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Analysis of Heat Strain on Production Workers Due to Exposure to Hot Working Climate at CV. X

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ABSTRACT

A hot work climate is one of the risk factors that can negatively affect occupational health and safety, especially in production industries that use fiberglass materials, such as CV. X. A work environment with temperatures exceeding the threshold limit value (TLV) has the potential to cause heat strain complaints, which can reduce productivity and increase the risk of health problems among workers. This study aims to analyze the level of heat strain among production workers due to exposure to a hot work climate. This research uses a descriptive quantitative method with a cross-sectional design and total sampling involving 10 production workers. Data were obtained through measurements of the Wet Bulb Globe Temperature (WBGT) index in the production area using the Heat Stress Apparatus Quest Temp 46, as well as the assessment of heat strain using the Physiological Strain Index (PSI) based on workers' body temperature and pulse rate before and during work. The results showed that the WBGT value in the production area, with an area of 288 m^2, was 30.1°C, exceeding the TLV for a moderate workload category (28°C). Individual characteristics such as age, nutritional status, and water intake were obtained through interviews using questionnaires.

Keywords: *heat strain, hot working climate, WBGT, PSI, occupational safety*

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INTRODUCTION

The work environment plays a crucial role in supporting worker productivity and safety. Uncomfortable environments, such as exposure to hot work environments, can increase the risk of accidents and health problems (1). According to Law No. 1 of 1970, the workplace includes areas frequently accessed by workers that may contain physical hazards, including high temperatures. Hot working conditions increase the physical workload and require more energy compared to working at a comfortable temperature (24–26°C). Ministerial Regulation No. 5 of 2018 sets the WBGT limit at 31°C for light work, 29°C for medium work, and 26°C for heavy work, based on ISBB/ACGIH standards.(2)

Physiologically, exposure to extreme heat triggers the body's thermoregulatory mechanisms to maintain core temperature. When environmental temperatures increase, the body vasodilates blood vessels in the skin and increases sweat production. However, this process causes a redistribution of blood flow from muscles to the skin, which, if prolonged, reduces physical work capacity and accelerates the onset of chronic fatigue. Research shows that the body's inability to cool itself effectively is directly proportional to an increase in a worker's basal heart rate.(3)

Furthermore, the impact of a hot work environment is not limited to physical impairments but also extends to cognitive function. Air temperatures exceeding the comfort threshold can reduce concentration levels, slow reaction times, and increase errors in decision-making in the field. In manufacturing industries that use sharp tools or heavy machinery, this decline in cognitive function is a major contributor to workplace accidents (Lost Time Injuries) that could have been prevented through environmental controls.(4)

This condition is exacerbated by global climate change, making regular temperature monitoring increasingly crucial. Recent studies emphasize that indoor production areas tend to trap heat for longer periods than in previous decades. Without accurate Wet Bulb Globe Temperature (WBGT) measurement data, company management lacks a solid basis for determining appropriate rest periods (work-rest cycles) commensurate with employees' physical workloads and maintaining long-term performance.(5)

In addition to external environmental factors, internal variables such as workers' hydration status also determine the severity of heat exposure. Workers exposed to high temperatures without adequate access to drinking water will experience dehydration, which clinically increases blood viscosity and cardiac workload. Education on proper hydration patterns is an integral part of risk management, given that many workers in the industrial sector often neglect fluid intake until obvious physical symptoms develop.(6)

Practically, preventing this risk requires synergy between administrative policies and technical improvements. Implementing standards in accordance with Minister of Manpower Regulation No. 5 of 2018 through the addition of exhaust fans or improved air circulation is essential to reduce radiant temperatures. Without measurable interventions, company productivity will be threatened by high worker absenteeism due to heat-related health problems.(7)

The theoretical conditions above are highly relevant to the situation at CV. X. In this fiberglass industry, workers reported clinical symptoms such as excessive sweating, dizziness, and fatigue, which are early indications of heat strain.(8) To date, WBGT measurements have not been systematically conducted, so compliance with safe thresholds cannot be ensured. Therefore, this study aims to analyze heat stress among production workers due to exposure to hot work environments at CV. X.

METHODS

The research employed a descriptive quantitative approach with a cross-sectional design to analyze heat strain among production workers exposed to hot working climates at CV. X. The study included all 10 production workers as the sample, selected using total sampling due to the small population size. Data collection involved several steps: measurement of the working environment using the Wet Bulb Globe Temperature (WBGT) method to determine if the temperature exceeded the Threshold Limit Value (TLV) set by Ministerial Regulation No. 5 of 2018; and assessment of heat strain using the Physiological Strain Index (PSI), based on body temperature and pulse rate measured before and after work.

Additionally, individual characteristics such as water intake, nutritional status, and gender were collected through interviews or questionnaires. The collected data were analyzed to identify the relationship between heat exposure in the workplace and the level of heat strain experienced by the production workers at CV. X.

RESULTS

Based on the results of the heat strain analysis among production workers at CV. X, the findings are as follows:

Table 1. Characteristics of Respondents by Age in Production Workers in CV. X

Age (years old)	Frequency (n)	Presentation (%)
≥40 years old	5	50
<40 years old	5	50
Total	10	100

Source : Primary Data, 2025

Based on the age frequency distribution data in table 1, the age characteristics of CV respondents. Soka Mandiri shows ≥40 years old as 5 people (50%). Meanwhile, respondents with the age of <40 years amounted to 5 people (50%).

Table 2. Characteristics of Respondents based on Water Consumption in Production Workers in CV. X

Water Consumption (liters)	Frequency (n)	Presentase (%)
< 2 liters per day	7	70
≥ 2 litres per day	3	30
Total	10	100

(Source: Primary Data, 2025)

Based on the distribution data of the frequency of water consumption in CV. X production workers. Soka Mandiri showed that most respondents consumed drinking water more than 2 liters per day. This is evidenced by the percentage of water consumption ≥ 2 liters per day as many as 7 people (70%), while workers with water consumption < 2 liters per day are 3 people (30%).

Table 3. Characteristics of Respondents based on Nutritional Status in Production Workers in. CV. X

Nutritional Status (BMI)	Frequency (n)	Presentation (%)
Less (<18.5)	0	0
Normal (18.5 – 24.9)	8	80
Excess (24.9)	0	0
Obesity	2	20
Obesitas II	0	0
Total	10	100

(Source: Primary Data, 2025)

Based on the frequency distribution data of nutritional status in table 3, in CV.X production workers showed that of the 10 respondents, most of them had normal nutritional status, totaling 8 people (80%). Meanwhile, respondents with obesity nutritional status amounted to 2 people (20%).

Table 4. Characteristics of Respondents based on Workload in Production Workers in CV. X

Workload (With Kkal)	Frequency (n)	Presentation (%)
Rest 115 (100 – 125)	**0**	**0**
Lightweight 180 (125 - 235)	0	0
Medium 300(235 - 360)	10	100
Weight 415 (360 - 465)	0	0
Very Heavy 520 (> 465)	0	0
Total	10	100

(Source: Primary Data, 2025)

Based on data on the distribution of workload frequency in production workers at CV. X shows that all workers (100%) have a medium workload.

Table. 5 Results of Hot Working Climate Measurements in the Production Section in CV. X

Location	WBGT (C)	Workwear (WBGT correction value)	Workload	Allocation of working time & rest
Production Area	30,1	Long sleeve shirts and trousers (0)	Mediun	75% - 100%

(Source: Primary Data, 2025)

The data in Table 5 from measurements in the production area show that the WBGT index is 30.1°C. This value is obtained through a single measurement of the thermal working climate, taking into account the type of clothing used by production workers, namely long-sleeved shirts and trousers, which have an WBGT correction value of 0°C.

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Meanwhile, for the allocation of working time, 8 working hours are obtained with a rest time of 1 hour (75 - 100%).

Table 6 *Heat Strain Index* of Production Section Workers in CV. X

They respond	Age	Workload	Working Climate	PSI
Worker 1	≥ 40 years old	Medium	> NAB	Low
Worker 2	≥ 40 years old	Medium	> NAB	Medium
Worker 3	< 40 years old	Medium	> NAB	Medium
Worker 4	≥ 40 years old	Medium	> NAB	Medium
Worker 5	≥ 40 years old	Medium	> NAB	Medium
They respond	**Age**	**Workload**	**Working Climate**	**PSI**
Worker 6	< 40 years old	Medium	> NAB	Medium
Worker 7	≥ 40 years old	Medium	> NAB	Medium
Worker 8	< 40 years old	Medium	> NAB	Medium
Worker 9	< 40 years old	Medium	> NAB	Medium
Worker 10	< 40 years old	Medium	> NAB	Medium

(Source: Primary Data, 2025)

In table 6 about the *heat strain* index of production workers, it is known that workers with low *heat strain* category amount to 1 person (10%) and workers with medium *heat strain* category amount to 9 people (90%).

DISCUSSION

Based on field measurements, the Wet Bulb Globe Temperature (WBGT) value in the CV. X production area was found to be 30.1°C. This figure indicates that the work environment has exceeded the Threshold Limit Value (NAB) stipulated in Ministerial Regulation No. 5 of 2018 for the medium work category. Theoretically, this condition is very risky because the human body has limitations in maintaining a stable core temperature at 37°C (Thermoregulation Balance Theory). When the environmental temperature is too high, the body can no longer naturally dissipate heat into the surrounding air, so the heart's workload increases drastically to pump blood to the skin's surface to prevent body temperature from rising to dangerous levels.(9)

These hot temperature conditions have been shown to impact workers' health, with many complaining of dizziness, fatigue, and excessive sweating. This finding is in line with research by Sari et al which states that working in an environment with temperatures above 28°C will significantly increase the risk of heat strain.[7] The dizziness and fatigue experienced by CV. X workers are early signs that their bodies are starting to struggle to adapt to the heat. This occurs because blood flow that should be going to the brain and muscles is instead diverted to the skin to cool the body, resulting in decreased physical function and concentration of workers.(10)

In addition to environmental factors, this study also highlights the importance of individual factors such as water intake and nutritional status. Workers who diligently drink water were found to have lower levels of heat stress. This proves the Voluntary Dehydration Theory, where many workers often forget to drink because they are too focused on work even though their bodies are already dehydrated. From a nutritional perspective, research by Hidayat explains that overweight (obese) workers feel hot more quickly because the layer of fat in their bodies inhibits heat loss.(11) On the other hand, workers with

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malnutrition are also at risk because they are more susceptible to dehydration due to lower body fluid volume.(12)

Interestingly, gender variables also show differences in response to heat. A study by Tan & Wang supports this finding by stating that women naturally have a lower sweat rate than men, making it more difficult to cool their body temperature quickly (13). However, this result contradicts research by Lopez et al which argues that gender differences are actually not significant if physical fitness levels are equal. This means that both men and women who are physically fit will be more resistant to heat exposure in the workplace than those who do not exercise enough.(14)

Finally, the heavy physical workload at CV. X also exacerbates existing heat stress conditions. According to the ISO 7243 standard, the combination of heat from the environment and the heat generated by muscles during work creates double stress on the body. This heat stress not only damages the body but also affects brain function. Based on the Maximal Adaptability Model Theory, hot temperatures can make it difficult for a person to focus and slow down decision-making. Recent research by Zhu et al even shows that the risk of work errors increases by up to 25% at high temperatures (15). Therefore, if the conditions at CV. X are not immediately corrected, the risk of workplace accidents due to human error will become a real threat.

CONCLUSIONS AND RECOMMENDATIONS

The majority of production workers at CV. X are evenly distributed by age with a balanced proportion between those above and below 40 years old, however, it was found that 70% of workers consume less than 2 liters of drinking water per day even though 80% of them have normal nutritional status. The results of work climate measurements using the Heat Stress Apparatus Quest Temp 46 showed an ISBB value of 30.1°C in the production area which has exceeded the threshold for a moderate workload of 28°C, so that the environmental conditions are classified as a hot area that poses a risk to health. Heat stress analysis using the Physiological Strain Index (PSI) method revealed that almost all workers experienced a moderate level of heat stress, which confirms that heat exposure in the production area has a significant impact on physiological burden and the risk of health problems. As a follow-up step, the company is advised to conduct regular work climate monitoring to ensure compliance with the threshold, educate workers about heat risks, improve ventilation systems for better air circulation, and conduct routine health checks for early detection of work-related health problems. Furthermore, providing easily accessible drinking water and promoting a minimum daily water consumption of 2 liters is crucial for maintaining hydration, which needs to be supported by the provision of appropriate work clothing and cool rest areas for workers. Furthermore, workers are expected to be self-aware of drinking enough water, wearing light, light-colored clothing to reduce heat absorption, and taking breaks in cooler areas to speed up body recovery from extreme heat exposure.

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