Impact of Work Climate, Workload, and Stress on Fatigue for Improving Health and Work Outcomes

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Abstract

Background: Fatigue is a prevalent health issue affecting physical and mental well-being, particularly in industrial workers. Prolonged fatigue can reduce cognitive function, increase susceptibility to illness, and lower work productivity. Factors such as poor work climate, excessive workload, and stress exacerbate fatigue and negatively impact productivity. Methods: This observational cross-sectional study was conducted at PT. Makassar Tene, a sugar refinery in Makassar, Indonesia, with 118 employees. Data on work climate, workload, stress, fatigue, and productivity were collected using a Heat Stress Monitor, reaction timers, and structured interviews. Path analysis was employed to examine the direct and indirect effects of these variables on productivity. Results: The study revealed a significant direct effect of work climate on fatigue ($p < 0.05$) and productivity ($p = 0.008$). Similarly, workload directly influenced fatigue ($p = 0.001$) and productivity ($p = 0.044$). Stress was found to impact productivity indirectly through fatigue ($p = 0.018$). Fatigue emerged as a critical mediator, significantly reducing productivity. Conclusion: Poor work climate and excessive workload contribute to fatigue, which in turn diminishes productivity. Addressing environmental and workload factors is essential to improving employee well-being and optimizing productivity in industrial settings. Implementing effective interventions to manage work stress and fatigue is crucial for enhancing both health and work outcomes.

Keywords: Fatigue, Work Climate, Workload, Stress, Employee Productivity.

Significance | This study determined the critical relationship between workplace conditions, fatigue, and productivity, emphasizing the need for improved working environments to enhance employee well-being.

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Introduction

Fatigue is a significant health concern that affects physical and mental well-being. Prolonged fatigue can lead to reduced cognitive function, decreased work productivity, and increased susceptibility to illness. It is often associated with stress, poor work environments, and excessive workloads, exacerbating chronic conditions and diminishing overall health quality. Industrial workers face significant risks of accidents, which can lead to a decrease in productivity (Wahyuningsih et al., 2021). The modern industrial world, with its increased production rates and faster pace, has amplified the risk of workplace accidents (Taşdelen & Özpınar, 2020). Data from the U.S. Bureau of Labor Statistics (2011), cited by NIOSH (2016), reported 4,190 cases of heat-related injuries or illnesses, causing a loss of working hours. The Centers for Disease Control and Prevention (CDC) further reported 423 deaths between 1992 and 2006 due to heat exposure at work (Coco et al., 2016). In hot work environments, if precautions are not taken, workers can suffer from various health issues such as heat exhaustion, heatstroke, dehydration, and fatigue (Arianto & Prasetyowati, 2019).

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A study by the International Labor Organization (ILO) in 2020 found that 32% of workers globally experience mental workload due to their job, with reported complaints ranging from 18.3% to 27% (Venintia et al., 2024). Uncertain rest periods, high workloads, and short deadlines contribute to mental strain, elevating the risk of work-related stress and accidents (Christiani Berek et al., 2022). In Indonesia, a report

by the Ministry of Research and Technology (2020) revealed that 55% of Indonesians experience stress, with 0.8% experiencing very high stress levels (Fatin et al., 2023).

According to the ILO, two million workers die annually due to workplace accidents, with fatigue being a major factor. Among the 58,115 workers surveyed, 32.8% reported experiencing fatigue, a condition linked to diminished productivity (Thamrin, 2020). In Indonesia, more than 65% of workers seek medical attention due to fatigue resulting from both internal factors (such as personal capacity) and external factors (including workload and environmental conditions) (Usman & Yuliani, 2019). High workloads, exceeding workers' physical and mental capabilities, alongside exposure to hot environments, result in lost work hours and reduced productivity (Kjellstrom et al., 2009).

To address these issues, the current study focused on employee productivity at PT. Makassar Tene, a leading sugar refinery in eastern Indonesia. Established on December 7, 2003, the factory has contributed significantly to regional sugar production by maintaining competitive pricing and supporting sugarcane farmers. Observations at the factory revealed challenging work conditions, such as high heat from machinery and the manual handling of heavy sugar sacks without proper protective gear. This has contributed to fatigue and reduced productivity, with six work accidents occurring between 2020 and 2022. The objective of this study was to examine the relationship between the workplace environment, workload, stress, fatigue, and productivity among employees at PT. Makassar Tene.

Materials and Methods

Study Design

This research was an observational study with a cross-sectional design, focusing on the employees of PT. Makassar Tene, a sugar refinery in Makassar City, South Sulawesi. The study aimed to examine the relationship between work climate, workload, stress, fatigue, and work productivity. Cross-sectional design was chosen to assess the current conditions at a single point in time, allowing for a detailed analysis of the various factors influencing employee productivity.

Ethical Approval

The study was conducted following ethical guidelines after obtaining approval from the Research Ethics Commission of the Faculty of Public Health at Hasanuddin University, Makassar, under the registration number 579/UN4.14.1/TP.01.02/2024.

Population and Sampling

The research population consisted of 118 employees working at PT. Makassar Tene. A total sampling technique was employed, meaning that all 118 employees were included in the study. This method was selected to ensure comprehensive coverage and to provide a thorough assessment of the entire workforce at the refinery.

Data Collection Tools

Several tools were utilized to measure the key variables in this study. To assess the work climate, a Heat Stress Monitor (HSM) was used. This device measured essential environmental factors, including temperature, humidity, air movement, and radiant heat, all of which are critical in determining the suitability of the work environment for physical labor. Workload was measured by recording the pulse rates of participants using a stopwatch, with pulse rates expressed in beats per minute, providing an indirect measure of the physical exertion experienced by employees. To assess work fatigue, a reaction timer was employed. Fatigue levels were determined by measuring the response times of employees to visual or auditory stimuli, where slower reaction times indicated higher fatigue levels.

For work stress and productivity, direct interviews were conducted using a structured questionnaire. This questionnaire had been pre-tested for validity and reliability, with a Cronbach's alpha of 0.744 for the work stress section, indicating acceptable internal consistency. Productivity was self-reported by the employees based on their output and perceived work efficiency.

Hypothesis Testing

The study's conceptual framework involved testing several hypotheses: first, that there is a significant direct effect of work climate on work fatigue; second, that work climate significantly affects work productivity both directly and indirectly through work fatigue; third, that workload has a direct effect on work fatigue and indirectly influences work productivity; fourth, that work stress directly impacts fatigue but does not directly affect work productivity; and finally, that fatigue mediates the relationship between stress and productivity.

Statistical analysis

The data collected were analyzed using a combination of univariate, bivariate, and multivariate techniques. Univariate analysis involved descriptive statistics to summarize each variable, calculating means, standard deviations, frequencies, and percentages to provide an overview of the distribution of key variables, such as work climate, workload, fatigue, stress, and productivity. Bivariate analysis, specifically the chi-square correlation test, was employed to explore relationships between two categorical variables. This helped determine whether work climate, workload, stress, or fatigue had significant correlations with work productivity.

Multivariate analysis, specifically path analysis, was used to examine both direct and indirect relationships among the variables. This advanced statistical method allowed for understanding the complex interplay between work climate, workload, stress, and fatigue, and how these factors collectively impacted work productivity. Path analysis was particularly useful in identifying mediating effects, such as the role of fatigue in the relationship between work climate and productivity.

Data analysis was conducted using statistical software, including SPSS and AMOS, to perform univariate, bivariate, and path analysis tests. Significance levels were determined using a p-value threshold of < 0.05.

Result

The results clearly demonstrate the significant direct and indirect relationships between work climate, workload, work stress, fatigue, and productivity. Notably, work climate and workload both directly impact productivity, while work stress has an indirect effect through fatigue. Fatigue, in turn, plays a critical mediating role, particularly in the relationship between work stress and productivity. The findings suggest that managing environmental factors such as heat, humidity, and air movement, as well as reducing workload and stress, can improve both employee well-being and productivity levels in industrial settings.

The study involved 118 participants, and hypothesis testing was performed using Pathway Analysis to assess the direct and indirect relationships between work climate, workload, work stress, work fatigue, and work productivity. The results are summarized in Table 1 and Table 2, demonstrating the significant statistical relationships observed between the key variables.

Direct Effects

The pathway analysis results, as outlined in Table 1, revealed several key insights. First, there was a significant direct effect of work climate on work fatigue, with a T-statistic of 9.981 (>1.96) and a p-value of 0.000 (<0.05), indicating that poor work conditions, such as extreme temperatures or poor ventilation, significantly increase employee fatigue levels. Additionally, work climate had a significant direct effect on work productivity, as shown by a T-statistic of 2.635 (>1.96) and a p-value of 0.008 (<0.05), suggesting that unfavorable environmental conditions directly reduce productivity.

In terms of workload, the analysis identified a significant direct effect on work fatigue, with a T-statistic of 3.377 (>1.96) and a p-value of 0.001 (<0.05), demonstrating that higher workloads contribute to elevated fatigue levels. Similarly, workload was found to have a significant direct impact on work productivity, with a T-statistic of 2.017 (>1.96) and a p-value of 0.044 (<0.05), indicating that excessive workloads negatively affect productivity.

Work stress also played a role, having a significant direct effect on fatigue, as evidenced by a T-statistic of 5.431 (>1.96) and a p-value of 0.000 (<0.05), showing that higher stress levels lead to increased fatigue. However, work stress did not show a direct effect on productivity, with a T-statistic of 0.746 (<1.96) and a p-value of 0.456 (>0.05), suggesting no direct relationship between stress and productivity.

Finally, the analysis revealed a significant direct effect of work fatigue on work productivity, with a T-statistic of 2.486 (>1.96) and a p-value of 0.013 (<0.05), indicating that increased fatigue results in decreased productivity.

Indirect Effects

The analysis further examined the indirect relationships between work climate, workload, work stress, and work productivity, with work fatigue acting as a mediating variable. The results revealed several key findings (Table 2). First, there was a significant indirect effect of work climate on productivity through fatigue, with a coefficient of -0.390 and a p-value of 0.031 (<0.05). This indicates that an unfavorable work climate reduces productivity by increasing employee fatigue. Second, no significant indirect effect was found for workload on productivity through fatigue, as shown by a coefficient of 0.235 and a p-value of 0.110 (>0.05), suggesting that fatigue does not mediate the relationship between workload and productivity. Lastly, work stress was found to have a significant indirect effect on productivity through fatigue, with a coefficient of 0.248 and a p-value of 0.018 (<0.05). This means that although work stress does not directly impact productivity, it indirectly decreases productivity by increasing levels of fatigue.

In **Figure 1**, the pathway diagram illustrates the relationships between the variables, including both the direct and indirect effects. The significant paths are marked with solid lines, while non-significant paths are represented with dashed lines. The arrows show the direction of influence, highlighting how work climate, workload, and work stress impact productivity through fatigue.

Discussion

4.1 Effect of Work Climate on Fatigue and Its Impact on Work Productivity

A hot work climate, characterized by temperature, humidity, air movement, and radiant heat, can substantially affect workers' health and productivity. When body heat production from labor combines with adverse environmental conditions, fatigue often results (Permenakertrans, 2011). In this study, a large proportion of the participants (99.1%) experienced fatigue due to the factory's hot work climate, indicating that non-conducive environments significantly impact employee well-being. Tools producing high temperatures further exacerbate this effect, increasing the likelihood of worker fatigue.

Path analysis demonstrated a direct effect of the work climate on productivity (p = 0.008), as well as an indirect effect through fatigue,

Table 1. Effect of Coefficient and Its Relationship with Research Hypothesis of Direct Effect on PT. Makassar Tene Employees

No.	Effect between Variable	Estimate	T Statistics	P Value	Conclusion
1.	Work climate → Work fatigue	0.623	9.981	0.000	Significant
2.	Work climate → Work Productivity	0.499	2.635	0.008	Significant
3.	Workload → Work fatigue	0.375	3.377	0.001	Significant
4.	Workload → Work productivity	-0.350	2.017	0.044	Significant
5.	Work stress → Work fatigue	-0.396	5.431	0.000	Significant
6.	Work stress → Work productivity	-0.111	0.746	0.456	Not Significant
7.	Work fatigue → Work productivity	-0.626	2.489	0.013	Significant

Table 2. Effect of Coefficient and Its Relationship with the Research Hypothesis of the Indirect Effect on PT. Makassar Tene Employees

Hypothesis Path	Indirect Effect	Total Effect
Work Climate → Work Fatigue → Work Productivity	-0.390	0.031
Workload → Work Fatigue → Work Productivity	-0.235	0.110
Work stress → Work Fatigue → Work Productivity	0.248	0.018

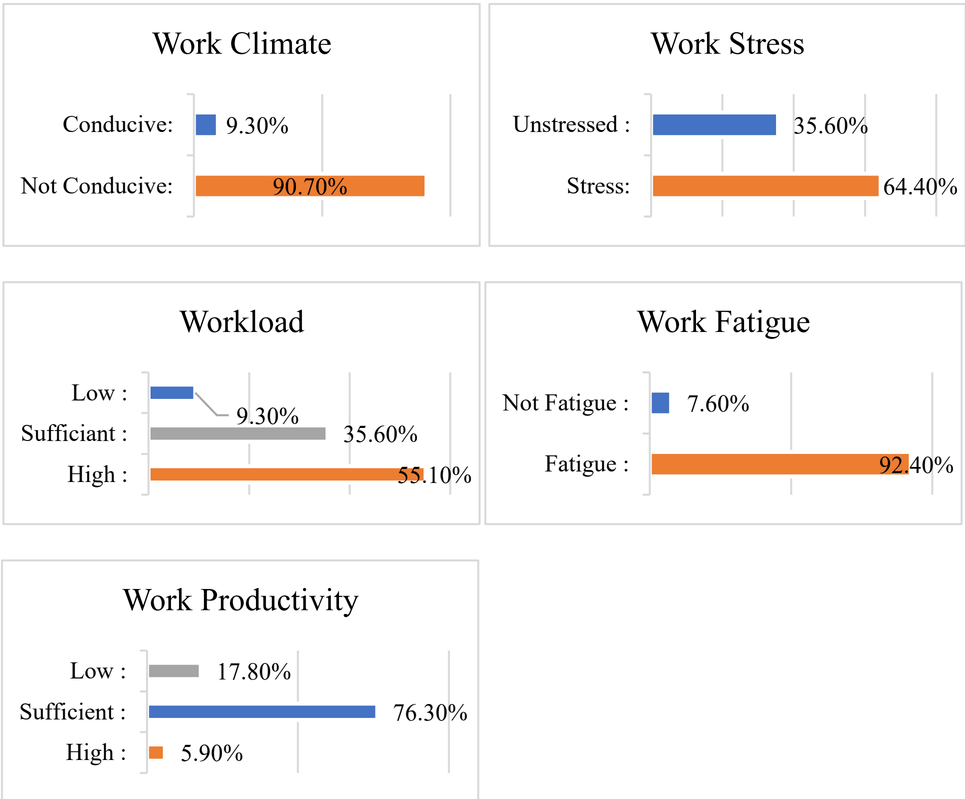

Figure 1. Respondents' Distribution on Work Climate, Workload, Work Stress, Work Fatigue, and Work Productivity at PT. Makassar Tene

with a coefficient value of -0.390. This suggests that unfavorable work environments not only diminish productivity directly but also contribute to higher fatigue levels, indirectly reducing worker efficiency. The physiological basis of this phenomenon is supported by Siswantara (2006), who noted that sustained physical activity in hot environments leads to elevated heart rates compared to cooler conditions. Workers in such environments experience difficulties in heat dissipation, which leads to an increase in metabolic heat, hampered by high ambient temperatures. This process can slow decision-making, reaction times, and movement, resulting in discomfort and impaired work performance (Eka & Agnes, 2019).

Furthermore, prolonged exposure to heat without adequate acclimatization may cause excessive sweating, rapid heart rates, lowered blood pressure, and eventually fatigue or fainting (Sukma et al., 2019). Hijah et al. (2021) found a similar relationship between work climate and fatigue in welding workshop workers (p = 0.041), reinforcing the findings of the present study. A hot work environment increases the workload, making it difficult for workers to maintain their performance, ultimately resulting in excessive fatigue (Hijah et al., 2021). These findings emphasize the need for effective climate control in workplaces to prevent the cascading effects of heat-induced fatigue on productivity.

4.2 Effect of Workload and Work Stress on Fatigue and Its Impact on Productivity

Workload and work stress also play critical roles in determining levels of fatigue, which in turn impact work productivity. High workloads, lack of supervision, and repetitive tasks contribute to work-related stress (Steven & Prasetio, 2020). In the present study, workers involved in producing refined sugar daily, often under pressure to maintain speed and precision, reported high levels of monotony and boredom. This repetitive nature of work, coupled with an excessively hot environment, significantly contributed to work stress and fatigue.

Work stress can trigger a range of emotional and physiological reactions, including fatigue. Tarwaka (2015) explains that stress leads to changes in emotional responses and physiological states, including fatigue, which impairs productivity. This is consistent with findings from Oktariani et al. (2022), who demonstrated a significant relationship between work stress and fatigue (p = 0.000) among workers at PT. X Rokan Hulu. In situations of high stress, the body's natural response often leads to physical exhaustion, which further hampers performance.

Interestingly, this study contrasts with findings from research by Zelviana & Febriyanto (2019), who found no significant relationship between work stress and fatigue (p = 0.162) among firefighters in Samarinda City. The discrepancy could be due to the organizational factors and a supportive work environment for the firefighters, which could mitigate stress-induced fatigue. This underlines the importance of a conducive work environment that promotes safety, comfort, and motivation, which can counteract the negative effects of stress on productivity.

Although this study found no direct effect of work stress on productivity, path analysis suggests that stress negatively influences productivity indirectly through its impact on fatigue. This finding aligns with Faliza's theory, which suggests that while stress itself may not directly reduce productivity, its effects on worker health and fatigue significantly hinder optimal work performance. Employees experiencing high stress levels struggle to perform at their best, resulting in reduced productivity (Faliza, 2018). Therefore, addressing stress in the workplace is essential for maintaining high levels of productivity.

Conclusion

In conclusion, the work climate and workload significantly contribute to fatigue, which in turn affects productivity. Both physical and mental stressors in the workplace need to be effectively managed to enhance employee well-being and optimize performance. These findings emphasize the need for interventions aimed at improving work environments, reducing excessive workloads, and managing work stress to mitigate fatigue and promote productivity in clinical and industrial settings.

Author contributions

F.A. developed the study proposals, conducted the literature review, and handled data processing and visualization. Q.A. guided the interpretation of the research findings, contributed to the discussions, and provided oversight for the conclusions.

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Competing financial interests

The authors have no conflict of interest.

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