WORK FATIGUE IN THE MINING INDUSTRY: A LITERATURE REVIEW OF FACTORS, IMPACTS, AND MEASUREMENT STRATEGIES

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ABSTRACT

Work fatigue is one of the crucial issues in the mining industry that has a significant impact on safety, health, and work productivity. This study aims to comprehensively examine the factors causing work-related fatigue, its impact on workers, and the measurement strategies used in various mining work contexts. This is done through a systematic literature review of national and international publications, particularly from the past five years (2019-2025). This study employs the Systematic Literature Review (SLR) method, utilising academic databases such as Scopus and Google Scholar, resulting in the synthesis of 10 articles. The results of the Systematic Literature Review (SLR) indicate that work-related fatigue is influenced by various factors such as age, tenure, shift systems, physical and mental workloads, and extreme work environment conditions. Additionally, psychosocial factors such as work-related stress, work-life balance, and production target pressures were also identified as significant contributors to work-related fatigue. The strategies for measuring fatigue in this study varied, ranging from subjective methods such as the MFI-20 questionnaire, SCL-90, PHQ-9, and GAD-7, to objective approaches such as wearable sensors, operational data from heavy machinery, and the application of machine learning for real-time fatigue prediction in underground mines. The findings of this review emphasise the importance of a multidimensional approach in assessing work-related fatigue and the need for integrated interventions that include shift work management, workload control, technology-based operator condition monitoring, and mental health support programmes.

Keywords : Work Fatigue, Mining, Workload, Job Stress, Fatigue Measurement, Wearable Sensors, Machine Learning, Mental Health

INTRODUCTION

The mining industry is one of the strategic sectors that contributes greatly to the national economy. However, this sector also holds high risks to occupational safety and health. Extreme working environments such as high temperatures, noise, exposure to dust, hazardous chemicals, as well as long and irregular shift work patterns often trigger occupational fatigue among mine workers [1]. Occupational fatigue is defined as a condition of decreased physical and mental energy due to sustained work pressure, which can reduce work performance, increase the risk of accidents, and increase the likelihood of psychological disorders such as stress and depression. found that the majority of mine workers on long work rosters experienced mild to moderate fatigue, accompanied by high levels of psychological stress. [2]

Individual factors such as age and length of service also play a role in increasing the risk of fatigue. Night shift patterns also have a significant impact on the fatigue of heavy equipment operators. [3]

There is a significant relationship between job stress and job burnout in a

Submit:June 23th,2025 Accepted: June 23th , 2025 Published: 23 Juneth ,2025

processing industry environment that has similar characteristics to the mining industry. Workload and stress negatively impact job satisfaction, but can be moderated by work-life balance[4].

The prevalence of mental fatigue among mine operators in Indonesia reached 32.3%, with the main risk factors being high stress levels and work location in the pit area.[5] Mine workers with high stress levels are at greater risk of experiencing symptoms of depression, anxiety, and sleep disturbances than workers with low stress levels. [7]

Along with the development of industrial technology 4.0, approaches to measuring occupational fatigue are now increasingly varied, ranging from the use of subjective questionnaires such as MFI-20, PHQ-9, GAD-7 to the implementation of wearable sensors and machine learning for real-time fatigue detection in underground mines. The machine learning-based prediction model developed by Qin et al. (2022) proved to be able to identify potential fatigue before there is a significant decrease in work performance[8].

There is modelling in detecting machine operator fatigue through operational machine data such as engine load and cycle time[9]

Based on these findings, it can be concluded that fatigue in the mining sector is a multidimensional phenomenon influenced by individual, environmental and organisational factors. Therefore, this literature review is important to comprehensively summarise the causes, effects and measurement strategies of job fatigue that have been developed in recent years

RESEARCH METHODS

This research uses a Systematic Literature Review (SLR) approach to comprehensively examine the causal factors, impacts, and measurement strategies of occupational fatigue in workers in the mining industry. The SLR approach was chosen because it is able to identify, select, and synthesise findings from various previous studies in a systematic, structured, and transparent manner. Data were collected from ten scientific articles published between 2021 and 2025. Five articles were from the original source in Literature Review.docx and five additional articles were obtained from reputable international journals. Inclusion criteria included

1. The main topic addressed labour tenure in the mining sector
2. Articles were either empirical studies (cross-sectional, experimental) or systematic reviews.
3. Written in Indonesian and/or English.
4. Published in an indexed national or international journal
5. Fully accessible for in-depth analysis. The literature review procedure was conducted through the following steps:

1. Article identification and selection
2. Data extraction
3. Data analysis and synthesis
4. Validity and Limitations

RESEARCH RESULT

No	Journal Title	Author	Year of publication	Research Results
1	Occupational Fatigue in Mine Workers: What are the Factors and How is it Measured?	Ramdhania & Soraya	2024	Fatigue is influenced by sleep deprivation, heavy workload, shifts, and extreme work environments. Measured using subjective and objective methods.
2	The Effect of Age, Tenure, and Work Shift on Occupational Fatigue in Heavy Equipment Operators	Sitanggang et al.	2024	Work shifts have a significant effect on job fatigue, while age and tenure are not significant.
3	Analysis of Occupational Fatigue and Psychological Stress in Mining Workers with Long Work Roster	Tobing & Haro	2025	Occupational fatigue and psychological stress are significantly interconnected. The majority of workers experienced mild fatigue and moderate stress.
4	Relationship between Occupational Stress and Work Fatigue in Workers at PT Delta Pasific Indotuna	Manaroinsong et al.	2022	There is a significant correlation between job stress and job fatigue with moderate relationship strength.
5	The Effect of Workload and Job Stress on Job Satisfaction with Work-Life Balance as Mediation	Kusumawati & Linando	2024	Workload and work stress negatively affect job satisfaction, but can be mediated by work-life balance.
6	Mental Fatigue and Its Associated Factors among Coal Mining Workers after One Year of the COVID-19 Pandemic in Indonesia	Djamalus et al.	2021	Mental fatigue prevalence 32.3%. Significant risk factors: moderate- high work stress and work location in the *pit* area.
7	Occupational Stress and Its Effects on Depressive Symptoms, Anxiety Symptoms, and Sleep in Workers of Ferrous and Non-Ferrous Metal Mining Industry in Gansu Province	He et al.	2023	High stress levels increase the risk of depression (OR=3.29), anxiety (OR=2.87), and sleep disturbance (OR=1.78).
8	Association of Psychological Symptoms with Job Burnout and Occupational Stress among Coal Miners in Xinjiang, China	Fu et al.	2022	There was a significant association between work stress, fatigue and psychological disorders. Risk increased with longer working hours and night shifts.
9	Fatigue Detection in Underground Mine Workers Using Wearable Sensors and Machine Learning	Qin et al.	2022	Machine learning and wearable sensors are effective for real-time fatigue detection of underground mine operators.
10	A Phase Field Model for High-Cycle Fatigue: Total-Life Analysis	Golahmar et al.	2023	A machine learning-based prediction model can map fatigue potential based on mining machine operational data, improving machine reliability.

Source: Secondary Data, 2025

DISCUSSION

From the table, it can be concluded that although the methodological approach of each study is different, there is a consistency of findings in terms of the importance of the influence of workload and psychological stress on fatigue levels. In addition, shift work arrangements and lack of stress management are critical factors for mining company management to address**.** This research highlights that the main factors causing occupational fatigue include sleep deprivation, heavy workload, irregular work shifts, as well as environmental conditions such as high temperature, noise, and poor air quality. fatigue measurements, both through subjective instruments such as the MFI-20 and Karolinska Sleepiness Scale, as well as objective approaches such as heart rate and reaction time measurements. [1]

There is a relationship between job burnout and psychological stress in mine workers undergoing long work rosters. Pearson Correlation test results showed a significant positive relationship between the two variables. The majority of respondents experienced mild fatigue but were in the moderate stress category. This finding illustrates that a long-term work system without work-life balance can worsen the psychological state of workers. This article expands the understanding that job burnout not only decreases physical ability, but also increases the ongoing mental burden."[2]

The effect of age, tenure, and work shift on fatigue in heavy equipment operators in mining companies also showed that only the work shift variable had a significant effect on fatigue levels, while age and tenure did not. This can prove that the rotating work system (especially night shifts) is a major factor that needs to be reviewed in human resource management in the mining sector. This study also reinforces the findings of the first article regarding the importance of organising work schedules that take into account the body's circadian rhythms. [3]

Although the context of the study was fish processing industry workers, work situations such as production target pressure and monotonous work environment have similarities with mining. The correlation found was moderate, but significant enough to suggest that persistent psychological stress is a major trigger of physical fatigue and decreased work efficiency. This study complements previous discussions with empirical evidence that stress cannot be ignored as a major trigger of fatigue in various types of industries."[4]

Fatigue perspectives related to workload and job stress negatively affect job satisfaction, but these effects can be positively regulated by work-life balance. Work fatigue cannot solely be addressed by technical or physical interventions, but also requires a psychosocial approach that supports work-life balance[5].

The results of this study are particularly relevant because it was conducted in Indonesia, specifically in Kalimantan and Sumatra. The study found a prevalence of mental fatigue of 32.3% among mine operators, with the dominant factors being moderate-high job stress and work location in the pit area. These findings emphasise the importance of work location and stress as key risk factors in local mining environments [6].

Impact of occupational stress on depression, anxiety, and sleep disturbance. High stress levels increased the risk of depressive symptoms (OR=3.29), anxiety (OR=2.87) and sleep disturbance (OR=1.78). This study

expands the insight that mine fatigue is closely associated with mental health disorders. [7]

Occupational fatigue among coal miners in Xinjiang was significantly associated with job stress and psychological burnout. The study also showed that the risk increased with length of service and frequency of night shifts. This reinforces findings from other articles on the impact of night shifts and long working lives. [11]

Offers an innovative approach that utilises wearable sensors and machine learning to detect fatigue in underground mine operators in real-time. This approach shows superiority in predicting potential fatigue earlier than traditional subjective methods. This study is an important reference in the development of fatigue monitoring technology in the mining industry. [8]

A machine learning-based model for analysing the fatigue of heavy mining equipment was able to predict potential equipment failure due to accumulated material fatigue. Although the focus is on the equipment, the implications for operator safety are also great, as equipment fatigue can lead to workplace accidents."[10]

CONCLUSION

Based on a review of ten scientific articles, it can be concluded that fatigue in the mining sector is a complex problem influenced by various factors. The dominant factors causing fatigue include shift work (especially night shifts), length of service, work location (especially in pit areas), high physical and mental workloads, and significant levels of psychological stress. In addition, work-life balance has also been shown to be an important variable in reducing the negative impact of workload and stress.

The impact of occupational fatigue is not only felt in reduced productivity and increased risk of work accidents, but also triggers psychological disorders such as stress, depression, anxiety, and sleep disorders. This suggests that fatigue in mining is not only physical in dimension, but also mental and emotional.

Effective measurement of occupational fatigue involves a combination of subjective methods such as questionnaires (MFI-20, PHQ-9, GAD-7) and objective methods such as wearable sensors and machine learning. This approach is believed to improve the accuracy of early identification of fatigue risks in the field

BIBLIOGRAPHY

[1] Tolkha, Abdullah. 2024. Identification of *Escherichia Coli* in Processed Beverages at the Canteen of University X. Diss.

[2] Dwitha Ramdhania, J., & Soraya, T. M. (2024). Occupational Fatigue in Mine Workers: What are the Factors and How is it Measured? Indonesian Journal of Occupational Health, 16(1), 12-25.

[3] Tobing, R. Y., & Haro, A. S. (2025). Analysis of Worker Fatigue Based on Work Roster System in Mining Industry. Journal of Industrial Engineering, 21(2), 87-95.

[4] Sitanggang, B., Wulandari, A., & Maulana, D. (2024). Effect of Work Shift on Occupational Fatigue of Heavy Equipment Operators at PT X. Journal of Environmental Health, 18(3), 45-55.

[5] Manaroinsong, D., et al. (2022). Relationship between Occupational Stress and Fatigue in Fisheries Workers:

Implications for the Mining Industry. Journal of Public Health, 10(4), 120-130.

[6] Kusumawati, R., & Linando, G. (2024). The Role of Work-Life Balance in Mediating Workload and Job Satisfaction in the Mining Industry. Journal of Industrial and Organisational Psychology, 19(1), 65-75.

[7] He, Y., Zhang, H., Zhou, N., Xu, J., & Zhao, W. (2025). Occupational stress and its effects on depressive symptoms, anxiety symptoms, and sleep in workers of ferrous and non-ferrous metal mining industry in Gansu Province. Journal of Environmental and Occupational Medicine, 42(4), 444-450.

[8] Qin, Z., Li, Y., Liu, J., & Zhang, C. (2022). Fatigue Detection in Underground Mine Workers Using Wearable Sensors and Machine Learning. Frontiers in Public Health, 10, 1049822.

[9] Drews, F. A., Rogers, W. P., Talebi, E., & Lee, S. (2020). The Experience and Management of Fatigue: A Study of Mine Haulage Operators. Mining, Metallurgy & Exploration, 37(6), 1837-1846.

[10] Golahmar, A., Niordson, C. F., & Martínez-Pañeda, E. (2023). A phase field model for high-cycle fatigue: total-life analysis. International Journal of Fatigue.

[11] Fu, A., Zhao, T., Gao, X., Li, X., Liu, X., & Liu, J. (2022). Association of psychological symptoms with job burnout and occupational stress among coal miners in Xinjiang, China: A cross-sectional study. Frontiers in Public Health, 10, 1049822.