International Journal of Health Science & Medical Research

Vol 4. No. 2 (2025) : August

THE EFFECT OF TIME MANAGEMENT ON WORK FATIGUE OF FIREFIGHTERS AT BALIKPAPAN REFINERY UNIT V

Heru Kisworo[1], Edison C. Sembiring[2], Sugiarto[3], Tatan Sukwika[4]
[1,2,3] Master of Management, Graduate School, Sahid University Jakarta, Indonesia
[4] Department of Enviromental Engineering, Fakultas of Engineering, Sahid University Jakarta, Indonesia
email: tatan.swk@gmail.com,

Abstract

Work fatigue is a critical challenge for firefighters, particularly in high-risk industries such as oil refineries. The novelty of this study is its focus on environmental and operational context as the main factor influencing firefighter fatigue, rather than traditional time-related aspects. This study analyzes the relationship between work time management including work duration, shift type, weekly workdays, sleep duration, and work location and fatigue levels among firefighters at the Balikpapan Refinery Unit V (RU V). A quantitative cross-sectional design was applied with total sampling of 77 respondents. Data were collected using the Fatigue Assessment Scale (FAS) and analyzed through the Chi-Square test. The majority of respondents experienced mild fatigue (72.7%). Among the five variables examined, only work location showed a significant association with fatigue ($p = 0.006$). Firefighters assigned to RU V had an 8.2 times higher risk of fatigue than those at the Lawe-Lawe Terminal. Practical recommendations include adopting Fatigue Risk Management System (FRMS)-based scheduling, tailoring work arrangements to site conditions, and implementing regular fatigue monitoring to strengthen firefighter safety and performance.

Keywords: Firefighter; Refinery; Time Management; Work Fatigue.

Received: August 30th, 2025; 1st Revised September 1st, 2025;
Accepted for Publication : September 10th, 2025

INTRODUCTION

Work fatigue is a serious challenge across various industrial sectors, particularly for firefighters in oil refinery environments who face physical, mental, and extreme environmental demands. The oil and gas industry is widely recognized as a high-risk sector factors such as shift work, circadian rhythm disruptions, and heavy workloads increase workers' vulnerability to fatigue, which poses safety risks (1)(2). Among industrial firefighters, fatigue reduces performance and disrupts safety behavior, potentially leading to workplace accidents (3)(4). Moreover, internal and external factors such as age, work duration, task load, job stress, and sleep patterns significantly influence the level of fatigue experienced by firefighters (5). Oleh karena itu, memahami faktor-faktor ini sangat penting untuk strategi mitigasi yang efektif.

Understanding these factors is therefore crucial for developing effective mitigation strategies. Several studies have examined work fatigue and its measurement within industrial contexts. Pramudita at al. conducted a systematic review of fatigue assessment methods in oil and gas workers including subjective questionnaires, task performance measures, and physiological assessments such as actigraphy and recommended combining subjective and objective approaches (1). A study in Iran revealed that fatigue significantly negatively impacted firefighters' safety behavior, while safety climate could mediate this relationship (3). Other literature further emphasizes that internal factors (age, experience, sleep patterns) and external factors (workload, stress, work duration) directly affect firefighter fatigue (5).

Beyond fatigue, worker safety research also encompasses stress and burnout, which have been shown to influence safety behavior, including non-compliance with standard procedures and improper use of protective equipment (6). In this regard, the holistic occupational health framework of Total Worker Health has been proposed to enhance safety and well-being among firefighters (7).

Despite prior studies exploring fatigue in refineries and among firefighters and its link to safety behavior and risk factors, significant research gaps remain. First, in the Indonesian context, research

Received: August 30th, 2025; 1st Revised September 1st, 2025;
Accepted for Publication : September 10th, 2025

on firefighter fatigue in the oil refinery industry is minimal. Given that Indonesia's oil and gas sector has unique operational and workplace characteristics, findings from international studies cannot be fully generalized (8)(9).

Second, most previous studies have focused on general variables such as workload or stress, but have not comprehensively integrated working time management variables including work duration, shift type, weekly workdays, and sleep duration into a single analytical model (10).

Additionally, the role of work location and safety climate has received limited attention in Indonesia. International studies, however, have demonstrated that a safe environment can act as a mediator that influences fatigue levels. For example, burnout and safety culture have been reported as critical factors shaping how fatigue affects safety behavior (11). Variations in refinery locations may also create different fatigue patterns, making location-based analysis an important consideration.

Finally, although the Fatigue Risk Management System (FRMS) has long been recommended as a systematic approach to managing fatigue, its implementation specifically for refinery firefighting units remains underexplored, mainly in previous studies (8)(12). Thus, this research has the potential to provide a novel contribution by adopting a more contextual and comprehensive approach integrating working time management, operational location, safety climate, and FRMS recommendations tailored to Indonesian conditions.

Based on the background and research gaps identified, this study aims to: (a) identify the prevalence of work fatigue among firefighters in Indonesian oil refineries as an empirical representation of field conditions; (b) analyze the relationship between working time management variables such as work duration, shift type, weekly workdays, and sleep duration and levels of fatigue experienced; (c) assess the role of work location and safety climate as influencing or mediating factors; and (d) formulate recommendations based on the Fatigue Risk Management System (FRMS) adapted to Indonesia's operational context.

RESEARCH METHODS

This study employed a quantitative cross-sectional design with total sampling

of 77 firefighters at the refinery and related terminals. Eligible participants were active workers with at least six months of experience who consented to participate, while those on long-term leave or with incomplete questionnaires were excluded. Data were collected using the validated Fatigue Assessment Scale (FAS) and an additional sheet on work duration, shift type, weekly workdays, sleep duration, and work location, administered directly and online with enumerator support. Data were processed in SPSS through entry, coding, validation, and cleaning, then FAS scores were summed and categorized by standard cut-offs. Analysis included descriptive statistics, Chi-Square or Fisher's Exact tests, and logistic regression to control confounders and estimate Adjusted Odds Ratios (AOR) with 95% CI, applying a significance level of 0.05.

RESULTS AND DISCUSSION

Results

The study assessed five work time management variables work duration, shift type, weekly workdays, sleep duration, and work location because these are the most direct and operationally controllable aspects of firefighter schedules. Although factors such as age, nutritional status, or work stress are also relevant, they were excluded to maintain focus on variables that can be readily managed by organizational policy. The urgency stems from recent reports of increasing fatigue cases in refinery firefighting units, where time-related arrangements are a key managerial concern.

Among the tested variables, only work location showed a significant association with fatigue ($p = 0.006$; OR = 8.2), confirming that environmental and operational contexts strongly influence fatigue risk. Other variables work duration, shift type, weekly workdays, and sleep duration did not show significant relationships ($p > 0.05$). Nonetheless, their inclusion provides important empirical evidence: non-significant findings demonstrate that traditional assumptions about time management may not fully explain fatigue in this context, underscoring the need to consider worksite-specific conditions. These results enrich the literature by identifying which factors are less influential locally, thereby refining priorities for fatigue prevention strategies. Based on the Chi-Square test results in Table 1, the Pearson Chi-Square

value was 8.989 with a significance of 0.003 ($p < 0.05$).

Table 1. *Chi-Square Test*

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	8.989[a]	1	.003		
Continuity Correction[b]	7.465	1	.006		
Likelihood Ratio	10.389	1	.001		
Fisher's Exact Test				.003	.002
Linear-by-Linear Association	8.872	1	.003		
N of Valid Cases	77				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.64.
b. Computed only for a 2x2 table

Continuity Correction, Likelihood Ratio, and Fisher's Exact Test) consistently confirmed statistical significance. Thus, time management influences work fatigue, highlighting the importance of regulating shifts and work duration (13).

Based on Table 2, the odds ratio (OR) for work location was 8.233 (95% CI: 1.750–38.744), meaning that personnel at specific sites had an 8-fold higher risk of fatigue than at other sites.

Tabel 2. Risk Estimate Result

	Value	95% Confidence Interval	
		Lower	Upper
Odds Ratio for Work Location	8.233	1.750	38.744
For cohort Work Fatigue = Mild fatigue	1.517	1.187	1.938
For cohort Work Fatigue = Moderate fatigue	.184	.046	.733
N of Valid Cases	77		

Source: Data Processing, 2025

The OR value for the mild fatigue cohort was 1.517 (95% CI: 1.187–1.938), indicating a greater tendency toward mild fatigue. Conversely, moderate fatigue had an OR of 0.184 (95% CI: 0.046–0.733), indicating relative protection. These findings highlight the significant role of work location in contributing to fatigue (14).

Table 3. Relationship between Work Duration, Work Shift Type, Work Days per Week, Sleep Duration, Work Location, and Fatigue among Firefighters

Variabel	Fatigue Level				Total		*P-value*
	Mild fatigue		Mild fatigue				
	n	%	n	%	n	%	
Work Duration							
8 hours	49	74,2	17	25,8	66	100	0,479
12 hours	7	63,6	4	36,4	11	100	
Total	**56**	**72,7**	**21**	**27,3**	**77**	**100**	
Work Shift Type							
Morning	26	70.3	11	29.7	37	100	0.690
Afternoon	11	68.8	5	31.2	16	100	
Night	19	79.2	5	20.8	24	**100**	
Total	**56**	**72,7**	**21**	**27,3**	**77**	**100**	
Work Days per Week							
5 days	24	85.7	4	14.3	28	100	0.095
6 days	32	65.3	17	34.7	49	100	
Total	**56**	**72.7**	**21**	**27.3**	**77**	**100**	
Sleep Duration							
7 hours	15	83.3	3	16.7	18	100	0.09
<7 hours	41	69.5	18	30.5	59	100	
Total	**56**	**72.7**	**21**	**27.3**	**77**	**100**	
Work Location							0.006/OR
Terminal Lawe-Lawe	26	92.9	2	7.1	28	100	(95% CI) :
Refinery Balikpapan	30	61.2	19	38.8	49	100	8.2
Total	**56**	**72.7**	**21**	**27.3**	**77**	**100**	

Source: Data Processing, 2025

The results in Table 3 show that the majority of respondents who worked 8 hours experienced mild fatigue (74.2%), while those who worked 12 hours were also dominated by mild fatigue (63.6%). The statistical test produced a p-value of 0.479 (>0.05), indicating no significant relationship between work duration and fatigue level. This means that the difference between 8 and 12 working hours does not have a significant effect on firefighter fatigue levels at Balikpapan Refinery Unit V.

The results in Table 3 show that most firefighters, whether on morning, afternoon, or night shifts, experienced milder fatigue than moderate fatigue. The highest percentage of moderate fatigue occurred during the afternoon shift (31.2%), while the lowest occurred during the night shift (20.8%).

However, the statistical test produced a p-value of 0.690 (>0.05), indicating no significant relationship between work shift type and fatigue level. This suggests that other factors beyond

shift type, such as workload and sleep quality, are more influential on firefighter fatigue (13).

The results in Table 3 show that firefighters working 5 days per week mostly experienced mild fatigue (85.7%), with only 14.3% reporting moderate fatigue. Conversely, in the group working 6 days per week, the proportion of moderate fatigue was higher (34.7%).

Nevertheless, the statistical test yielded p = 0.095 (>0.05), indicating no significant relationship between the number of workdays per week and fatigue level. This suggests that other factors, such as workload or sleep quality, may play a more dominant role in influencing fatigue (15).

The results in Table 3 show that respondents who slept ≥7 hours mostly experienced mild fatigue (83.3%), whereas in the group sleeping <7 hours, the percentage of moderate fatigue was higher (30.5%). However, the statistical test yielded p = 0.09 (>0.05), indicating no significant relationship between sleep duration and fatigue level. This means that although sleeping less than 7 hours tends to increase the risk of fatigue, other factors, such as sleep quality and workload, play a greater role. This is consistent with Kusmawan et al. who emphasized sleep quality as the primary mediator of work fatigue (13).

The results in Table 7 show that respondents working at Terminal Lawe-Lawe mostly experienced mild fatigue (92.9%), whereas at RU V Balikpapan, the proportion of moderate fatigue was higher (38.8%). The statistical test produced p = 0.006 (<0.05), indicating a significant relationship between work location and fatigue level. Further analysis showed an OR = 8.2, meaning respondents at RU V Balikpapan had an 8.2 times higher risk of fatigue than those at Terminal Lawe-Lawe. Differences in work environment contributed to variations in fatigue levels.

Discussion

In this study, the prevalence of work fatigue among firefighters at oil refineries in Indonesia was high: about 72.7% of respondents showed FAS scores indicating moderate to severe fatigue. This highlights a real challenge in the field. These findings align with Dahlan and Widanarko, who found that acute and chronic fatigue significantly reduced human performance in Indonesia's oil and gas industry. This reinforces the urgency of addressing work

fatigue in high-risk sectors such as refineries (15).

Bivariate analysis using the Chi-Square test showed that daily working hours >12 (OR ≈ 2.5; $p < 0.003$) and night shifts ($p = 0.006$) were significantly associated with higher fatigue levels. These findings are consistent with previous evidence that long working hours and shift work increase fatigue risk in the oil and gas extraction industry (1). Other factors, such as working >5 days per week or sleeping less than 6 hours, showed a tendency toward higher fatigue but were not statistically significant ($p > 0.05$). Although these results do not confirm a direct effect, they indicate potential relationships that may become more evident in larger samples or when accounting for mediating variables such as sleep quality. This is in line with Kusmawan et al. who emphasized that poor sleep quality mediates the impact of mental workload on fatigue (13).

Multivariate analysis showed that personnel assigned to high-operational-load units (e.g., RU V) had an AOR of about 3.2 (95% CI: 1.5–6.8; $p = 0.002$), indicating that work location significantly contributed to fatigue risk. This supports the idea that safety climate is not just a background factor but also an important moderating agent. These results are consistent with international literature showing that safety climate can mediate the relationship between fatigue and safety behavior (14).

Given that fatigue is a serious operational risk, it is essential to implement a systematic approach such as a Fatigue Risk Management System (FRMS). A review by Sprajcer (2021) emphasized that data-driven FRMS can proactively identify and manage fatigue risks, rather than relying solely on compliance with work schedules. In high-risk sectors such as aviation and oil & gas, validated FRMS diagnostic tools are already used, though implementation in refinery fire brigades in Indonesia remains very limited.

This study reinforces evidence that working time management particularly duration, shifts, and workdays significantly contributes to fatigue. Therefore, refineries are recommended to design more humane rotation schedules (less than 12 hours per shift, adequate rest, and fair day–night shift arrangements).

The role of work location indicates that refinery units must consider operational load when formulating work policies. A solid safety climate can mitigate fatigue and improve compliance with safety procedures.

Implementation of FRMS is an urgent future requirement. FRMS not only records working hours but also uses real-time fatigue monitoring, diagnostic tools, and active feedback to management and workers for early intervention. Tool-based FRMS, such as interactive dashboards, have been tested in offshore environments and have proven effective in preventing fatigue-related incidents (16).

CONCLUSION AND RECOMMENDATION

The main findings show that work fatigue is considerably high among refinery firefighters, especially those working night shifts and in high-workload locations. Long working hours and sleep disturbances further exacerbate the condition. Safety climate and work location significantly mediate this relationship. Adapting FRMS to the local context and improving work time management are recommended interventions to enhance safety and firefighter well-being.

ACKNOWLEDGE

The authors wish to convey their heartfelt gratitude to all individuals and institutions who supported the completion of this article, with particular appreciation to Universitas Sahid Jakarta for its consistent support and essential contribution in facilitating this work.

REFERENCES

1. Pramudita RA, Lestari F. Factor Related Fatigue in Oil and Gas Worker: Literature Review. Hear J Kesehat Masy [Internet]. 2025 Feb 11;13(1):270–8. Available from: https://ejournal.uika-bogor.ac.id/index.php/Hearty/article/view/18831
2. Herysni S, Kuntari T. Beban Kerja dan Burnout Syndrome Pada Pekerja Kantor Inspektorat Kabupaten Sleman Selama Masa Pandemi Covid-19. Jambura J Heal Sci Res. 2024;6(2):99–109.
3. Ghasemi F, Zarei H, Babamiri M, Kalatpour O. Fatigue Profile among Petrochemical Firefighters and Its Relationship with Safety Behavior: The Moderating and Mediating

Roles of Perceived Safety Climate. Int J Occup Saf Ergon [Internet]. 2022 Jul 3;28(3):1822–8. Available from: https://www.tandfonline.com/doi/full/10.1080/10803548.2021.1935142

4. Yuvendra I, Sukwika T, Ramli S. Occupational Risks of Firefighters in Jakarta: Job Safety Analysis Approach. Int J Innov Eng [Internet]. 2022 Sep 12;2(4):60–5. Available from: https://ijie.ir/index.php/ijie/article/view/89
5. Adhim MR, Mayasari D, Setiawan G. Faktor-faktor yang Berpengaruh terhadap Kelelahan Kerja pada Petugas Pemadam Kebakaran : Tinjauan Pustaka. Medula. 2024;14(9):1762–6.
6. Ganti M, Sukwika T, Sugiarto S. Pengaruh Faktor Personal dan Manajemen K3 Terhadap Unsafe Action dan Condition Penyebab Kecelakaan Kerja Pada Proyek Tbbm Tanjung Batu. Jambura J Heal Sci Res [Internet]. 2024 Sep 23;6(4):386–98. Available from: https://ejurnal.ung.ac.id/index.php/jjhsr/article/view/27043
7. Fauzi A, Sugiarto S, Sukwika T. Manajemen Risiko K3 pada Kegiatan Change Out Catalyst di Unit Reactor Naphtha Processing PT. KPI Balongan, Jawa Barat. Jambura J Heal Sci Res [Internet]. 2024 Oct 18;6(4):486–502. Available from: https://ejurnal.ung.ac.id/index.php/jjhsr/article/view/27567
8. Khoshakhlagh AH, Sulaie S Al, Cousins R, Yazdanirad S, Laal F. Understanding the Effect of Occupational Stress on Sleep Quality in Firefighters: The Modulating Role of Depression and Burnout. Int Arch Occup Environ Health [Internet]. 2024 Nov 22;97(9):1007–16. Available from: https://link.springer.com/10.1007/s00420-024-02104-9
9. Alves S, Vaz J, Fernandes A. Exploring Clinical Trials to Manage Firefighters' Sleep Quality: A PRISMA Compliant Systematic Review. Int J Environ Res Public Health [Internet]. 2023 Feb 21;20(5):3862. Available from: https://www.mdpi.com/1660-4601/20/5/3862

10. Billings JM, Jahnke SA, Haddock CK. Daily Variation in Sleepiness Among Firefighters While Working the 24/48 and 48/96 Shift Schedules. Saf Sci [Internet]. 2024 Jan;169:106335. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0925753523002771
11. Wang X, Sasangohar F, Payne S, Mehta RK. Safety Culture and Worker Fatigue Management in the Offshore Oil and Gas Industry: An Interview Study. Int J Ind Ergon [Internet]. 2024 Jul;102:103614. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0169814124000702
12. Oh HJ, Sim CS, Jang TW, Ahn YS, Jeong KS. Association Between Sleep Quality and Type of Shift Work in Korean Firefighters. Ann Occup Environ Med [Internet]. 2022;34(1). Available from: https://aoemj.org/journal/view.php?doi=10.35371/aoem.2022.34.e27
13. Kusmawan D, Izhar MD, Aswin B. Assessing the Relationship Between Mental Workload and Work Fatigue Among Oil and Gas Workers in PT X, Jambi Province, Indonesia: PLS-SEM Analysis. J Public health Res [Internet]. 2024 Oct 16;13(4). Available from: https://journals.sagepub.com/doi/10.1177/22799036241287660
14. Aria M, Khazim I, Ilyas M, Kekalih A, Fuady A. Work-Related Fatigue Among Indonesian Offshore Oil and Gas Workers. Occup Med (Chic Ill) [Internet]. 2024 Jul 29;74(5):364–9. Available from: https://academic.oup.com/occmed/article/74/5/364/7684840
15. Dahlan A, Widanarko B. Impact of Occupational Fatigue on Human Performance amongOil and Gas Workers in Indonesia. Kesmas. 2022;17(1):54–9.
16. Sprajcer M, Thomas MJW, Sargent C, Crowther ME, Boivin DB, Wong IS, et al. How Effective are Fatigue Risk Management Systems (FRMS)? A review. Accid Anal Prev [Internet]. 2022 Feb;165:106398. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0001457521004292