

A Narrative Review : *Heatstroke* Prevention Among Outdoor Industrial Workers in the Context of Climate Change: Stakeholder Responsibilities and Management Approaches in Indonesia

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Abstract

Global climate change has become a major challenge to Occupational Safety and Health, particularly in developing countries with tropical climates such as Indonesia. The increase in the Earth's average temperature by more than 1.5°C has had a significant impact on labor productivity and has increased the risk of heat-related disorders, such as heat exhaustion and heatstroke. This study aims to examine the impact of climate change on occupational health and the preventive measures against heatstroke based on Occupational Safety and Health (OSH) principles and relevant national policies. A narrative review was conducted by analyzing scientific literature published between 2013 and 2025. The review findings indicate that rising environmental temperatures due to climate change significantly increase the risk of heat-related disorders among outdoor workers. Factors such as high levels of physical activity, heavy workloads, and inadequate hydration further exacerbate this risk. The implementation of Occupational Safety and Health (OSH) strategies, including work scheduling, acclimatization, worker training, and the provision of cooling facilities and drinking water has been proven effective in reducing the incidence of heatstroke. The enforcement of employer-based and governmental policies is essential to ensure safe and climate-adaptive working conditions. Climate change has a substantial impact on occupational health by elevating the risk of heatstroke among outdoor workers. Implementing OSH-based preventive strategies, supported by strong governmental policy and intersectoral collaboration, is essential to protect worker health and maintain productivity in an era of escalating global temperatures.

Keywords: Climate change; Occupational health; Heatstroke prevention; Occupational safety; Industrial workers; Indonesia

Introduction

Climate change is an unavoidable situation. Exposure to climate change will affect not only daily activities but also other aspects. The impact of climate change on the economy continues to increase gradually, especially on the proportion of the population of developing countries that are vulnerable to poverty, for example in Africa and Asia.¹ In addition to its impact on the economy, climate change also has a direct impact on Occupational Safety and Health, especially for workers exposed to extreme temperatures in the work environment. Workers in developing countries such as Indonesia are the group most affected by climate change because countries or regions with very long periods of hot weather have a high risk of work accidents due to the effects of heat.²

Mechanistically, future climate change is closely related to increasing greenhouse gas concentrations, which cause rising air temperatures and, ultimately, affect working conditions. Working in ambient temperatures above 38°C can increase worker's risk of health problems due to overheating. Data from *The Economics Daily* shows that in 2019, there were 43 occupational deaths related to heat exposure in the workplace, and in 2018, this number increased to 49 workers who experienced work-related deaths. In the past 10 years, 41.9% of workers died due to exposure to environmental heat while working. Exposure to heat can cause a number of immediate disturbances like heat stroke, heat exhaustion, heat syncope, heat cramps, or heat rash. Long-term effects of heat exposure include permanent damage to organs that can lead to chronic health problems.³

These findings have prompted global health organizations, including the World Health Organization (WHO), to emphasize the importance of limiting greenhouse gas emissions as part of a global strategy to protect worker's health.^{2,4} In the context of Occupational Safety and Health (OSH), climate change-related hazards which is increases in the temperature of the work environment, not only endanger worker's health but also reduce their work capacity and effectiveness.^{5,6}

However, existing research largely focuses on general heat exposure or is conducted in developed countries. In Indonesia, studies on heatstroke prevention in outdoor workers remain fragmented and descriptive, lacking a synthesis that integrates risk factors, Occupational Safety and Health (OSH)-based prevention strategies, and the role of stakeholders in addressing the impacts of climate change.

Furthermore, available literature reviews generally discuss prevention efforts partially and fail to critically examine the interrelationships between the responsibilities of workers, employers, and the government in developing a work protection system that adapts to rising global temperatures. Therefore, a significant research gap remains, particularly regarding the need for a comprehensive study that synthesizes heatstroke prevention efforts in outdoor workers within the context of climate change and the national regulatory framework in Indonesia.

Method

1. Type of Review

This study uses a narrative review method to synthesize scientific literature discussing heatstroke prevention in outdoor workers in the context of climate change . literature done through PubMed, Scopus, ScienceDirect, Google Scholar, and ProQuest databases.

Search strategy used keyword combination “heatstroke”, “pressure hot work”, “workers outside space”, “change climate”, “safety and health work”, and “Indonesia” with the Boolean operator AND/OR. The articles under consideration are publication 2013–2025 in Indonesian and English.

2. Inclusion and Exclusion Criteria

Inclusion criteria included original research articles, review articles, and policy documents relevant to occupational heat exposure, heatstroke prevention efforts, and occupational health regulatory aspects. Articles without full text, non-scientific publications, and studies irrelevant to the topic were excluded from the review. The selection process was carried out through title and abstract screening, followed by full-text review. Selected articles were analyzed using a thematic synthesis approach. Each article was reviewed to identify heatstroke risk factors, forms of intervention or occupational health-based prevention efforts, and the role of stakeholders. Similar findings were then

grouped into main themes and critically compared to identify patterns, consistencies, and differences between studies. This approach allows for more integrative conclusions and strengthens the study's contribution to climate change and occupational health in Indonesia.

3. Literature Selection Flowchart (PRISMA Narrative)

An initial literature search was conducted through several scientific databases, namely PubMed, Scopus, ScienceDirect, Google Scholar, and ProQuest, resulting in approximately 120 articles. Subsequently, a duplication removal process was conducted, resulting in 92 articles for screening based on title and abstract. At this stage, 54 articles were eliminated because they were not directly related to the topic of heatstroke prevention in outdoor workers or did not address the context of climate change. Based on an evaluation of the established inclusion and exclusion criteria, 22 articles were excluded due to methodological limitations, lack of full-text availability, or being solely opinion pieces. Thus, 16 articles were deemed eligible for inclusion in the thematic synthesis process. However, after further adjustments were made to reflect the focus of the research title and compliance with relevant government regulations, only 10 articles were deemed to fully meet the criteria and were used as primary sources in this study.

Results

A narrative review of the literature indicates that rising ambient temperatures due to climate change are closely associated with an increased risk of heat stroke in outdoor workers. Most studies report that a combination of increased ambient temperature, high humidity, heavy physical workloads, prolonged sun exposure, and inadequate hydration are the main contributing factors to heatstroke. This risk is reported to be higher in tropical climates, including Indonesia, which consistently experiences year-round exposure to ambient heat.

Table 1. Summary of Main Article Review ¹⁻⁹

No	Author & Year	Location/ Context	Study Focus	Key Findings
1	Kjellstrom et al., 2016 and 2017	Southeast Asia and Global	Climate & health Work	Rising global temperatures reduce work capacity and increase the risk of heatstroke.
2	Ankomah- Appiah et al., 2021	Developing country	Heat stress & safety Work	Heat stress is a major threat to the safety of outdoor workers.
3	Aulia et al., 2023	Indonesia	Exposure hot Work	Heat load tall relate with disturbance health I
4	Maharani et al., 2024	Indonesia	Heatstroke on the spot Work	Education, hydration, and acclimatization are effective in preventing heatstroke.
5	Abokhashabah et al., 2021	Global	Outdoor workers & climate change	The need for approach integrated policies and OSH

In line with the identification of these risk factors, the literature also highlights various preventive approaches proven effective in reducing the incidence of heat stroke. The most frequently reported strategies include regulating work and rest periods, implementing heat acclimatization programs, worker education, providing adequate drinking water, and using cooling facilities in the workplace. However, the effectiveness of these interventions is greatly influenced by the level of worker compliance and, more importantly, by the commitment and active support of

employers in implementing Occupational Safety and Health (OSH) principles.

Furthermore, several studies confirm that heat stroke prevention cannot rely solely on individual worker adaptation. A more comprehensive approach is needed through the involvement of various stakeholders. In this context, government policy support, enforcement of OSH regulations, and employer responsibility in providing a safe work environment are key factors in addressing heat risks due to climate change. Therefore, policy implementation at the company and government levels is crucial for ensuring safe, adaptive, and sustainable working conditions for outdoor workers in Indonesia.

Discussion

In a global context, the Intergovernmental Panel on Climate Change (IPCC) reports that global temperature increases have reached a range of 1.5°C to 2°C compared to pre-industrial levels. This temperature increase has the potential to cause widespread impacts, including reduced food sector productivity, increased health risks, and economic losses. Global warming mitigation efforts are considered capable of reducing the population exposed to climate-related risks and reducing poverty by hundreds of millions by 2050. Countries in tropical and subtropical regions, such as Southeast Asia, the Middle East, Africa, and other regions of the southern hemisphere, are projected to experience the most significant impacts on economic growth if global warming increases from 1.5°C to 2°C.¹

In line with these findings, the Occupational Safety and Health Administration (OSHA) states that workers are exposed to extreme heat when the working environment temperature exceeds 38°C. This condition poses a significant risk of health problems, especially in developing countries that are not yet socially and economically able to adequately mitigate the impacts. According to the WHO, one of the main strategies to reduce the risk of health problems and reduced work productivity in the Southeast Asia region is to limit greenhouse gas emissions from the largest producing countries, exceeding existing national targets.^{2,4} However, despite global commitments through the Intended Nationally Determined Contributions (INDCs), projections indicate that global temperatures still have the potential to rise by up to 2.7°C, exceeding internationally agreed safe limits. Therefore, additional efforts are needed to further reduce greenhouse gas emissions to mitigate the impacts of climate change and protect worker health, particularly in Southeast Asia.^{5,6}

From an Occupational Safety and Health perspective, health hazards related to climate change include increased environmental temperatures, which have health impacts such as heat exhaustion, heat stroke, chronic kidney disease, and chemical poisoning. High heat exposure increases the risk of heat exhaustion and heat stroke, and is subjectively perceived as uncomfortable.^{5,6}

Heat stroke is divided into exertional heat stroke (EHS) and non-exertional or classic heat stroke (NEHS). EHS typically occurs in young, healthy individuals during strenuous physical activity without adequate heat acclimatization, while NEHS results from prolonged exposure to high temperatures. EHS is characterized by neurological disorders accompanied by gastrointestinal and musculoskeletal complaints, and a decline in general condition. In severe cases, heatstroke can progress to multiorgan dysfunction, including disorders of the nervous system, respiratory system, heart, kidneys, and liver.⁴ Therefore, understanding the types and symptoms of heatstroke is crucial for implementing Occupational Safety and Health (OSH) principles in high-temperature work environments.

Physiologically, one of the primary mechanisms of heatstroke is the loss of body fluids due to excessive sweating. Heat exposure increases the risk of dehydration, which, if not promptly compensated, can reduce plasma

volume and reduce a worker's physical and cognitive abilities. A fluid loss of 5% or more has the potential to lead to heat illnesses, such as heat cramps, heat exhaustion, and heat stroke, ultimately increasing the risk of work-related injuries.⁸

Table 2. The occupational health impacts that occur in Southeast Asian countries according to WHO. ^{5,6}

Climate Hazards	Vulnerable Groups	Health Impact
High heat exposure (temperature and humidity)	<ul style="list-style-type: none"> Workers who perform heavy physical tasks; outdoor workers exposed to direct sunlight Workers in heat stress situations who are not adequately hydrated Workers exposed to volatile chemicals, such as organic solvents; high heat increases exposure to chemicals in the workplace. 	<ul style="list-style-type: none"> Heat exhaustion, heat stroke Chronic kidney disease Chemical poisoning
Extreme weather, wind	<ul style="list-style-type: none"> Outdoor workers in affected areas; emergency workers; all workers when the workplace is closed due to weather 	<ul style="list-style-type: none"> Injury, drowning
Ecological conditions that are indirectly related to climate	<ul style="list-style-type: none"> Outdoor workers, especially farmers who need to work at dawn and dusk 	<ul style="list-style-type: none"> Infectious diseases, non-communicable diseases, mental health problems, etc.
Other hazards indirectly related to climate	<ul style="list-style-type: none"> Low-income groups with limited health coverage; workers with non-climate related health problems exacerbated by heat 	<ul style="list-style-type: none"> Vector-borne diseases, diseases associated with ecological change

According to the Institute of Medicine, the fluid requirement for workers in hot environments (30-35°C) with active to very active physical activity is 6-8 liters per day per person. This amount far exceeds the fluid requirements of individuals under normal conditions, so the standard fluid intake of 2 liters per day is considered inadequate for outdoor workers.⁸

1. Heatstroke Management Based on OSH by Individuals and Preventive Management by Employers

Exposure to extreme heat triggers various physiological and behavioral responses as the body attempts to maintain thermal balance. When someone experiences heat stroke or is under conditions of high heat stress, the body will engage in compensatory mechanisms to prevent an excessive increase in core temperature. A person's natural reaction to heat is to reduce physical activity, thereby reducing the body's internal heat production. This reaction is known as "self-pacing" or "autonomous adaptation."

In addition to behavioral responses, the body can also be helped through external cooling interventions. Body cooling is an active cooling method that aims to maintain a stable core body temperature or prevent it from rising too high. Body cooling can increase body heat dissipation through evaporation, conduction, and convection, thus preventing excessive heat retention and reducing the level of heat strain in the human body. However, the consequences of this preventative response are reduced hourly work capacity and reduced economic productivity during periods of heat exposure, as the body needs time to rest and cool down.^{5,6}

People who work or engage in heavy physical activity are particularly affected by this condition, as physical activity generates heat in the body that must be released to maintain a stable body temperature. Kjellstrom stated that

acclimatization is thought to be able to mitigate some of the effects of heat exposure. However, although health risks are indeed higher in individuals who have not yet acclimatized, physiological acclimatization has limitations. The physiological acclimatization process generally lasts less than two weeks and is primarily characterized by increased sweating. However, physical limitations in the process of sweat evaporation, particularly in high-humidity environments, remain a barrier, as is interindividual variation.

As an illustration, a study of mine workers in South Africa showed that before acclimatization, only about 14% of new workers were able to work in extreme heat conditions with heavy workloads. After a two-week systematic acclimatization program, this proportion increased to 29%. Thus, the majority of workers (around 71%) remain unable to tolerate extreme heat conditions despite undergoing physiological acclimatization.

In addition to physiological acclimatization, behavioral acclimatization through adjusting work rhythms or self-pacing also plays a crucial role in reducing the risk of heat-related health problems. However, this strategy requires longer rest periods and a reduced work pace, ultimately leading to decreased productivity. In line with these findings, this article further presents various estimates of economic output losses due to heat exposure, focusing on countries in the Asian region.^{5,6}

While physiological and behavioral adaptations at the individual level play a role in reducing the risk of heat disorders, evidence suggests that these capabilities have limitations and cannot stand alone without the support of adequate work systems.

To reduce workload, companies are advised to regularly conduct training on proper ergonomic lifting techniques to prevent injury. Education regarding the risks of lifting heavy loads without assistance is also necessary. Workers should collaborate when lifting and moving heavy materials, and implement regulations requiring the use of assistive devices for heavy-duty tasks. Regular stretching is recommended to help workers reduce muscle tension and improve blood circulation. Additionally, using ergonomic work equipment with appropriate handles can reduce stress on the limbs during work.⁸

To prevent heatstroke, regular and periodic temperature assessments are necessary. Heat exposure in the work environment or climate can be assessed using the Wet Bulb Globe Thermometer (WBGT) method or other techniques such as Effective Temperature (ET), Corrected Effective Temperature (CET), or Wet Globe Temperature (WGT). WBGT combines air humidity, radiation, and wind speed with ambient temperature, making it a more robust measure of heat stress than ambient temperature. Measurements can be taken at close range to avoid bias and maintain the accuracy of worker environmental measurements in each area. This assessment can be used to determine the level of heat stress experienced by workers in their work environment and determine how to reduce it to prevent heat-related injuries.³

The thermal conditions of the work environment are influenced by factors such as humidity, temperature, air movement, type of activity, and personal factors, which, if not appropriate, can lead to work discomfort. Sources of heat exposure can come from outside, such as solar radiation, or from within the work environment, such as room conditions and equipment that generates heat. Preventive efforts focus on controlling modifiable factors, including temperature and humidity, ventilation, workload, and the use of heat-generating equipment or materials and appropriate work clothing. However, the effectiveness of various technical measures undertaken by employers depends on the national OSH policy and regulatory framework.

2. Stakeholder Policies

Table 3. International policies and standards for managing health problems related to extreme heat stress based on recommendations from the International Labour Organization (ILO).⁹

Standard	Objective
Occupational Safety and Health Convention, 1981 (No. 155) Recommendation Companion C155 (No. 164)	Providing guidance to member states: In the preparation and implementation of national policies related to occupational safety and health (OSH).
Recommendation Worker's Housing 1961 (No. 115)	
Recommendation Protection of Workers' Health Act , 1953 (No. 97)	Recommend regulation: For managing heat stress risk and provide guide about effort adaptation for workers, entrepreneurs, and organization government.
Recommendation Hygiene (Business and Office), 1964 (No. 120)	

Preventing heatstroke is not only the responsibility of individuals or companies but also requires the active participation of governments and other stakeholders. These efforts can be achieved through appropriate regulatory frameworks, such as labor agreements, standards, and work regulations. International labor standards play a crucial role in supporting adaptation to mitigate the impacts of rising global temperatures. These standards provide guidelines and tools for managing health problems caused by extreme heat stress and ensuring decent and safe working conditions.⁹

According to Maharani (2024), several aspects need to be considered in preventing heatstroke in workers, including:⁴

1. Arrange work and rest times for workers in high-temperature environments to allow the body time to cool down. This includes adjusting the working hours of workers exposed to heat, ensuring adequate hydration, physical exercise, and a healthy diet.
2. Gradually acclimate workers to the work environment.
3. Provide training on the risks, symptoms, and prevention of heatstroke. Administrative controls are also necessary, such as explaining workload and workload limits, and clothing or protective equipment requirements based on the Wet Bulb Globe Temperature (WBGT) to mitigate the effects of heat exposure in the workplace.
4. Conduct monitoring and early detection, and instruct workers to report immediately if they experience early symptoms of heatstroke.

As work environments become increasingly hot, greater attention is needed to worker well-being and performance, including psychosocial stress, decreased productivity, longer working hours, increased production costs,

work accidents and injuries, absenteeism and presenteeism, and increased insurance claims.²

Minister of Manpower Regulation Number 5 of 2018 explains workplace safety and health related to heat, as outlined in Article 1, points 16, 17, 18, Article 9, Article 18, and Article 31. Companies or employers must comply with these regulations to maximize worker performance and prevent illnesses caused by climate change.¹⁰ This Ministerial Regulation stipulates that the work climate is the result of a combination of temperature, humidity, air movement speed, and radiant heat that affect worker's physical condition.

To assess the level of heat stress in the workplace, the Wet and Bulb Global Temperature Index (WBGT) is used, which is calculated based on dry air temperature, natural wet temperature, and bulb temperature. Working climate measurement and control are mandatory in workplaces with potential heat or cold stress hazards, such as areas with excessive heat sources or inadequate ventilation. Control efforts are carried out through various means, including eliminating or isolating heat sources, providing ventilation and drinking water, regulating exposure time, and using appropriate work clothing and personal protective equipment. Furthermore, artificial lighting can be used when natural lighting is insufficient, provided it does not cause excessive heat, and the building's roof must be able to protect from the sun and rain without leaking or being damaged.⁹

Top management commitment and worker participation in the hazard identification, risk assessment, and implementation of control measures are key procedures in managing occupational safety and health. These practices need to focus not only on existing health hazards but also on additional risks arising from climate change. Using the BRACE (Building Resilience against Climate Effects) adaptive management approach can help employers and workers adapt to new and evolving conditions. The following aspects reflect employer preparedness:⁹

1. Resource allocation for the hazard identification process
2. Identification of vulnerable groups in the workplace
3. Ensuring the implementation of control measures in accordance with available policies, procedures, and equipment

Employer preparedness also includes adjustments to building safety, work schedules, operational processes, and interaction patterns, including integration with other preparedness efforts. Examples include involving the fire department in process safety management or developing communication systems to reach workers at home. The National Institute for Occupational Safety and Health (NIOSH) recommends that emergency responders be prepared for all conditions. Furthermore, NIOSH encourages the integration of health monitoring systems into incident command structures to enable long-term monitoring of potential health impacts following exposure to emergency response activities (Emergency Responder Health Monitoring and Surveillance Framework).

The Ministry of Manpower regulations also state that OSH testing is intended to assess an object's OSH technically and/or medically that poses a risk of harm by applying a test load or using other testing techniques in accordance with established technical or medical provisions. Testing must be conducted routinely and by institutions designated by law.

In conclusion, findings in various journals indicate that climate change, particularly increasing ambient temperatures, poses a real challenge to occupational safety and health, particularly for outdoor workers. However, the limited comprehensive and contextual studies in Indonesia emphasize the need for further, more in-depth research, both

quantitatively and qualitatively, to identify specific risk factors, the effectiveness of prevention strategies, and their impact on work productivity.

Conclusion

Climate change, which is causing rising global temperatures, has a direct impact on human health and occupational safety. Increasingly warming environmental conditions increase the risk of heat-related health problems, including heatstroke, especially for workers exposed to prolonged sunlight and high temperatures. To address this challenge, implementing Occupational Safety and Health (OSH) principles is a crucial step in protecting the workforce. Preventive measures can be implemented through controlling the work environment, providing adequate facilities, regulating working hours, and educating workers about the dangers and management of extreme heat conditions.

The author believes that more comprehensive research and data collection are needed that integrate all aspects related to outdoor workers in Indonesia, from job characteristics, environmental exposure, individual factors, to Occupational Safety and Health (OSH) policies and practices. Ideally, this data synthesis should be compiled into a single integrated study or journal to provide a comprehensive overview and serve as a strong scientific reference.

Furthermore, educational and capacity-building efforts for workers, employers, and relevant stakeholders need to be strengthened so that understanding of the risks of heat stress and its prevention can be consistently applied in the field. The development and implementation of specific OSH guidelines for each work sector is also a strategic step to ensure worker safety. With an evidence-based approach, ongoing education, and standardized and climate-adaptive OSH practices, it is hoped that worker safety can be optimally protected and work can be carried out safely, effectively, and productively.

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