELELAHAN_JAGA	Correlation Coefficient	1.000	.836**
		Sig. (2-tailed)	.000	.000
		N	160	160
	HUMAN_ERROR	Correlation Coefficient	.836**	1.000
		Sig. (2-tailed)	.000	.000
		N	160	160

** . Correlation is significant at the 0.01 level (2-tailed).

The research results show a positive and significant relationship between watch fatigue and human error. This indicates that fatigue experienced by crew members can affect their ability to perform their duties optimally. Watch fatigue causes decreased concentration, alertness, thinking ability, and speed of decision-making. (Grech, 2016) Michelle's research consistently shows that seafarers rate sleep deprivation and inconsistent sleep times as major contributors to fatigue, suggesting that opportunities for adequate sleep are not being provided. In line with that opinion Minge fei ma (Ma & Liao, 2025), ome studies showed that a large number of seafarers suffered mental health problems and fatigue. For example, Hebbar and Mukesh surveyed 288 seafarers, of whom 40% felt unhappy, 30% endured stress and over 15% felt completely fatigued. Fatigue was reported to be associated with poor sleep.

This condition increases the likelihood of errors in observation, communication, decision-making, and the implementation of work procedures. The higher the level of fatigue experienced by crew members, the greater the risk of human error. (Maza et al., 2026) Galieriková claims, according to her research of the maritime accidents, that the human error represents 75% to 96% incidents in the shipping sector with the fatigue as one of the most common failure. Analysis of the maritime accidents also shows that alarming number of the human failures were the results of the errors in judgement by maritime workers, suffering from extreme fatigue.

This finding aligns with the human error theory, which states that the human factor is a major cause of workplace accidents in the shipping industry. Fatigue can reduce cognitive performance, increasing the likelihood of operational errors. Therefore, managing work hours, rest periods, and implementing watch procedures according to regulations are crucial aspects in efforts to minimize human error. (Ain et al., 2025) Youn and Lee's opinion, Extended working hours and lack of adequate rest are primary contributors. Seafarers often face irregular sleep patterns due to shift work, which disrupts their circadian rhythms. (Chowdhury et al., 2024) Muidun said that within the realm of marine engineering, a profound revelation surfaces: the primary causes of maritime accidents often stem from the behavioral factors exhibited by seafarers. The culprits, as highlighted in this research, encompass a spectrum of challenges. Inadequate training emerges as a significant concern, encompassing physical constraints, poor communication, flawed judgement, exhaustion, and weariness.

The shipping industry, like other modes of transportation such as rail, aviation, and commercial road transport, operates continuously around the clock. According to Damayana (Kasus et al., 2026), to address these risks, the international convention, the STCW Convention, has established stringent safety management instruments. One of its main pillars is Section A-VIII/2, which regulates specific regulations regarding the balance of work hours and rest hours. Ideally, every officer and crew member on watch must receive a minimum of 10 hours of rest in a 24-hour period to ensure a high level of fitness for duty. This regulation legally prohibits seafarers from taking navigational control if their physical or mental condition is degraded by fatigue. (Péry et al., 2021) Carine stated that living and working in such conditions for long periods can affect crew morale and increase stress levels, ultimately leading to fatigue, loss of concentration and focus, decreased productivity, and ultimately accidents. Current regulations regarding work hours and rest periods are still unable to address the problem of fatigue experienced by seafarers. This condition is suspected to be a factor contributing to the increasing level of fatigue in the maritime workplace. (Fan & Yang, 2024) Also, some studies show that sleep on watch usually occurs in teams working 00–04, particularly with free watch disturbance [29]. It is evident that sleepiness peaks in the early morning and evening, which coincides with the fact that many maritime accidents occur.

The correlation coefficient value of 0.836 indicates that the relationship between the two variables is very strong. Thus, it can be concluded that watch fatigue is a factor closely related to the occurrence of human error in accidents on board ships. This is in line with the opinion of (Ilmiah & Indonesia, 2023), fatigue is when a person feels very tired or exhausted physically or mentally. This can be caused by various things, such as stress, high workload, lack of sleep, excessive physical activity, or certain health problems. Fatigue can also cause various symptoms such as weakness, poor concentration, irritability, and sleep disturbances. (Ilmiah & Pendidikan, 2025) Gustian added that work fatigue is a fundamental risk factor and a significant root cause behind the high incidence of accidents in the Indonesian maritime industry, which is often misattributed solely to human error. The research results show a strong positive correlation between fatigue and the potential for human error. Neurocognitively, fatigue affects:

- Decreased selective attention
- Impaired working memory
- Decreased executive decision-making

This finding aligns with the maritime safety policy emphasized by the International Maritime Organization regarding the importance of managing rest time of at least 10 hours in a 24-hour period. In the context of maritime education, a busy practice watch system has the potential to increase the risk of simulation errors such as:

- Misidentification of radar targets
- Delays in avoidance maneuvers
- Bridge communication errors

Uğurlu (Can et al., 2026) analysed grounding accidents in oil tankers, and mentioned that they led to economical loss with 91% and pollution with 9%. According to their research, the main contributing factors to grounding accidents are interpretation failure of the officer on watch and lack of effective communication in the bridge team management. Akyuz said that, conducted research for obtaining grounding accident causal factors. According to this research, a poor and improper work environment, which can be defined as poor safety requirements.

According to Kurnia (Kurnia et al., 2024), radar is a navigational tool used on ships to detect weather and measure the distance to certain objects such as logs, boats, and other hazardous objects. In simulated navigation situations that require precision and rapid response, fatigue can potentially lead to misidentification of radar targets, resulting in inaccurate understanding of the position or movement of other vessels. According to Arleiny (Sartoto & Parerungan, 2018), optimizing radar use by the crew on board is crucial for ensuring safe navigation from one port to another and avoiding unwanted hazards. Therefore, proficiency in radar use is required, not only for determining ship course and distance between vessels, but also in adverse weather conditions to reduce the risk of collision at sea.

Fatigue can increase the likelihood of negligence, such as forgetting to adjust radar settings, responding late to changes in display, or being inaccurate in interpreting detected targets. As a result, the quality of information used to support navigational decision-making can decline and increase the potential for human error during watchkeeping. Sunusi (Mv & Kintamani, 2025), stated that the integration of optimization and navigation theory shows that appropriate radar utilization can minimize the risk of collision at sea while simultaneously supporting ship operational efficiency.

Furthermore, this state of guard fatigue can affect the ability to receive, understand, and convey information accurately. As a result, communication errors can occur in the form of incomplete, unclear information, late delivery, or non-compliance with communication procedures. According to Hanzu (Rozar et al., 2025), communication breakdowns often stem from language barriers, unfamiliar jargon, background noise, or unclear speech, leading to misunderstandings, mistakes, and potentially accidents.

Based on the table above, the R value is 0.836. Thus, the R^2 value obtained is 0.69, which means that the fatigue level variable contributes 69% to the potential for human error, while the remaining 31% is influenced by other factors not examined in this study. As material for further research, the type of fatigue that influences human error can be identified. Fatigue consists of physical and mental fatigue.

The R^2 value of 0.69 indicates that fatigue is a significant factor, but not the sole determinant. Other factors such as experience, stress, and technical competence also play a role. (Maternov et al., 2023), Man-made threats, such as crises, inflation, cultural shifts, globalisation,

strikes, conflicts, and wars, indirectly influence safe ship operations. Human error at the level of preconditions for unsafe acts, most frequently influenced by alcohol and fatigue, combined with poor vessel design, are factors of lower significance in the likelihood of death occurrence on board. Although human error emerged as the predominant causal factor, it is important to note that not all accidents involved human failure specifically. Some accidents were only caused by technical or meteorological factors. However, certain accidents were caused by multiple level so human failure, for instance: in ad equate communication, fatigue, and stress combined with the routine violation of rules. This combination of factors intensified the occurrence of accidents.

DISCUSSION

Hasil penelitian menunjukkan bahwa terdapat hubungan positif dan signifikan antara tingkat kelelahan jaga dengan potensi *human error* pada *Cadets* yang melaksanakan praktik jaga navigasi. Berdasarkan hasil uji korelasi Rank Spearman terhadap 160 responden, diperoleh nilai koefisien korelasi sebesar 0,836 dengan nilai signifikansi 0,000. Nilai tersebut menunjukkan bahwa hubungan antara kedua variabel berada pada kategori sangat kuat dan memiliki arah hubungan positif. Artinya, semakin tinggi tingkat kelelahan yang dialami taruna selama melaksanakan tugas jaga, semakin tinggi pula potensi terjadinya *human error*. (Kuganda et al., 2026) Menurut Ahsberg, dimensi kelelahan yang paling sering muncul pada pekerja transportasi adalah lack of energy (kehilangan tenaga) dan sleepiness (rasa kantuk berlebih). Temuan ini diperkuat oleh hasil penelitian yang menunjukkan bahwa sebagian *Cadets* mengalami *microsleep*, kehilangan konsentrasi, dan penurunan fokus ketika melakukan pemantauan situasi navigasi. Dengan demikian, penelitian ini memberikan gambaran empiris bahwa kelelahan selama dinas jaga tidak hanya menjadi kondisi subjektif berupa rasa lelah atau mengantuk, tetapi berkaitan dengan meningkatnya potensi *human error* dalam pelaksanaan tugas navigasi.

Keterbaruan penelitian ini terletak pada fokusnya terhadap cadets sebagai calon tenaga profesional di bidang pelayaran, khususnya taruna yang sedang menjalani praktik jaga navigasi. Christopher (Christopher & Devota, 2025), memahami pengalaman langsung para kadet selama menjalani praktik laut sangat penting. Dengan mendengarkan cerita mereka, kita dapat mengidentifikasi kesenjangan dalam pendidikan maritim dan mengeksplorasi tantangan yang mereka hadapi di laut. Penelitian terdahulu yang dibahas dalam artikel lebih banyak mengkaji kelelahan dan *human error* pada pelaut atau awak kapal profesional. Sementara itu, penelitian yang secara khusus menguji hubungan statistik antara tingkat kelelahan taruna dengan potensi *human error* dalam konteks jaga navigasi masih relatif terbatas. (Suprati, n.d.) Cadet readiness highlights the critical role that educational and training institutions play in preparing individuals for the demands of the maritime industry. (Simanjuntak, 2024) At the heart of this educational endeavour lies the imperative to equip cadets with the requisite knowledge and skills to excel in their roles as stewards of the seas.

Hasil penelitian ini sejalan dengan berbagai penelitian sebelumnya yang menunjukkan bahwa kelelahan merupakan faktor penting yang berkaitan dengan penurunan kemampuan manusia dalam menjalankan tugas keselamatan di lingkungan maritim. (Rahmaningtyas & Widanarko, 2026) Secara fisiologis, aktivitas otot yang dilakukan secara terus-menerus tanpa pemulihan yang memadai dapat menyebabkan akumulasi kelelahan yang ditandai dengan penurunan kapasitas otot, peningkatan beban biomekanik, serta penurunan kapasitas neuromuskular. Kondisi ini mempercepat timbulnya kelelahan terutama pada pekerjaan yang bersifat manual dan repetitif, serta berdampak langsung terhadap efisiensi dan ketelitian kerja. Temuan tersebut memiliki kesesuaian dengan hasil penelitian ini karena sistem jaga navigasi menuntut konsentrasi, ketelitian dan kewaspadaan yang berkelanjutan, sehingga kondisi kelelahan dapat meningkatkan kemungkinan terjadinya *human error*.

Temuan penelitian ini juga konsisten dengan Lyu Hongguang (2023) yang menjelaskan bahwa kelelahan dapat timbul akibat kurang tidur, periode terjaga yang panjang, ketidaksesuaian waktu kerja dan istirahat dengan ritme sirkadian, serta tuntutan fisik maupun mental. Kondisi tersebut dapat mengganggu kewaspadaan dan kemampuan seseorang dalam menjalankan tugas keselamatan di kapal. Selain itu, (Albert, 2024) menjelaskan bahwa pola kerja yang panjang dan tidak teratur dapat mengganggu *situational awareness*, waktu reaksi, serta kemampuan pengambilan keputusan pelaut. Hal tersebut memperkuat hasil penelitian ini yang menunjukkan hubungan positif antara kelelahan dan potensi *human error* dalam jaga navigasi. Hasil yang diperoleh juga sejalan dengan Hussain (2025), yang menjelaskan bahwa gangguan

kognitif akibat kelelahan, seperti menurunnya kemampuan pengambilan keputusan, melambatnya waktu reaksi, dan menurunnya *situational awareness*, merupakan faktor penting yang dapat menyebabkan kesalahan navigasi dan kesalahan dalam penggunaan peralatan. (Maza et al., 2026) Moreno juga menempatkan kelelahan sebagai faktor risiko dalam sistem keselamatan maritim yang dapat memengaruhi kemampuan kognitif, fisik, dan perilaku. Sementara itu, (Fan & Yang, 2024) Fan menunjukkan bahwa rasa kantuk memiliki kaitan dengan periode jaga malam dan dini hari, ketika kecenderungan mengantuk meningkat dan berpotensi berhubungan dengan kejadian kecelakaan maritim.

Dengan demikian, hasil penelitian ini memperkuat temuan sebelumnya bahwa kelelahan merupakan faktor manusia yang perlu diperhatikan dalam keselamatan operasi navigasi. Selanjutnya, Nakano (2023) menyatakan bahwa kelelahan dapat berkaitan dengan kurangnya waktu istirahat dan berdampak pada penurunan performa serta pengawasan terhadap kondisi sekitar kapal. Gustian (2025) juga menjelaskan bahwa jam kerja berlebih, waktu istirahat yang tidak memadai, beban kerja, stres, dan kondisi lingkungan kerja dapat secara kumulatif memicu kelelahan dan menurunkan kewaspadaan, konsentrasi, serta kemampuan pengambilan keputusan. (Maza et al., 2026), sebagaimana dicantumkan dalam artikel, juga mengaitkan kelelahan dengan peningkatan risiko *human error* pada sektor pelayaran. Kesamaan hasil tersebut menunjukkan bahwa hubungan antara kelelahan dan *human error* tidak hanya ditemukan pada satu kelompok atau kondisi tertentu, tetapi juga muncul dalam berbagai konteks pekerjaan maritim.

Kesamaan antara hasil penelitian ini dengan penelitian terdahulu kemungkinan disebabkan oleh karakteristik pekerjaan maritim yang sama-sama menuntut tingkat kewaspadaan, konsentrasi, ketelitian, dan kemampuan pengambilan keputusan yang tinggi. Sistem kerja bergilir dan aktivitas jaga pada malam atau dini hari dapat mengganggu pola tidur dan ritme sirkadian. Apabila kondisi tersebut disertai beban kerja dan waktu istirahat yang tidak optimal, kelelahan dapat berkembang menjadi penurunan kemampuan kognitif maupun fisik. Kondisi tersebut pada akhirnya dapat meningkatkan kemungkinan terjadinya kesalahan dalam mengamati situasi, menginterpretasikan informasi navigasi, berkomunikasi, mengambil keputusan, maupun melaksanakan prosedur.

Meskipun demikian, terdapat perbedaan konteks antara penelitian ini dengan sebagian penelitian terdahulu. Penelitian sebelumnya banyak menggunakan populasi pelaut atau awak kapal profesional, sedangkan penelitian ini berfokus pada *Cadets* yang sedang menjalani praktik jaga. Perbedaan karakteristik responden tersebut dapat memengaruhi kondisi kelelahan dan potensi *human error*. *Cadets* tidak hanya menghadapi tuntutan tugas jaga, tetapi juga berada dalam proses adaptasi terhadap lingkungan kerja kapal, sistem jaga, penggunaan peralatan navigasi, serta pengembangan pengalaman dan kompetensi. Oleh karena itu, hasil penelitian ini memberikan konteks yang lebih spesifik mengenai bagaimana kelelahan dapat berkaitan dengan potensi kesalahan pada kelompok calon pelaut.

Perbedaan juga dapat dipengaruhi oleh metodologi penelitian. Penelitian ini menggunakan pendekatan kuantitatif korelasional dan melibatkan 160 responden, dengan pengukuran tingkat kelelahan dan potensi *human error* melalui instrumen penelitian. Data penelitian tidak berdistribusi normal sehingga hubungan kedua variabel dianalisis menggunakan korelasi Rank Spearman. Pendekatan tersebut berbeda dengan penelitian yang menggunakan analisis kecelakaan, observasi operasional, kajian sistematis, atau metode lain. Oleh karena itu, hasil penelitian ini terutama menunjukkan hubungan statistik antara kelelahan dan potensi *human error*, bukan membuktikan hubungan sebab-akibat secara langsung.

Kontribusi utama penelitian ini adalah memberikan bukti empiris mengenai hubungan antara kelelahan jaga dan potensi *human error* pada *Cadets* dalam konteks pendidikan dan praktik maritim. Hasil korelasi sebesar 0,836 menunjukkan adanya hubungan yang sangat kuat dan searah antara kedua variabel. Selain itu, hasil analisis determinasi dalam artikel menunjukkan nilai R^2 sebesar 0,69, yang menunjukkan bahwa variasi potensi *human error* dalam model penelitian berkaitan dengan tingkat kelelahan, sedangkan sebagian variasi lainnya berkaitan dengan faktor lain yang tidak diteliti. Temuan tersebut memperlihatkan bahwa pembahasan mengenai keselamatan navigasi pada lingkungan pendidikan maritim perlu mempertimbangkan kondisi manusia, khususnya kelelahan, sebagai bagian dari sistem keselamatan.

Kebaruan penelitian juga terlihat dari pengintegrasian aspek kelelahan dengan beberapa bentuk *human error* dalam kegiatan jaga navigasi, yaitu kesalahan kognitif, persepsi, tindakan, komunikasi, dan prosedur. Kelelahan tidak hanya berpotensi menyebabkan rasa mengantuk, tetapi

juga dapat berkaitan dengan penurunan konsentrasi, lambatnya respons, kesalahan membaca informasi radar, keterlambatan melakukan manuver, serta kesalahan komunikasi di anjungan. Dalam konteks pendidikan maritim, temuan tersebut memberikan dasar bahwa pembentukan kompetensi navigasi tidak cukup hanya berorientasi pada kemampuan teknis, tetapi juga perlu memperhatikan kesiapan fisik dan kognitif taruna selama melaksanakan tugas jaga.

Secara praktis, hasil penelitian ini memberikan implikasi bagi institusi pendidikan maritim untuk memperkuat penerapan manajemen kelelahan dalam kegiatan praktik dan pembelajaran jaga navigasi. Pengaturan jadwal jaga, waktu istirahat, pemantauan kondisi taruna, serta pemberian edukasi mengenai tanda-tanda kelelahan dapat menjadi bagian dari strategi pencegahan *human error*. Perhatian khusus juga perlu diberikan terhadap periode jaga malam dan dini hari karena pada periode tersebut rasa kantuk dapat meningkat. Penggunaan simulator dapat dimanfaatkan untuk melatih kemampuan *Cadets* dalam menghadapi situasi navigasi ketika mengalami beban kerja tinggi, sekaligus meningkatkan kesadaran mengenai pentingnya menjaga kondisi fisik dan kognitif sebelum melaksanakan tugas jaga.

Secara akademis, penelitian ini memperkuat kajian mengenai hubungan faktor manusia dengan keselamatan navigasi, khususnya pada kelompok *Cadets*. Temuan ini dapat menjadi dasar bagi penelitian selanjutnya untuk mengembangkan model yang memasukkan faktor lain seperti kualitas tidur, durasi jaga, beban kerja, stres, pengalaman, kompetensi teknis, kondisi lingkungan, dan pola kerja bergilir. Penelitian lanjutan juga dapat menggunakan desain longitudinal atau pendekatan observasional sehingga perubahan tingkat kelelahan dan performa navigasi dapat diamati secara lebih objektif dari waktu ke waktu.

Dengan demikian, hasil penelitian menegaskan pentingnya memandang kelelahan sebagai bagian dari sistem keselamatan navigasi, bukan semata-mata sebagai kondisi pribadi individu. Pengelolaan kelelahan yang baik pada tahap pendidikan dan praktik dapat mendukung pembentukan budaya keselamatan sejak taruna masih berada dalam proses pendidikan. Upaya tersebut diharapkan dapat membantu mengurangi potensi kesalahan dalam pengamatan, pengambilan keputusan, komunikasi, penggunaan peralatan navigasi, dan pelaksanaan prosedur selama tugas jaga, sekaligus menjadi bekal bagi taruna ketika memasuki lingkungan kerja pelayaran profesional.

CONCLUSION

Based on the observation results, the fatigue level of cadets is in the high category, thus related to human error in sea practice on board ships. There is a positive and significant relationship between fatigue and the potential for human error with an r value of 0.836. Fatigue contributes 69% to human error. Thus, the high R value explains that watch fatigue is related to human error, this has an impact on safety in the world of shipping. As material for further research, the type of fatigue that influences human error can be identified. Fatigue consists of physical and mental fatigue. It is also important to know how to manage watch fatigue. Fatigue management is a primary preventive strategy in improving navigational watch safety. This step is used to prevent or minimize the risk of collision, grounding, or other risks related to accidents on board ships.

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- Arief, J., & Hakim, R. (2025). *PELAYARAN DI KAPAL PENUMPANG PERUSAHAAN SURABAYA Universitas Hang Tuah (UHT) Email : mudiyanto@hangtuah.ac.id 1 . LATAR BELAKANG Aspek yang menuntut dalam pelayaran seperti ketidakmampuan awak kapal untuk meninggalkan lokasi kerja , kondisi cuaca ekstrim , jauh dari rumah dalam waktu lama , dan pergerakan di tempat kerja . Beberapa diantaranya tidak dapat diubah dan merupakan cerminan sifat domain tersebut . Ada banyak faktor manusia yang mempengaruhi keselamatan dalam domain ini seperti yang kelelahan , kesadaran situasi , komunikasi , serta stress . Isu-isu ini ditinjau dalam rangka yang mengusulkan bahwa individual ini dapat menjadi penyebab kecelakaan , namun iklim keselamatan di kapal juga akan mempengaruhi apakah seseorang melakukan perilaku aman atau tidak . Faktor penyebab kecelakaan kapal diakibatkan oleh faktor manusia (Mazaheri et al . 2015) . Tinjauan tersebut juga mempertimbangkan status terkini dari upaya*

- untuk mengatasi permasalahan faktor manusia yang lazim terjadi di industri pelayaran . Penyebab kecelakaan kapal terbentuk berdasarkan proses pembentukan perilaku kognitif (Li , Hongxi , Zhang , Lianfeng , Zheng 2014). Tinjauan tersebut menunjukkan bahwa terdapat banyak kesenjangan dalam literatur maritim , dan sejumlah masalah metodologis dalam penelitian yang dilakukan hingga saat ini . Terkait masalah komunikasi seringkali dapat mengakibatkan kesalahan atau kecelakaan . Kecelakaan kapal di laut dapat menyebabkan banyak korban jiwa dan kerusakan pada laut , Masyarakat dan lingkungan maritim (Zhang and Thai 2016). Kasus kecelakaan pada kapal penumpang diakibatkan oleh kurangnya kesadaran awak kapal terhadap memahami kesadaran awak kapal tentang keselamatan pelayaran (Ruponen P , Pennanen P 2019). Faktor manusia diadopsi sebagai konsep yang dipertimbangkan dari faktor faktor-faktor lain yang relevan , termasuk kondisi tempat kerja , lingkungan fisik dan alam , prosedur , pelatihan , organisasi , manajemen . Beberapa peneliti telah mempelajari Lardjane , S . , Morel , G . , Clostermann , J . -P . & Langard 2013). Kecelakaan kapal telah menunjukkan bahwa sebagian besar kecelakaan ini melibatkan kesalahan manusia . Faktanya , sekitar 80 % kecelakaan kapal terjadi selama pelayaran (Bea R . , Holdsworth R . 1997). Industry perkapalan telah berfokus pada perbaikan struktur kapal dan anjungan serta meningkatkan keandalan sistem peralatan untuk mengurangi korban jiwa dan meningkatkan efisiensi dan produktivitas . Cara. 25, 215–228. <https://doi.org/10.33556/jstm>
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