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The Effect of Noise, Work Stress, Nutritional Status and Working Period on Work Productivity Through Work Fatigue at PT Semen Bosowa Maros

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Abstract

Work productivity is vital in manufacturing, where high-risk conditions exist. Factors like noise and work stress can affect performance directly and indirectly through fatigue. This study aims to analyze the influence of noise and work stress on work productivity through work fatigue in workers at PT Semen Bosowa Maros. This study used an analytical observational design with a cross-sectional approach. The study population was all workers in the production and packaging departments, with a total sampling technique. Noise data were obtained through direct measurements using a sound level meter, while data on work stress, work fatigue and work productivity were collected using a structured questionnaire. Data analysis was performed using univariate, bivariate and multivariate methods using path analysis. The results of the study indicate that noise levels and work stress significantly influence work fatigue. Work fatigue has also been shown to significantly influence work productivity. Furthermore, noise and work stress have an indirect effect on work productivity through work fatigue as a mediating variable. These findings indicate that the higher the noise exposure and work stress levels, the higher the work fatigue experienced by workers, thus impacting work productivity. Occupational fatigue plays a key role as a mediator in the relationship between noise and work stress on productivity. Therefore, companies are advised to implement noise control, work stress management and improve work environment conditions to reduce fatigue and increase worker productivity.

Keywords: Noise, Work Fatigue, Work Productivity, Work Stress.

Introduction

Work productivity is a crucial indicator of organizational performance and is influenced by individual, organizational and environmental factors. In occupational settings, productivity is not only determined by workers' skills and knowledge but also by working conditions, length of employment, exposure to physical hazards, work stress and fatigue. Fluctuations in labor productivity in Indonesia indicate the need to examine workplace factors that may contribute to changes in employee performance (1). Therefore, understanding how occupational exposures and psychosocial factors affect productivity is important for improving both worker well-being and organizational outcomes. Noise is one of the most common physical hazards in the workplace, particularly in industrial sectors. Millions of workers worldwide are exposed to occupational noise, which may contribute not only to hearing loss but also to reduced concentration, fatigue, stress and decreased work performance (2). Exposure to noise levels exceeding the threshold limit value of 85 dB for an eight-hour working period can become a significant occupational hazard because it affects workers not only physically but also psychologically. Prolonged exposure to excessive noise may trigger physiological responses such as increased heart rate, elevated blood pressure, hormonal stress reactions and hearing-related complaints. At the same time, noise can interfere with concentration, communication, comfort and emotional stability in the workplace. When workers are continuously exposed to this condition, their bodies require more effort to maintain focus and complete tasks, which may accelerate the onset of work fatigue. Over time, this fatigue can reduce alertness, accuracy, motivation and work speed, ultimately contributing to decreased productivity and lower overall work performance (3, 4). Previous studies

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have also shown that increased noise exposure can reduce productivity and increase occupational stress among workers (5, 6).

Prolonged exposure to noise may affect productivity through both auditory and non-auditory pathways. Auditory effects include hearing impairment, while non-auditory effects include impaired communication, reduced attention, sleep disturbance, mental fatigue and emotional strain. Research has shown that most workers exposed to noise levels above 85 dB experience symptoms of hearing disturbance or hearing loss (7). In addition, non-auditory effects such as impaired concentration, fatigue and stress may worsen work performance, increase work errors and contribute to workplace accidents (8, 9). In addition to noise exposure, working period and job demands are important factors related to fatigue and productivity. Longer working periods may increase cumulative exposure to occupational hazards, while excessive job demands may accelerate physical and mental fatigue. Fatigue is a multidimensional condition involving reduced physical capacity, decreased mental alertness, lower motivation and impaired work efficiency. Long working hours, repetitive work and continuous exposure to workplace risk factors may increase fatigue, which in turn reduces the quality and quantity of work output (10). Work fatigue has been recognized as a serious occupational health problem because it contributes to reduced productivity, work errors, accidents and occupational diseases (11).

The theoretical foundation of this study is supported by occupational stress and fatigue models, particularly the Job Demand–Resources (JD-R) model and occupational stress theory. The JD-R model explains that every occupation has specific job demands, such as workload, time pressure, noise exposure, physical strain, emotional pressure and unfavorable working conditions. When these demands exceed the worker's available physical, cognitive and emotional resources, they can create strain and gradually reduce the worker's capacity to function optimally. Similarly, occupational stress theory emphasizes that prolonged exposure to workplace stressors can disturb physiological and psychological balance, resulting in exhaustion, reduced concentration, emotional instability and declining work efficiency. In this context, adverse occupational conditions are not only external risk factors but also important triggers that can affect workers' internal condition and performance outcomes.

Within this framework, work fatigue is positioned as a mediating variable because it represents an early psychophysiological response to excessive occupational demands. Fatigue can emerge when workers are continuously exposed to stressors such as high workload, noise, long working hours, or poor work environments and this condition may weaken their ability to maintain productivity. Therefore, fatigue does not merely function as the final outcome of workplace stress, but also as an intermediary mechanism that explains how occupational exposures are translated into lower work productivity. For example, noise exposure or work stress may not directly reduce productivity in all workers, but these factors can first increase fatigue, which then leads to slower task completion, reduced accuracy, decreased motivation and lower overall performance. Thus, selecting work fatigue as a mediating variable is theoretically relevant because it clarifies the pathway between workplace demands and productivity decline.

Job stress also plays an important role in decreasing productivity. Prolonged stress can disrupt concentration, reduce motivation, impair decision-making and increase both physical and mental fatigue (12, 13). When stress persists, workers may experience reduced energy and lower work effectiveness, which can ultimately decrease productivity. Thus, the relationship between job stress and productivity may occur directly or indirectly through work fatigue as a mediating factor. This condition is relevant to PT Semen Bosowa Maros, where several work areas are reported to have noise levels exceeding the threshold limit value and workers are exposed to high work pressure. These conditions may contribute to complaints of fatigue, stress and decreased productivity among employees. Based on this background, this study aims to analyze the effects of noise and job stress on work productivity through work fatigue. The findings are expected to provide evidence for improving workplace conditions, reducing occupational fatigue and enhancing employee productivity.

Methodology

Study Design and Place

This study used a quantitative observational design with a cross-sectional approach. The design was selected to examine the relationship between noise exposure, work stress, work fatigue and work productivity at a single point of measurement without any intervention. The study was conducted in the production department of PT Semen Bosowa Maros, South Sulawesi Province, Indonesia. The company's Maros plant is located in Maros, South Sulawesi, with the company address identified in Desa Baruga, Maros. The approximate geographic coordinates of PT Semen Bosowa Maros are 4°56′37.1″S, 119°36′28.5″E. This area was selected because production workers are exposed to occupational noise and job demands during daily operational activities. Data collection was carried out over a two-month period according to the research schedule. Figure 1 shows the study location at PT Semen Bosowa Maros.

Figure 1: PT Semen Bosowa Maros

Population and Sample

The population in this study consisted of all 102 employees working in the production department of PT Semen Bosowa Maros. The sampling technique used was total sampling, in which all eligible workers were included as research participants. Total sampling was applied because the population size was relatively small and accessible, allowing the study to represent the actual conditions of workers in the production department. The inclusion criteria were: active employees in the production department, workers who had been employed for at least six months, workers who were present during the data collection period and workers who agreed to participate by signing the informed consent form. The exclusion criteria were workers who were on leave during data collection, workers with incomplete questionnaire responses, workers who did not complete the measurement procedures and workers with conditions that could interfere with physiological measurements, such as acute illness during data collection. From the total population of 102 workers, all respondents met the inclusion criteria and completed the data collection procedures. Therefore, the final sample consisted of 102 respondents. No respondents were excluded due to incomplete data or invalid measurements.

Data Collection

Data were collected using both primary and secondary data sources. Primary data were obtained directly from respondents through questionnaires and direct measurements, including noise exposure, work stress, work fatigue, nutritional status, length of service and work productivity. Secondary data were obtained from company documents, internal reports, reference books, regulations and scientific journals relevant to occupational noise, work stress, work fatigue and productivity. Before data collection, the respondents were informed about the objectives, procedures, benefits and potential risks of the study. Respondents who agreed to participate were asked to sign an informed consent form. Data collection was conducted during working days and adjusted to the operational schedule of the production department to ensure that measurements reflected actual workplace conditions.

Research Instruments

The instruments used in this study consisted of an informed consent form, a respondent identity form, direct measurement tools and a work productivity questionnaire. The respondent identity form included age, work unit and length of service. Noise intensity was measured using a sound level meter and expressed in dB(A), referring to the threshold limit value of 85 dB(A) for eight working hours based on the Indonesian Ministry of Manpower Regulation No. 5 of 2018. Work stress was assessed through salivary alpha-amylase levels using a Cocoro Meter as a non-invasive physiological stress indicator. Nutritional status was determined based on body mass index, calculated from body weight and height measured using a body scale and microtoise. Work fatigue was measured using a reaction timer, in which longer reaction time indicated higher fatigue. Work productivity was measured using a Likert-scale questionnaire and categorized into poor and good productivity based on the total score obtained. All instruments were checked before use to ensure that they were functioning properly during data collection.

Data Analysis

Data analysis was performed using SPSS version 25. Univariate analysis was used to describe respondent characteristics and the distribution of each research variable. Numerical variables were presented using mean, standard deviation, minimum and maximum values, while categorical variables were presented using frequency and percentage. Bivariate analysis was conducted using the chi-square test with a 95 percent confidence level to examine the relationship between independent variables and work productivity. A p-value of less than 0.05 was considered statistically significant. Multivariate analysis was conducted using path analysis to examine the direct and indirect relationships among noise exposure, work stress, work fatigue and work productivity. Work fatigue was analyzed as a mediating variable between noise exposure and work productivity, as well as between work stress and work productivity. Because this study used a cross-sectional design, the mediation pathway was interpreted as a statistical indirect association rather than a confirmed causal mechanism.

Results and Discussion

PT Semen Bosowa Maros is a national private cement industry company under the auspices of Bosowa Corporation, which was founded by HM Aksa Mahmud on February 22, 1973. The forerunner of Bosowa Corporation started from CV Moneter which was engaged in general trading, then developed into PT Moneter Motor and then PT Bosowa Berlian Motor as the sole dealer of Mitsubishi vehicles in Eastern Indonesia. Along with the development of the business, Bosowa Group grew into a large business group with various business lines, including the cement industry. PT Semen Bosowa Maros officially operated in July 1998 with Portland Cement Type I products and all of its shares are owned by the Aksa Mahmud family as national entrepreneurs.

PT Semen Bosowa Maros is located in Bantimurung District, Maros Regency, South Sulawesi, with a raw material concession area of approximately 1,000 hectares and a factory area of 60 hectares. The company has a large cement and clinker production capacity, supported by European-made machine technology and the development of production facilities through the construction of line 2 in the 2013–2015 period. The main raw materials such as limestone and clay are obtained from areas around South Sulawesi, while supporting materials come from various regions in Indonesia and abroad. With the support of a workforce of approximately 1,200 people and a land and sea distribution network, PT Semen Bosowa Maros targets to meet national cement needs and plays an important role in industrial development and the development of the Eastern Indonesia region.

Table 1: Distribution of Respondent Characteristics and Research Variables

Variables	Category	Frequency (n)	Percentage (%)
Age (Years)	26–35	10	9.8
	36–46	40	39.2
	47–55	39	38.2
	56–65	13	12.7

Gender	Man	102	100.0
Years of service	< 5 Years	29	28.4
	≥ 5 Years	73	71.6
Work Duration	> 8 Hours	102	100.0
Nutritional status	Underweight	11	10.8
	Normal	48	47.1
	Obesity	43	42.2
Work Stress	No Stress	101	99.0
	Very Stressed	1	1.0
Work Fatigue	Normal	17	16.7
	Light	57	55.9
	Currently	23	22.5
	Heavy	5	4.9
Work Productivity	Good	45	44.1
	Not enough	57	55.9
Noise	Qualify	41	40.2
	Not eligible	61	59.8

Based on Table 1, the majority of respondents were in the productive age groups of 36–46 and 47–55 years and all were male. Most workers had worked for ≥5 years and worked more than 8 hours per day. Respondents' nutritional status was predominantly normal and obese. Although almost all respondents did not experience work stress, most workers experienced mild to moderate levels of work fatigue. Furthermore, more than half of respondents had low work productivity and worked in environments with substandard noise levels. These conditions illustrate the potential risk of fatigue and decreased productivity related to physical and environmental factors.

Table 2: Relationship between Noise, Nutritional Status, Length of Service and Job Stress

Variables	Category	Good Productivity n (%)	Lack of Productivity n (%)	p-value
Noise	Not eligible	21 (34.4)	40 (65.6)	0.016
	Qualify	24 (58.5)	17 (41.5)	
Nutritional status	Underweight	5 (45.5)	6 (54.5)	0.878
	Normal	20 (41.7)	28 (58.3)	
	Overweight	20 (46.5)	23 (53.5)	
Years of service	< 5 Years	13 (44.8)	16 (55.2)	0.927
	≥ 5 Years	32 (43.8)	41 (56.2)	
Work Stress	No Stress	45 (44.6)	56 (55.4)	0.372
	Very Stressed	0 (0.0)	1 (100.0)	

Based on Table 2, the results of the bivariate analysis show that the noise variable has a significant relationship with work productivity, where workers exposed to unqualified noise tend to have lower work productivity than workers who work in environments with qualified noise. Meanwhile, the variables of nutritional status, length of service and work stress do not show a significant relationship with work productivity. However, descriptively, it can be seen that the proportion of work productivity is more or less large in almost all variable categories, which indicates that worker work productivity is influenced by various factors simultaneously and not independently. This finding indicates that physical environmental factors, especially noise, are more dominant in relation to work productivity than individual factors in PT Semen Bosowa Maros workers.

Table 3: Relationship between Noise, Nutritional Status, Length of Service and Job Stress

Variables	Category	Normal n (%)	Light n (%)	Medium n (%)	Weight n (%)	p-value
Noise	Not eligible	9 (14.8)	24 (39.3)	23 (37.7)	5 (8.2)	0.001
	Qualify	8 (19.5)	33 (80.5)	0 (0.0)	0 (0.0)	
Nutritional status	Underweight	1 (9.1)	3 (27.3)	6 (54.5)	1 (9.1)	0.051
	Normal	6 (12.5)	26 (56.3)	12 (25.0)	3 (6.3)	
	Overweight	10 (23.3)	27 (62.8)	5 (11.6)	1 (2,3)	
Years of service	< 5 Years	6 (20.7)	13 (44.8)	9 (31.0)	1 (3,4)	0.432
	≥ 5 Years	11 (15.1)	44 (60.3)	14 (19.2)	4 (5.5)	
Work Stress	No Stress	17 (16.8)	57 (56.4)	23 (22.8)	4 (4.0)	0.001
	Very Stressed	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	

Based on Table 3, the results of the bivariate analysis indicate that noise and work stress have a significant relationship with work fatigue in workers at PT Semen Bosowa Maros. Workers exposed to unqualified noise and workers with high levels of work stress tend to experience work fatigue at mild to severe levels. Meanwhile, nutritional status and length of service did not show a significant relationship with work fatigue, although descriptively, variations in fatigue levels were seen in each category. These findings indicate that work environment factors and psychosocial conditions play a greater role in the occurrence of work fatigue than demographic factors or individual characteristics in production workers at PT Semen Bosowa Maros.

The test results indicate that all variables are not normally distributed, as all significance values are less than 0.05. Therefore, the assumption of normality is not met. Therefore, further statistical analysis should use a non-parametric method or the Partial Least Squares (PLS) approach, which does not require data normality. In this study, a path analysis was conducted using SMART PLS software. The following are the results of the path analysis in Figure 2.

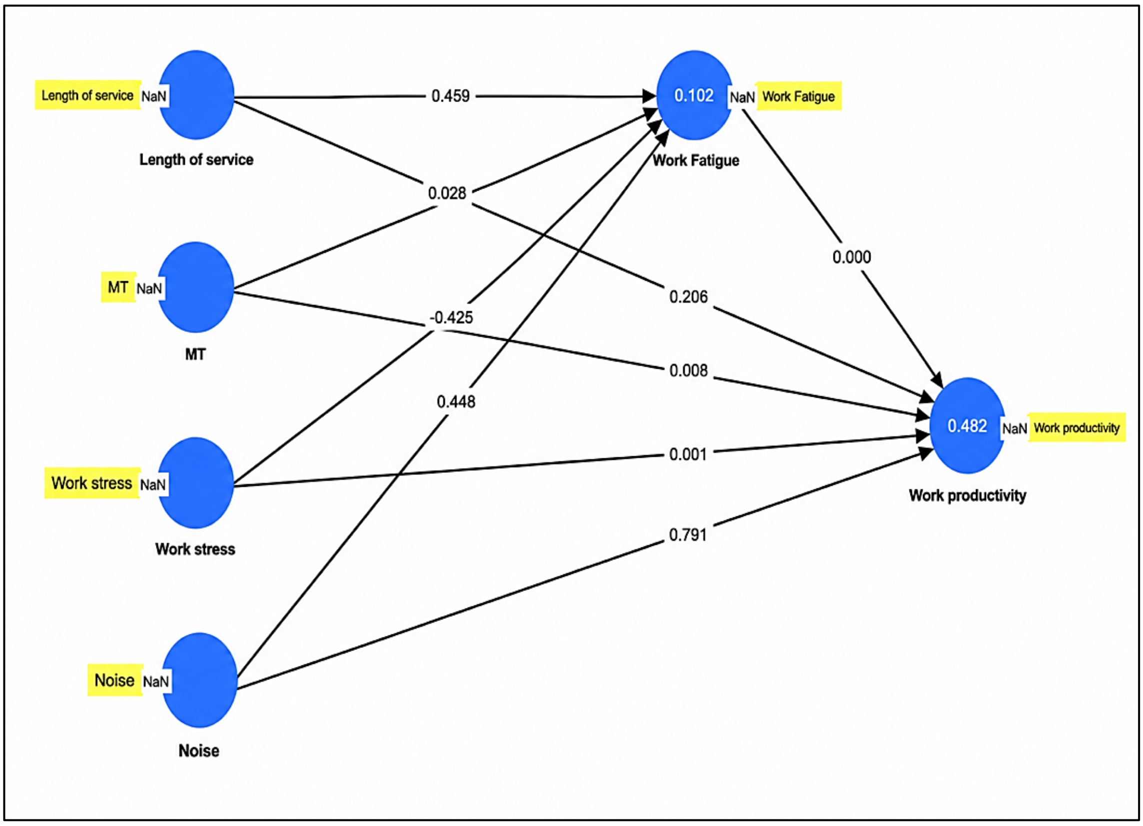

Figure 2: Research Model

Table 4: Direct Influence Hypothesis

Hypothesis	Path Coefficient/Estimate	p-value	95% Path Coefficient Confidence Interval Lower Limit	95% Path Coefficient Confidence Interval Upper Limit	F-Square	Note
Nutritional Status -> Work Fatigue	0.294	0.028	-0.015	0.491	0.339	Big
Nutritional Status -> Work Productivity	0.204	0.008	0.046	0.345	0.262	Currently
Noise -> Work Fatigue	0.084	0.448	-0.162	0.256	0.739	Big
Noise -> Work Productivity	-0.023	0.791	-0.174	0.120	0.959	Big
Job Stress -> Job Fatigue	0.048	0.675	-0.141	0.255	0.916	Big
Work Stress -> Work Productivity	-0.258	0.001	-0.424	-0.141	0.142	Small
Working Period -> Work Fatigue	0.093	0.459	-0.112	0.322	0.794	Big

Working Period -> Work Productivity	-0.105	0.206	-0.252	0.068	0.588	Big
Work Fatigue -> Work Productivity	0.572	0,000	0.428	0.714	0.023	Small

Based on Table 4, the results of hypothesis testing using SMARTPLS show that nutritional status has a significant effect on work fatigue (p-value = 0.028) and work productivity (β = 0.204; p-value = 0.008; F-square = 0.262), while noise has no significant effect on either work fatigue (p-value = 0.448) or work productivity (p-value = 0.791) despite having a large F-square value. Work stress has no significant effect on work fatigue (p-value = 0.675), but has a negative and significant effect on work productivity (β = −0.258; p-value = 0.001; F-square = 0.142). Work period is not proven to have a significant effect on work fatigue (p-value = 0.459) or work productivity (p-value = 0.206), despite showing a relatively large F-square value. Meanwhile, work fatigue has a positive and significant effect on work productivity (β = 0.572; p-value = 0.000), but with a small contribution (F-square = 0.023). Overall, these findings indicate that nutritional status and work stress are factors that play a direct role in work productivity, while work fatigue is an important variable that is significantly related to productivity among PT Semen Bosowa Maros workers in 2025.

Table 5: Indirect Influence Hypothesis

Hypothesis	Path Coefficient/Estimate	p -value	95% Path Coefficient Confidence Interval		Z-Sobel	Note
			Lower Limit	Upper Limit		
Nutritional Status -> Work Fatigue -> Work Productivity	0.168	0.028	0.025	0.298	2,223	Influential
Noise -> Work Fatigue -> Work Productivity	0.048	0.425	-0.087	0.135	0.802	No effect
Work Stress -> Work Fatigue -> Work Productivity	0.028	0.673	-0.084	0.152	0.423	No effect
Working Period -> Work Fatigue -> Work Productivity	0.053	0.426	-0.073	0.181	0.800	No effect

Based on Table 5, the results of the indirect effect test show that work fatigue only plays a significant role as a mediator in the relationship between nutritional status and work productivity, with an indirect effect coefficient of 0.168 and a p-value of 0.028 ($p<0.05$), a 95% confidence interval of 0.025–0.298 and a Sobel Z value of 2.223 (>1.96). Meanwhile, the indirect effect of noise on work productivity through work fatigue was not significant (coefficient = 0.048; p-value = 0.425; CI 95% = −0.087–0.135; Z Sobel = 0.802), as were the indirect effects of work stress (coefficient = 0.028; p-value = 0.673; CI 95% = −0.084–0.152; Z Sobel = 0.423) and work period (coefficient = 0.053; p-value = 0.426; CI 95% = −0.073–0.181; Z Sobel = 0.800), all of which indicate that work fatigue does not mediate the relationship between the three variables and work productivity in PT Semen Bosowa Maros workers in 2025.

The working environment of PT Semen Bosowa Maros, as a cement manufacturing industry, places production workers in physically and psychologically demanding conditions. Machine-intensive processes, repetitive physical tasks, environmental noise exposure, production targets and shift-based work systems create an occupational setting in which fatigue and productivity are shaped by multiple interacting factors. Therefore, work productivity in this context should not be understood as the result of a single determinant, but rather as the outcome of interactions between individual characteristics, work organization, physiological capacity and exposure to physical and psychosocial hazards. Nutritional status is an important individual factor because it is closely related to energy availability, physical endurance and the body's ability to recover after work. In physically demanding occupations, workers with non-ideal nutritional status, either undernutrition or excess body weight, may experience reduced stamina, slower recovery and a greater tendency toward fatigue. This is particularly relevant in the cement industry, where workers are required to maintain physical readiness during continuous production activities. Previous studies have also shown that nutritional status is associated with work capacity and fatigue, supporting the view that nutritional condition is not only a general health indicator but also an important component of occupational performance (14, 15).

Nutritional status may also influence productivity through biological and functional pathways. Workers with adequate nutritional status tend to have more stable energy levels, better physical endurance and greater ability to maintain performance during working hours. In contrast, imbalanced nutritional status may limit mobility, increase physical strain and accelerate fatigue, thereby reducing work efficiency. Several international studies have reported that excess body weight and poor nutritional conditions are associated with reduced productivity, absenteeism and work limitations (16, 17). However, the strength of this relationship may differ across workplaces depending on job demands, work duration, age distribution and the availability of workplace health programs. Therefore, nutritional intervention should be considered as part of a broader occupational health strategy rather than as an isolated individual responsibility.

Noise exposure remains one of the main physical hazards in cement production. In this study context, noise may not always appear to have an immediate or direct effect on fatigue and productivity because workers may develop physiological and psychological adaptation after long-term exposure. In addition, the use of personal protective equipment, work rotation and standardized operational procedures may reduce the perceived effect of noise on daily performance. Nevertheless, this does not mean that occupational noise is harmless. Previous studies have emphasized that noise exposure can contribute to auditory problems, physiological stress responses, reduced concentration and long-term health risks when not properly controlled (18, 19). Therefore, even when the direct statistical relationship between noise and productivity is weak or inconsistent, noise should still be treated as a latent occupational risk factor that requires continuous monitoring and control.

Tenure is often assumed to improve productivity because longer work experience may increase technical skill, procedural familiarity and understanding of workplace risks. However, in industries with strict standard operating procedures, machine-based production systems and structured work roles, the influence of tenure on productivity may become less pronounced. Experienced workers may have better operational knowledge, but training systems, job standardization and supervision can reduce performance differences between newer and longer-tenured workers. This interpretation is consistent with previous literature showing that the effect of tenure on performance depends on organizational context, job complexity and the extent to which work tasks allow individual experience to influence output (20, 21). Therefore, tenure should be interpreted not only as the length of employment but also in relation to work design, skill utilization and organizational support.

Occupational stress is an important psychosocial factor in the cement industry because workers are exposed to production targets, safety responsibilities, time pressure and the need to maintain operational consistency. Based on occupational stress theory and the Job Demand–Resources model, persistent job demands may deplete workers' psychological and physical resources, leading to reduced motivation, impaired concentration and lower work effectiveness. Previous studies have shown that work stress is consistently related to decreased productivity, particularly through cognitive and motivational pathways (22, 23). However, the effect of stress on fatigue may vary depending on workload intensity, coping ability, social support, rest opportunities and organizational climate. This suggests that stress does not operate independently, but interacts with other occupational and individual factors in shaping worker performance.

Work fatigue plays a central role in explaining how individual and workplace factors may influence productivity. From an occupational health and ergonomics perspective, fatigue represents a psychophysiological response that occurs when job demands exceed workers' available capacity. Fatigue may reduce attention, slow reaction time, impair decision-making and increase the likelihood of errors or accidents. In this study, work fatigue is positioned as an intermediary mechanism linking occupational exposures and work stress with productivity. This interpretation is consistent with previous studies showing that unmanaged fatigue contributes to reduced work quality, decreased efficiency and long-term performance decline (24, 25).

However, because this study used a cross-sectional design, the pathway between noise, work stress, work fatigue and productivity should be interpreted carefully. The analysis can identify statistical associations and possible indirect relationships, but it cannot confirm causal direction or temporal sequence among variables. For example, fatigue may reduce productivity, but low productivity or high work pressure may also contribute to increased fatigue. Therefore, future studies using longitudinal designs, repeated physiological measurements, or intervention-based approaches are needed to confirm the causal mechanisms underlying these relationships. The findings highlight the importance of a holistic approach to productivity improvement in the cement industry. Productivity should not be addressed only through performance targets or technical supervision, but also through fatigue management, nutritional health promotion, stress prevention, work-rest balance and environmental hazard control. Continuous monitoring of noise exposure, strengthening the use of personal protective equipment, improving recovery opportunities and developing workplace health programs may help reduce fatigue and maintain sustainable productivity among production workers.

Conclusion

Based on the results of this study, nutritional status has a direct effect on work fatigue and work productivity, as well as an indirect effect on productivity through work fatigue. Noise has no direct or indirect effect on work fatigue and productivity. Work stress has no direct effect on work fatigue and no indirect effect on productivity through work fatigue, but it has a direct effect on work productivity. Work period also shows no direct or indirect effect on work fatigue and productivity. In addition, work fatigue has a direct effect on work productivity. This study is limited by its cross-sectional design, which cannot establish causal relationships and by its focus only on workers in the production department of PT Semen Bosowa Maros, so the findings may not be generalized to all work settings. Future studies are recommended to use a longitudinal design, involve broader research locations and add other relevant variables such as sleep quality, shift work, physical workload, ergonomic factors and health history. Further research should also combine subjective and objective measurements of fatigue and productivity. Based on these findings, PT Semen Bosowa Maros is advised to strengthen noise control, consistently implement the Hearing Conservation Program, manage workload and rest periods, monitor work fatigue regularly and improve the Occupational Safety and Health program. Workers are also expected to use personal protective equipment properly, optimize rest time, maintain a healthy lifestyle and report fatigue or stress complaints early.

Abbreviations

BMI: Body Mass Index, dB: Decibel, NAB: Nilai Ambang Batas (Threshold Limit Value), SPSS: Statistical Package for the Social Sciences, PLS: Partial Least Squares.

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Author Contributions

Akhmad Vauzan: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing Original Draft, Syamsiar S Russeng: Conceptualization, Methodology, Validation, Supervision, Writing, Review and Editing, Masyitha Muis: Methodology, Validation, Supervision, Writing, Review and Editing, M Furqaan Naiem: Supervision, Validation, Fridawaty Rivai: Supervision, Validation.

Conflict of Interest

There is no conflict of interest in this research.

Declaration of Artificial Intelligence (AI) Assistance

The authors declare that no generative artificial intelligence (AI) or AI-assisted technologies were used in the writing, analysis, or preparation of this manuscript. All content was developed independently by the authors based on the research conducted. The authors take full responsibility for the content's originality, interpretation and accuracy.

Ethics Approval

This study was approved by the Ethics Committee of the Faculty of Public Health, Hasanuddin University, with ethical approval number 1899/UN4.14.1/TP.01.02/2025. All participants were informed about the objectives, procedures, benefits and confidentiality of the study before data collection. Written informed consent was obtained from all participants prior to their involvement in the study.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy and institutional restrictions.

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