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Comparison of Fatigue Dimensions between Warehouse Staff and Heavy Equipment Technicians in the Mining Sector

Mohammad Ikram Bahari[1], Dewi Friska[2], Ahmad Fuady[2], Nuri Purwito Adi[2], Dewi Yunia Fitriani[2]

[1]Master Program in Occupational Medicine Program, Department of Community Medicine, Faculty of Medicine, Universitas Indonesia, Jakarta, Indonesia
[2]Department of Community Medicine, Faculty of Medicine, Universitas Indonesia, Jakarta, Indonesia

*Corresponding author: Mohammad Ikram Bahari
E-mail: *ikrambahari@gmail.com*

Abstract

Background: Work-related fatigue is a multidimensional condition that can reduce productivity and increase the risk of workplace accidents, particularly in professions with high physical and mental demands such as heavy equipment technicians and warehouse workers in the mining sector. Both professions work under shift systems and high workloads; however, studies comparing the dimensions of fatigue between the two remain limited.
Objective: To determine the proportion of fatigue levels and compare fatigue dimensions between warehouse workers and heavy equipment technicians.
Methods: A descriptive-comparative cross-sectional study was conducted on 132 male workers (100 heavy equipment technicians and 32 warehouse workers) at a mining company in South Kalimantan, Indonesia. Demographic and job-related characteristics were collected. Fatigue was measured using the Swedish Occupational Fatigue Inventory (SOFI) in Indonesian, which has been validated, covering five dimensions: energy deficiency, physical exertion, physical discomfort, sleepiness, and lack of motivation. Descriptive and comparative statistical analyses were conducted.
Results: Mild fatigue (among technicians and warehouse staff were 90% and 93.8%). Moderate fatigue was experienced by 10% of technicians and 6.3% of warehouse staff. No participants experienced severe fatigue. Among heavy equipment technicians, the highest dimension was physical exertion, while the highest dimension of fatigue among warehouse staff was lack of energy. Work factors, age, work experience, and nutritional status were not significantly associated with fatigue levels.
Conclusion: Mild fatigue dominates in both work groups, as this company is a supporting company for a mining company, there have never been any near misses or incidents, and has an appropriate management. For the overall fatigue dimension, heavy equipment technicians scored higher than warehouse staff. However, fatigue checks should still be carried out regularly among workers.
Keywords: occupational raleted satigue, SOFI, mining industry

Abstrak

Latar belakang: *Kelelahan kerja merupakan kondisi multidimensional yang dapat menurunkan produktivitas dan meningkatkan risiko kecelakaan kerja, terutama pada profesi dengan tuntutan fisik dan mental tinggi seperti teknisi alat berat dan petugas gudang di sektor pertambangan. Kedua profesi ini bekerja dengan sistem shift dan beban kerja tinggi, namun kajian mengenai perbandingan dimensi kelelahan antara keduanya masih terbatas.*
Tujuan: *Mengetahui proporsi derajat kelelahan dan perbandingan dimensi kelelahan antara petugas gudang dan teknisi alat berat.*
Metode: *Penelitian potong lintang deskriptif-komparatif dilakukan pada 132 pekerja laki-laki (100 teknisi alat berat dan 32 petugas gudang) di sebuah perusahaan pertambangan di Kalimantan Selatan, Indonesia. Kelelahan diukur menggunakan Swedish Occupational Fatigue Inventory (SOFI) versi bahasa Indonesia yang telah divalidasi, mencakup lima dimensi: kekurangan energi, pengerahan tenaga fisik, ketidaknyamanan fisik, rasa mengantuk, dan kurang motivasi. Analisis statistik deskriptif dan komparatif dilakukan.*
Hasil: *Kelelahan ringan mendominasi pada teknisi alat berat dan petugas gudang (90% dan 93,8%). Kelelahan sedang dialami oleh 10% teknisi dan 6,3% petugas gudang. Tidak ada peserta yang mengalami kelelahan berat. Pada teknisi alat berat dimensi paling tinggi pada physical exertion dan dimensi kelelahan paling tinggi pada petugas gudang pada lack of energi. Faktor pekerjaan, usia, masa kerja, dan status gizi tidak berhubungan signifikan dengan derajat kelelahan.*
Kesimpulan: *Kelelahan ringan mendominasi pada kedua kelompok profesi, dikarenakan perusahaan ini merupakan perusahaan supporting pada perusahaan tambang, tidak pernah adanya near miss dan insiden, dan sudah memiliki pengelolaan manajemen yang tepat. Untuk keseluruhan dimensi kelelahan bahwa teknisi alat berat lebih tinggi dibanding petugas gudang. Namun demikian, pemeriksaan kelelahan secara berkala harus tetap dilakukan.*
Kata kunci: *Kelelahan kerja, SOFI, Industri Pertambangan*

Background

Occupational fatigue has well-documented adverse effects not only on worker safety—by increasing the risk of workplace accidents and near-miss incidents—but also on long-term employee health and organizational performance. Fatigue has been linked to musculoskeletal disorders, reduced cognitive function, absenteeism, presenteeism, and chronic health conditions, including cardiovascular disease and metabolic disorders. In the mining sector, these risks are accentuated by the physical and psychological demands of the work, high noise and vibration exposure, non-standard working hours, and often harsh environmental conditions.[1-4]

Among warehouse staff, primary fatigue risks stem from manual material handling, frequent lifting and moving of heavy objects, repetitive tasks, and suboptimal ergonomic conditions. Physical fatigue in this group may manifest as musculoskeletal discomfort, reduced endurance, and increased susceptibility to injury. Heavy equipment technicians, meanwhile, face their own set of hazards, including prolonged static postures, operation and maintenance of large machines, time pressure, mental concentration, and sometimes exposure to extreme temperatures or inclement weather. Mental fatigue is a concern, particularly where attention lapses or mistakes can have significant safety implications.[5, 6, 7]

Shift work is a particularly important factor, as it disrupts circadian rhythms and has been associated with impaired sleep quality, increased fatigue, and higher accident rates. The roster implemented at the studied site (5-2-5-3, with 12-hour shifts) typifies such challenges. With mining operations running continuously, employees may not achieve sufficient recovery between shifts, leading to cumulative fatigue. The combination of physical demands, shift work, and environmental hazards makes mining a critical context for fatigue research.[8]

Despite the importance of this issue, much of the available literature has focused on either operators or a single occupational group, with few studies directly comparing warehouse staff and technicians. Additionally, while fatigue is often treated as a unidimensional outcome, evidence supports a multidimensional conceptualization—distinguishing between physical, mental, and motivational aspects, each with potentially distinct determinants and outcomes. The Swedish Occupational Fatigue Inventory (SOFI) allows for the systematic assessment of these dimensions, providing a nuanced understanding relevant for targeted intervention planning.[9, 10]

Given these considerations, this study was designed to compare the prevalence and dimensional profile of work-related fatigue among warehouse staff and heavy equipment technicians in a mining setting. The study also aimed to identify demographic and occupational characteristics (age, length of service, nutritional status) associated with increased fatigue risk. The results are intended to inform both company-level occupational health strategies and broader efforts to enhance worker well-being and productivity in high-risk sectors.

Methods

Study design and setting

A cross-sectional, descriptive-comparative study was conducted at a branch site of a major mining equipment provider in South Kalimantan, Indonesia. The company serves the mining sector by providing equipment and maintenance services, and operates on a 24-hour schedule with a 12-hour shift system. Workers typically complete five days of morning shifts, followed by two days off; then five days of night shifts, followed by three days off. Data collection took place from the second to the third week of June 2025. The study protocol received approval from the Institutional Health Research Ethics Committee (No. KET-662/UN2.F1/ETIK/PPM.00.02/2025), and written permission was obtained from company management.

Study population and sampling

The study population comprised all warehouse staff and heavy equipment technicians employed at the branch site during the study period. Eligibility criteria included: male gender (reflecting the company's workforce demographics), employment in the target roles, and completion of all required questionnaires. Workers with incomplete data or with a history of serious illness (hypertension grade 2, cardiac disease, diabetes, psychiatric disorders under treatment) were excluded.

A total sampling approach was used, maximizing the representativeness of available data and ensuring adequate power to detect group differences. The final sample consisted of 132 workers: 100 heavy equipment

technicians and 32 warehouse staff. Sample size calculations based on expected differences in SOFI dimension scores indicated that the study was adequately powered to detect moderate between-group differences, with the minimum required group size of 32.

Data collection procedures

The data are secondary data collected through a combination of company records (medical check-ups) and online questionnaires completed by participants (occupation, age, length of employment). Data collection via online questionnaires was taken at the end of the work shift, under the supervision of Health, Safety and Environment (HSE) staff on site and an occupational health doctor to assist with technical issues or understanding.

The questionnaire consists of two sections:

1. Demographic and job characteristics: age, length of employment, type of work.
2. Fatigue assessment: the validated Indonesian version of the Swedish Occupational Fatigue Inventory (SOFI).

Fatigue measurement: Swedish Occupational Fatigue Inventory (SOFI)

The SOFI is a 20-item, multidimensional instrument that assesses subjective perceptions of work-related fatigue. It is structured into five subscales (dimensions):

- Lack of energy
- Physical exertion
- Physical discomfort
- Sleepiness
- Lack of motivation

Each dimension consists of four items, rated on a 7-point Likert scale from 0 (not at all) to 6 (very much). The SOFI has been validated in Indonesian populations, demonstrating high reliability (Cronbach's alpha = 0.969) and excellent validity.. The SOFI was administered at the end of work shifts to capture acute work-related fatigue.[11]

Total fatigue scores were categorized as follows:

- Mild fatigue: 0-50
- Moderate fatigue: 51-100
- Severe fatigue: >100

Scores for each SOFI dimension were also calculated and compared between groups.

Operational definitions

- Job type: classified as heavy equipment technician or warehouse staff.
- Age: dichotomized at 30 years (≥30, <30).
- Length of Service: categorised as ≤5 years or >5 years.
- BMI: categorised per WHO guidelines (underweight <18.5, normal 18.5–22.9, overweight 23–24.9, obese ≥25).
- Fatigue: categorised based on score distribution (mild fatigue 0-50, moderate fatigue 51-100, severe fatigue >100)

Statistical Analysis

Data were analyzed using SPSS version 26. Descriptive statistics (mean, SD, frequencies, percentages) summarized demographic, occupational, and fatigue data. The distribution of SOFI scores was assessed for normality using the Shapiro–Wilk test. Between-group comparisons were performed using independent-samples t-tests for normally distributed variables, and Mann–Whitney U tests for non-normally distributed variables. Chi-square or Fisher's exact tests were used to compare categorical variables.

Associations between demographic/occupational characteristics and fatigue levels were examined using bivariate analysis. Statistical significance was set at $p<0.05$. All analyses were conducted according to the STROBE guidelines for reporting observational studies.

Results

Sample characteristics

A total of 132 workers participated in the study, comprising 100 heavy equipment technicians (75.8%) and 32 warehouse staff (24.2%). All participants were male. The majority of workers were aged 30 years or older (n=72, 54.5%), while the remainder were under 30 years (n=60, 45.5%). Obesity was the most prevalent nutritional status, affecting 44.7% of respondents. More than half of participants had been employed for over five years (n=77, 58.3%). No participants reported a history of severe chronic disease as per the exclusion criteria.

Table 1. Distribution of participants by demographic and occupational characteristics (n=132)

	Warehouse staff (n=32)	Technicians (n=100)
Age		
≥ 30 years	17 (53%)	55 (55%)
< 30 years	15 (46%)	45 (45%)
Nutritional status		
Underweight (BMI 18.5)	2 (6,3%)	12 (12%)
Normal (BMI 18.5-22.9)	10 (31,3%)	31 (31%)
Overweight (BMI 23-24.9)	7 (21%)	11 (11%)
Obesitas (BMI >25)	13 (40,6%)	46 (46%)
Length of service		
≤ 5 years	14 (43,8%)	41 (41%)
> 5 years	18 (56,3%)	59 (59%)
Fatigue Level		
Severe	0 (0%)	0 (0%)
Moderate	2 (6,3%)	10 (10%)
Mild	30 (93,8%)	90 (90%)

Distribution of fatigue severity

Mild fatigue was predominant in both occupational groups. Among heavy equipment technicians, 90 (90%) reported mild fatigue, and 10 (10%) reported moderate fatigue. Among warehouse staff, 30 (93.8%) experienced mild fatigue, and 2 (6.3%) reported moderate fatigue. No participants in either group reported severe fatigue. The distribution of fatigue severity was further analyzed according to age, length of service, and BMI categories. In the mild fatigue group, warehouse staff were equally distributed by age, while obese status predominated. Among those with moderate fatigue, all warehouse staff were over 30 years old, with more than five years of length of service and obese status. For technicians with moderate fatigue, half were over 30 years old, half had more than five years of length of service, and 60% were obese.

Comparison of SOFI dimension scores

As can be seen from the table, the overall level of fatigue among technicians is higher than that among warehouse staff. For heavy equipment technicians, the highest fatigue dimension is physical exertion, whereas for warehouse staff, it is lack of energy. However, the overall scores for both groups are predominantly in the mild fatigue category. The table also shows that some warehouse staff reported a fatigue score of zero in the questionnaire.

Table 2. Comparison of fatigue dimensions in warehouse staff and heavy equipment technicians

Fatigue dimension (n=132)										
	Physical Exertion		Lack of Motivation		Physical Discomfort		Sleepiness		Lack of Energy	
	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max
Warehouse Staff	4,41±3,21	(0-12)	2±2,43	(0-9)	3,22±3,87	(0-16)	3,28±3,09	(0-10)	4,66±4,52	(0-15)
Technicians	6,99±2,33	(4-14)	4,91±1,53	(3-12)	5,82±2,52	(4-15)	5,95±2,38	(4-14)	6,77±3,33	(4-21)

Notes: The higher the mean value, the higher the level of fatigue.

Bivariate Analysis: Factors Associated with Fatigue

Bivariate analysis was performed to explore associations between fatigue level (mild vs moderate) and job type, age, length of service, and BMI. No statistically significant associations were found for any factor (all p>0.05). Odds ratios and confidence intervals indicated no increased risk of moderate fatigue by job type, age, length of service, or nutritional status.

Discussion

This study conducted an in-depth comparative analysis of work fatigue among warehouse staff and heavy equipment technicians in the mining sector, using the multidimensional framework of the Swedish Occupational Fatigue Inventory (SOFI). The findings indicate that mild fatigue is common in both groups, with moderate fatigue occurring in a small proportion of participants and no cases of severe fatigue identified. Notably, the most prominent fatigue dimensions were energy depletion and physical exertion, supporting a multidimensional understanding of work fatigue in physically demanding work environments.

The prevalence of mild fatigue aligns with international and national literature, which identifies the mining sector and related sectors as high-risk sectors for cumulative fatigue, though this is often mitigated by organisational safety programmes and health monitoring. The patterns observed in this study—where moderate fatigue is more common among obese workers but not significantly associated with age, length of employment, or job type—suggest that individual health status, particularly nutritional factors, may influence subjective fatigue experiences more than job classification alone in this context. [8, 7]

The absence of severe fatigue and the predominance of mild cases may be due to several factors. First, this company is a supporting company in mining and there have been no near misses or incidents to date. Second, the company's mandatory shift schedules and rest periods, as well as continuous health monitoring, may act as protective factors. Third, strict safety and health protocols in the mining sector, which often include regular medical examinations and worker health education, may help in the early detection and management of fatigue before it progresses to severe levels. Fourth, the cross-sectional design and timing of data collection—immediately after the shift ended—may only capture manifestations of fatigue at that moment, but should be revisited if work orders increase, employee turnover increases, near misses or incidents occur, and other changes occur.

Key findings indicate that the most prominent dimensions among those experiencing fatigue are lack of energy and physical exertion, consistent with previous studies showing that physical fatigue is prominent in environments with high manual demands and repetitive physical tasks. Warehouse staff, who frequently handle materials and stand for extended periods, and

Table 3. Bivariate analysis of factors associated with fatigue

Factor	Moderate Fatigue n (%)	Mild Fatigue n (%)	Total	p-value	OR (95% CI)
Job type					
Technicians	10 (10.0)	90 (90.0)	100	0.73	1.67 (0.35–8.04)
Warehouse staff	2 (6.3)	30 (93.8)	32		
Age				0.78	1.19 (0.36–3.94)
≥30 years	7 (9.7)	65 (90.3)	72		
<30 years	5 (8.3)	55 (91.7)	60		
Length of service				1.00	1.00 (0.30–3.33)
>5 years	7 (9.1)	70 (90.9)	77		
≤5 years	5 (9.1)	50 (90.9)	55		
Nutritional status				0.22	0.44 (0.11–1.69)
Overweight/Obese	9 (11.7)	68 (88.3)	77		
Underweight/Norm	3 (5.5)	52 (94.5)	55		

Notes: p-values calculated using Chi-square or Fisher's exact tests as appropriate.

technicians responsible for maintenance and repairs under time pressure, both face significant physical demands. However, this study did not find significant differences in fatigue profiles between the two groups, suggesting that organisational and environmental factors (e.g., shift work, sleep quality, ergonomics) may have a more widespread influence across job categories than task-specific risks alone.

Comparing these results with previous research, observed similar trends in industrial and warehouse settings, noting that musculoskeletal symptoms and general fatigue often stem from ergonomic and organisational factors. In line with Brighenti-Zogg research, this study reinforces the impact of shift work and circadian rhythm disruption on fatigue and well-being, even in the presence of safety protocols. Reports from the International Labour Organization (ILO) and statistics from the Indonesian Ministry of Manpower further highlight the persistent burden of fatigue and the need for ongoing monitoring and intervention.[5, 6, 12, 13]

Interestingly, this study did not find a statistically significant association between fatigue levels and age, length of employment, or nutritional status, although there was a trend indicating higher moderate fatigue among older workers and those who were obese. These findings may reflect limited statistical power due to small subgroup sizes, particularly among warehouse staff with moderate fatigue. They also suggest that multifactorial influences—including psychosocial factors, sleep patterns, and individual resilience—may play a role in shaping fatigue experiences beyond the measured variables.

Limitations

This study utilised a cross-sectional design, which is less effective in illustrating causal relationships. The measurement tool used was a self-assessment questionnaire. In addition, because this study utilised secondary data, several significant factors could not be examined, such as measured workload, sleep quality, work stress, and work shifts, due to the homogeneous nature of the sample and the unavailability of data. Single Company has limited generalizability.

Implications and Recommendations

Despite these limitations, this study has important implications for occupational health practices in the mining industry and other high-risk industries. The study's findings emphasise the importance of routine fatigue monitoring using multidimensional tools such as SOFI, targeted interventions for high-risk workers (especially those who are obese), and ongoing efforts to optimise shift scheduling, rest periods, and ergonomic design. Worker health education programmes that emphasise the risks of cumulative fatigue and its management strategies—including sleep hygiene, nutrition, and physical activity—should be prioritised. Comparing fatigue levels and fatigue dimensions in main and supporting companies in the mining sector will strengthen fatigue management in the workplace.

Conclusion

This study shows that the company has implemented good fatigue management, with mild fatigue commonly occurring among warehouse staff and heavy equipment technicians in the mining sector, moderate fatigue occurring less frequently, and severe fatigue not found. Although mild fatigue is prevalent, prevention programmes must still be implemented to prevent it from escalating to moderate fatigue, and intervention programmes for moderate fatigue must be carried out to reduce it to mild fatigue. These programmes must also be reviewed if work orders increase, turnover increases, or near misses occur. Lack of energy and physical effort are the most prominent dimensions of fatigue among warehouse staff and heavy equipment technicians. Although demographic and job factors did not show a statistically significant association with fatigue levels, trends suggest a potential role for nutritional status, particularly obesity. Organisational interventions focused on shift management, optimising rest periods, and health education are recommended to maintain and improve worker well-being. Further research is recommended to include longitudinal and objective measurements to better clarify causal pathways and support tailored prevention strategies in the mining industry and other sectors.

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