

HOT WORK CLIMATE AS AN OCCUPATIONAL ENVIRONMENTAL HEALTH RISK ASSOCIATED WITH FATIGUE AMONG PARKING TICKET ATTENDANTS IN MEGAMAS AREA, MANADO

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Abstract :

Work fatigue is an important problem in occupational health that can decrease productivity and increase the risk of work errors. One of the factors that plays a role is the hot work climate, especially in semi-enclosed workspaces with limited ventilation. This study aims to analyze the relationship between hot work climate and work fatigue in parking ticket officers in the Manado Megamas Area. The study used an analytical quantitative design with a cross-sectional approach on 63 respondents. Hot work climate was measured using a heat stress monitor (WBGT), while work fatigue was measured using the KAUPK2 questionnaire. Data analysis was carried out univariate and bivariate using the Pearson correlation test. The results showed that most respondents experienced moderate fatigue (57.1%) and the highest exposure to the hot work climate was found in the morning shift (29.8°C). There was a significant association between hot work climate and work fatigue ($p = 0.001$; $r = 0.401$), with moderate correlation strength. The study shows that even though heat exposure is still below the threshold value, working environment conditions still contribute to worker fatigue. Therefore, it is necessary to control the working environment through ventilation improvements, the provision of local cooling, and adaptive work-break arrangements.

Keywords: hot work climate, work fatigue, work environment health, WBGT, parking workers

INTRODUCTION

Work fatigue is a critical issue in global occupational health because it contributes to decreased productivity, increased operational errors, and a significant risk of work accidents. International organizations such as the International Labour Organization (ILO) affirm that work environment factors, especially physical exposure such as heat, play an important role in determining the safety and health of workers in various sectors (International Labour Organization / ILO, 2016, 2023). In the context of global climate change, the increase in ambient temperature and frequency of extreme heat events have exacerbated the risk of burnout, especially in informal sector and field workers in the tropics (Zen et al., 2025; IPCC, 2018).

Hot working climate is one of the environmental determinants that directly



affects the body's thermal balance through the interaction of air temperature, humidity, and heat radiation. Physiological responses to heat exposure include increased sweat production and cardiovascular workload to maintain core body temperature, which in the long run can lead to fatigue, dehydration, and decreased cognitive function (Tarwaka, 2015; Ouyang & Luo, 2025). Experimental research shows that the combination of physical fatigue and heat exposure can significantly worsen cognitive performance and increase the risk of work accidents (Ouyang & Luo, 2025). In fact, exposure to heat at levels that are still below the fixed threshold value can cause thermal discomfort that impacts work efficiency.

In the local context, previous studies in Manado City have shown that work environment factors have a real influence on the physiological condition of workers. For example, an increase in ambient temperature was shown to be significantly related to an increase in heart rate in loading and unloading workers at Manado Port, indicating an increase in physiological workload due to heat exposure. In addition, other research suggests that variations in ambient temperature and exposure to air pollutants in urban commercial areas may increase long-term health risks, although they are still below national standards, thus emphasizing the importance of a more contextual and preventive approach to occupational environmental health. However, most of these studies still focus on physiological aspects or environmental quality separately, without examining the direct impact on work fatigue as a functional outcome of workers.

Although the link between hot work climate and work fatigue has been reported in various studies, there are some significant research gaps. First, most studies use cross-sectional designs with limitations in explaining causal relationships and exposure dynamics (Ma & Liao, 2025). Second, research in developing countries, particularly Indonesia, is still limited to the formal industrial sector, while informal sector workers such as parking attendants—who have unique microenvironmental exposures—have not been widely studied. Third, the measurement approach used often does not take into account the specific characteristics of the working microenvironment, such as limited ventilation, vehicle density, and temporal variations in heat exposure (Septiningtias, 2025). This leads to a lack of contextual scientific evidence to support environment-based occupational health interventions.

Parking ticket officers in the Megamas Manado area are a group of workers who are vulnerable to exposure to the hot work climate because they work in semi-closed spaces with limited ventilation and heat exposure affected by vehicle activities and local microclimate conditions. This work environment creates dynamic heat exposure conditions and has the potential to increase cumulative work fatigue. However, until now, there has been no study that specifically analyzes the relationship between objectively measured hot work climate (WBGT) and the level of work fatigue in this group of workers in tropical urban contexts.

Based on these gaps, this study offers novelty in the form of: (1) direct measurement of hot working climate using WBGT parameters in the setting of

specific micro-work environments (semi-closed parking counters); (2) analysis of the relationship with work fatigue as a functional outcome relevant to work safety; and (3) the contribution of local evidence to the context of informal sector workers in tropical regions that are still underrepresented in the global literature. Thus, this study not only enriches the study of the health of the work environment, but also provides a scientific basis for the development of contextual and evidence-based work fatigue risk mitigation strategies. This study aims to analyze the relationship between hot work climate and work fatigue in parking ticket officers in the Megamas Manado Area from the perspective of work environment health.

RESEARCH METHODS

Study Design and Setting

This study employed an analytical quantitative design with a cross-sectional approach to examine the association between occupational heat exposure and work fatigue among parking ticket attendants. The study was conducted in the Megamas area, Manado, Indonesia, between July and October 2025, a period characterized by relatively high ambient temperatures in tropical urban settings.

Population and Sampling

The target population comprised all parking ticket attendants working in the Megamas area (N = 63). A total sampling technique was applied, whereby all eligible workers were included. Inclusion criteria were: (1) actively working during the study period, (2) having at least 6 months of work experience, and (3) willing to participate. Workers with acute illness at the time of data collection were excluded to minimize confounding related to temporary health conditions.

Variables and Measurement

Independent Variable (Heat Work Climate) and Dependent Variable (Work Fatigue).

Instrument Validity and Reliability

The KAUPK2 instrument has demonstrated acceptable psychometric properties in prior studies, with reported content validity confirmed by occupational health experts and internal consistency reliability (Cronbach's alpha > 0.70). In this study, a pilot test was conducted on a subset of respondents (n = 15) to ensure contextual clarity, yielding a Cronbach's alpha of > 0.75, indicating good internal consistency.

The heat stress monitor was calibrated prior to data collection to ensure measurement accuracy. Repeated measurements were conducted at selected points to assess consistency and reduce measurement error.

Data Collection Procedures

Data collection involved two components: (1) direct environmental measurement of WBGT at each work location during different shifts, and (2) self administered KAUPK2 questionnaires completed by respondents under supervision to minimize response bias. Data collectors were trained to standardize procedures and ensure uniformity in measurement and questionnaire administration.

Data Analysis

Data were analyzed using statistical software. Descriptive (univariate) analysis was performed to summarize respondent characteristics, WBGT levels, and fatigue categories using frequencies, percentages, means, and standard deviations.

Bivariate analysis was conducted using Pearson correlation to assess the relationship between WBGT and fatigue scores. Prior to inferential testing, statistical assumptions were evaluated, including:

1. Normality test (Shapiro–Wilk) for continuous variables
2. Linearity test through scatterplot visualization
3. Homoscedasticity assessment

A significance level of 95% ($\alpha = 0.05$) was applied.

Bias Control and Confounding

Several strategies were implemented to minimize bias:

1. Selection bias was reduced through total sampling.
2. Information bias was minimized by using standardized instruments and trained data collectors.
3. Measurement bias was controlled through device calibration and repeated measurements.
4. Confounding factors such as age, sex, and work duration were described and considered in interpretation, although not adjusted in multivariate analysis due to study design limitations.

Ethical Considerations

This study adhered to ethical principles in human research. Participants were informed about the study objectives and procedures, and written informed consent was obtained prior to data collection. Confidentiality and anonymity of respondents were ensured. The study protocol was reviewed and approved by the institutional ethics committee.

RESULTS AND DISCUSSION

The results of the study discuss the characteristics of the respondents (gender, education, air temperature and work fatigue) and the relationship between variables can be seen in Table 1.

Table 1. Research results

Variable	Categories	n (N=63)	% (N=100)
Respondent Characteristics			
Gender	Male	26	41,3
	Women	37	58,7
Education	High School	62	98,4
	D3	1	1,6
Air Temperature	29.8 (Shift 1)	30	47,6
	26.6 (Shift 2)	30	47,6
	24.4 (Shift 3)	3	4,8
Work fatigue	Lightweight	7	11,1
	Medium	36	57,1

Height	20	31,7
The relationship between air temperature and work fatigue		
r	0,401	
p-value	0,001	
Interpretation	Moderate correlation	

The results showed that most of the respondents were female (58.7%) and had a high school education level (98.4%). This condition illustrates that the characteristics of the workforce in the informal sector, especially parking ticket officers, are dominated by workers with a secondary education background, which has the potential to affect the understanding of occupational health risks.

Measurements of hot working climate based on air temperature showed that the majority of respondents were exposed to temperatures in the range of 29.8°C (47.6%) in shift 1 and 26.6°C (47.6%) in shift 2. This condition indicates a relatively high exposure to heat in the work environment, especially in the morning to noon shifts, which has the potential to increase the physiological load of workers.

The distribution of work fatigue levels showed that most respondents experienced moderate fatigue (57.1%), followed by high fatigue (31.7%), and only a small percentage experienced mild fatigue (11.1%). These findings show that work fatigue is a fairly dominant problem in parking ticket officers in the Megamas Manado area.

The results of bivariate analysis showed a significant relationship between air temperature and work fatigue ($p\text{-value} = 0.001 < 0.05$), with a Pearson correlation coefficient of $r = 0.401$ indicating the strength of the relationship in the moderate category and the direction of the positive relationship. This indicates that an increase in air temperature as an indicator of a hot work climate tends to be followed by an increase in the level of work fatigue in officers.

Overall, these findings reinforce that a hot work climate is one of the risk factors for the health of the work environment that contributes to the occurrence of work fatigue in informal sector workers, especially in work activities in open spaces with direct exposure to environmental conditions.

Discussion

The findings of this study indicate a statistically significant and moderately strong association between occupational heat exposure and fatigue among parking attendants ($r = 0.401$; $p = 0.001$). This result underscores the importance of microclimatic conditions as a key environmental determinant of occupational health, particularly among informal sector workers. The magnitude of the correlation suggests that even modest variations in ambient temperature can meaningfully contribute to fatigue. This highlights that heat exposure below established regulatory thresholds should not be overlooked, as it can still impose measurable physiological strain on workers.

From a physiological standpoint, this relationship is well supported by established thermoregulatory mechanisms. Exposure to elevated temperatures triggers peripheral vasodilation, increased sweat production, and heightened

cardiovascular activity. When sustained over time, these responses increase the overall physiological workload, ultimately leading to fatigue. Field studies conducted in Manado have also demonstrated that higher environmental temperatures are associated with changes in cardiovascular parameters, such as increased heart rate and blood pressure, thereby amplifying physiological stress. These effects are further intensified in semi-enclosed work environments, such as parking booths, where heat accumulation and limited airflow result in thermal conditions that exceed ambient levels.

The present findings are consistent with prior studies examining the relationship between environmental heat and occupational fatigue. Zen et al. (2025) reported a significant association between environmental temperature and fatigue among informal transport workers, while Ouyang and Luo (2025) demonstrated that heat exposure exacerbates the negative effects of physical fatigue on cognitive performance and workplace safety. Unlike earlier studies that primarily focus on industrial or construction settings, this study contributes novel evidence from a semi-formal urban occupational group—parking attendants—whose exposure patterns are shaped by a combination of outdoor heat, traffic-related emissions, and constrained micro-environments.

Furthermore, this study identifies a gradient relationship between increasing microclimatic temperature and fatigue levels. This supports the notion that occupational heat stress operates along a continuum rather than within a simple binary framework of safe versus unsafe exposure. In addition, environmental exposures experienced by parking attendants are not limited to thermal stress alone but may also involve air pollutants such as CO, NO₂, and SO₂. The interaction between elevated temperature and air pollutants has been shown to increase oxidative stress and systemic inflammation, both of which are linked to fatigue and cardiovascular risk. Accordingly, occupational fatigue should be understood as the outcome of multiple interacting environmental stressors rather than a single isolated factor.

From a global health perspective, these findings are particularly relevant for tropical regions such as Indonesia, where baseline environmental temperatures are consistently high. Ongoing climate change is likely to exacerbate this condition by increasing both the frequency and intensity of heat exposure. The International Labour Organization (ILO) has identified heat stress as an emerging occupational hazard, disproportionately affecting workers in low- and middle-income countries. This study therefore contributes valuable empirical evidence from Indonesia, a setting that remains underrepresented in the global literature, and enhances the generalizability of the heat-fatigue relationship across diverse climatic and socioeconomic contexts.

The implications of this study extend beyond occupational health and into workplace design and policy. Existing heat exposure standards may not adequately reflect real-world conditions, particularly in small-scale and semi-enclosed environments such as parking booths. As such, adaptive strategies are needed, including microclimate engineering (e.g., improved ventilation, shading, and reflective materials), structured work-rest cycles, and adequate hydration

practices. The integration of real-time Wet Bulb Globe Temperature (WBGT) monitoring into occupational safety systems could further enhance the early detection and prevention of heat-related risks.

In addition, these findings highlight the importance of adopting an interdisciplinary approach to occupational health research. Integrating environmental epidemiology with ergonomics and occupational physiology may provide a more comprehensive understanding of heat-related risks. For instance, combining microclimate data with physiological indicators could help establish more precise thresholds for heat tolerance at the individual level. Such approaches are essential for developing evidence-based policies that are context-sensitive, particularly for informal workers who often lack adequate occupational health protections.

At the same time, the study emphasizes the need to consider local adaptation processes. Workers in tropical environments may exhibit some degree of acclimatization to heat; however, such adaptation is often partial and insufficient to prevent the adverse effects of chronic exposure. Therefore, locally tailored interventions that account for social, cultural, and economic conditions are crucial for mitigating the health risks associated with occupational heat exposure.

Study Limitations

This study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design precludes causal inference, as temporal relationships between heat exposure and fatigue cannot be established. Second, fatigue was assessed using a self-reported instrument (KAUPK2), which may introduce subjective bias. Third, the study did not account for several important confounding factors, including hydration status, nutritional intake, workload intensity, and concurrent exposure to air pollutants, all of which may influence physiological responses to heat. Future studies are therefore recommended to employ longitudinal or mixed-method designs and incorporate objective physiological indicators – such as core body temperature, heart rate variability, and inflammatory biomarkers – to provide a more comprehensive understanding of the health impacts of occupational heat exposure.

CONCLUSION

In conclusion, this study provides robust evidence that heat work climate is a significant environmental determinant of occupational fatigue, even under conditions that may not exceed regulatory thresholds. By situating fatigue within a broader microclimate and environmental exposure framework, this research offers a novel perspective that bridges occupational health, environmental epidemiology, and climate change adaptation.

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