Title: Climate Change and Its Implications for Occupational Health and Safety: A Comprehensive Systematic Review

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To appear in: ***Health in Emergencies & Disasters Quarterly***

Received date: 2024/11/06

Revised date: 2025/05/14

Accepted date: 2025/05/11

First Online Published: 2025/12/12

Please cite this article as:

Mohsenian A, Esmaeili SV, Alboghobeish A, Poursadeghiyan M, Shahsavani A, Salehi Sahlabadi A. Climate Change and Its Implications for Occupational Health and Safety: A Comprehensive Systematic Review. Health in Emergencies & Disasters Quarterly. Forthcoming 2026. Doi: http://dx.doi.org/10.32598/hdq.2026.435.3

Abstract

Introduction: Physical and mental health promotion as well as social well-being of all employees is a central element of occupational health practice. It is becoming more evident that climate change is a core challenge confronting various global sectors, with substantial effects not only on environmental, social, and economic systems, but also on occupational health and safety in numerous industries. Due to the growing significance of climate change, the 2024 World Day for Safety and Health at Work has focused on its impact on occupational health and safety. Consequently, this study aimed to investigate how climate change influences workplace health and safety conditions.

Methods: Following the PRISMA protocol, this research was designed as a systematic review. To identify studies, relevant keywords were searched in reputable databases (Scopus, PubMed, Web of Science, ScienceDirect, Cochrane, Embase, and Google Scholar) between the years 2000 and 2024. The retrieved scientific studies were reviewed by two researchers based on inclusion and exclusion criteria. Duplicate and irrelevant articles were removed from the study. Key information, including the implications of climate change on health and occupational safety, the study location, a summary of the findings, the study design, sample size or study period, and the tools used for data collection, was extracted from the selected studies and analyzed using a descriptive approach.

Results: In this systematic review, 28 eligible studies were reviewed. The identified effects were divided into 9 different groups, which included: 1) increase in heat stress 2) consequences, symptoms and diseases related to heat 3) decrease in work capacity and productivity 4) increase in exposure to ultraviolet rays 5) increase in air pollution in the workplace 6) increase in infectious diseases and contagious 7) increase in occupational accidents 8) increase in cognitive impairment, psychological and behavioral effects 9) increase in severe weather events.

Conclusion: Adopting effective adaptation strategies to climate change to prevent the hazards associated with climate change and improve workplace conditions necessitates cooperation between different government sectors, academic institutions, fields of study, and local communities.

Keywords: Climate Change, Climate variability, Occupational Health and Safety

Introduction

Occupational health science contributes to the preservation of employee health and well-being and ultimately to community safety through the anticipation, recognition, assessment, and control of workplace health hazards (1). one of the hazards impacting the health and safety of employees that has received less attention is climate change (2).

Atmospheric scientists often characterize climate change as a major and persistent transformation in climatic conditions, marked by shifts in weather patterns occurring across intervals varying between decades and millions of years. There is ongoing debate in certain political and business sectors suggesting that these changes are mainly driven by natural factors such as biological processes, changes in solar energy levels, volcanic eruptions, and oceanic currents. Some argue that climate changes have occurred historically and do not result from human actions like fossil fuel combustion. However, the general agreement among scientists is that "the climate is undergoing change, and human activities are considered the primary cause of these shifts". Although many aspects remain to be clarified, the extensive evidence supports the idea that the models and hypotheses regarding climate change have remained robust despite rigorous scientific scrutiny over recent decades. The release of carbon dioxide into the air starting from the onset of the Industrial Revolution has resulted in a significant rise in worldwide temperatures, shrinking polar ice, elevated sea levels, and increasingly severe extreme weather events (3).

Climate change is increasingly recognized as a paramount challenge facing multiple sectors globally, profoundly influencing environmental, societal structures, and financial systems (4). The implications of climate change extend beyond ecological and atmospheric changes; it also impacts public health and occupational safety across various industries (5). Exploring how climate change impacts workplace health and safety is essential, as the workforce contends with a rapidly changing environment marked by rising temperatures, extreme weather events, and shifting ecological conditions (6).

Recent scientific studies have suggested that climate-induced environmental changes significantly contribute to the deterioration of health and safety within workplaces, especially among employees working in open-air sectors like agriculture and building trades, as well as in emergency response (7). Heat stress, for example, has increasingly become a concern, as rising global temperatures have led to a surge in heat-related health conditions like heat exhaustion and heatstroke (8). The

direct consequences of heat exposure include impaired physical and cognitive performance, which have been linked to a rise in workplace accidents (9).

In addition to heat stress, changing weather patterns have led to a rise in both the frequency and severity of natural disasters such as storms, severe flooding, and uncontrolled wildfires (10). These events not only threaten the safety of workers directly engaged in disaster response but can also disrupt supply chains and create hazardous conditions for employees returning to work post-disaster. Employers must develop comprehensive preparedness plans that prioritize worker safety despite increasingly common and severe events (11, 12).

The changing climate also has implications for the prevalence and distribution of occupational diseases. For instance, workers may face heightened exposure to vector-borne illnesses under warmer conditions, necessitating updated safety protocols and targeted health education (13). As the distribution of common vector species like mosquitoes grows, the likelihood of illnesses such as Lyme disease and West Nile virus spreading into previously unaffected labor sectors also increases (14).

Furthermore, intense weather phenomena can lead to the release of hazardous materials and pollutants during disasters, posing additional risks to workers engaged in cleanup and recovery operations (15). Cleanup crews following floods or chemical spills must contend with hazardous waste and potential biohazards, underscoring the necessity for rigorous health and safety guidelines and training specifically adapted to these changing circumstances (13).

Psychosocial stressors are another dimension of the OSHA nexus. Workers facing emotional and psychological strain due to extreme weather events, unpredictable work conditions, or catastrophic disruptions may experience increased mental health difficulties (16). This highlights the need for fostering supportive work environments that address mental health alongside traditional safety concerns despite climate-induced stressors (17).

The need for a proactive approach to OSH considering climate change cannot be overstated. Employers and decision-makers ought to allocate resources toward research that explores how climate-related elements affect the health and safety of workers (18, 19). This includes creating training programs that equip workers with the knowledge and skills to mitigate risks associated

with changing environmental conditions, whether by protecting against heat exposure, understanding new disease vectors, or responding to natural disasters effectively (13, 20).

Policies that integrate climate resilience into workplace safety regulations can also foster a safer working environment (21). As organizations begin to recognize the link between climate change and OSH, a systemic approach can emerge that emphasizes preventive measures and adaptive practices that safeguard workers amid evolving climate challenges (22).

As highlighted in this review, responding to climate-related risks in the workplace is not only essential for protecting today's workforce, but also pivotal for sustaining the long-term resilience of industries that may face heightened vulnerability in the future. In conclusion, tackling these complex challenges offers a vital opportunity to strengthen occupational safety by implementing evidence-based adaptations, establishing robust policy frameworks, and promoting targeted educational initiatives.

Due to the growing importance of climate change, the theme of the 2024 World Day for Safety and Health at Work has been chosen to focus on how climate change affects occupational health and safety. Accordingly, this study aims to conduct a comprehensive examination and evaluation of the impact of climate change on workers' health and safety. This research classifies and analyzes these impacts based on their nature and type, drawing attention to the increasing vulnerability of workers to various climate-related risks. The aim of this study is to offer crucial insights for decision-makers and those involved in occupational health, helping them take well-informed and effective actions to address the challenges posed by climate change exposure in the workplace.

Materials and Methods

The protocol for this study was developed and presented in accordance with the standards set by the PRISMA guidelines for systematic reviews and meta-analyses (23). First, articles were searched in reliable databases based on keywords. After selecting the articles and coding them, the required data were extracted and analyzed based on the main question of this research. The steps of this study are described.

Data collection

For the purpose of this research, articles were searched in PubMed, Scopus, ScienceDirect, Cochrane, Embase, Web of Science, and Google Scholar on March 31, 2024. For this purpose, two researchers (A.M and S.V.E) searched scientific databases using specified keywords. The database search by two researchers ensured the accuracy, systematicity, and reproducibility of the method.

Valid scientific studies were reviewed based on inclusion and exclusion criteria, and duplicate and irrelevant articles were excluded from the study**.** A senior investigator (A.S.S) resolved any conflicts or disagreements. The search strategy, including keywords and database selection, was developed in consultation with professors and members of the research team. The search strategy and keywords in the cited databases is described in Table 1.

Table 1. Search strategy and keywords

No.	Component	Search term
#1	Hazards/Exposures	"Climate change" OR "Climate variability"
#2	Occupational Health and Safety	"Occupational health and safety" OR "health and safety" OR "occupational health" OR "Outdoor workers"
#3	Outcomes	"Heat stress" OR "cancer" OR "mental stress" OR "fatigue" OR "asthma" OR "allergies" OR "traumatic" OR "death" OR "cardiovascular" OR "respiratory" OR "dermatitis" OR "syndrome" OR "musculoskeletal" OR "disease" OR "renal" OR "dehydration" OR "eye" OR "immune system" OR "kidney" OR "heatstroke" OR "syncope"
#4	Search time limit	2000-2024
	Overall Search Strategy	#1 AND #2 AND #3 AND #4

The inclusion criteria were as follows:

Original, experimental, and laboratory articles; English articles.

The exclusion criteria were as follows:

Articles with unrelated topics; non-research articles, including editorials, authors' notes, and letters to the editor; Types of studies include books and review articles. The articles identified based on

the database searches were entered into Endnote version 8.1 software. Figure 1 depicts the process of article selection.

The articles were reviewed, and the required data were extracted. This data included the first author's name,year of the study,title of the article, location of the study, a summary of the findings, the study design, sample size or study period, and the tools used for data collection.

Two researchers (A.M and S.V.E) independently carried out the quality evaluation of the included articles. Both researchers reviewed the articles from various aspects of methodology, accuracy of results, and transparency of reporting. In cases of disagreement, they reached an agreement through discussion and exchange of opinions so that articles of appropriate scientific quality were included in the analysis and articles with lower standards were discarded. This procedure was conducted to verify the accuracy and validity of the data included in the research and to ensure the overall quality of the final study. The methodological rigor and potential biases in the selected studies were evaluated using the JBI Critical Appraisal Tool (24).

Data analysis

The study followed the guidelines set out in the PRISMA checklist, focusing solely on articles that explored the relationship between climate change and occupational health and safety. A systematic search of databases was carried out using relevant keywords, and only those articles that met the inclusion criteria were selected. The selected studies were evaluated through a descriptive analysis. The results and discussion sections of each article were carefully reviewed, and the necessary data and findings were summarized.

Results

Appendix 1 presents a comprehensive overview of the findings from the selected articles. According to Figure 1, 1402 articles were found in the initial search. Of these, 409 articles were removed due to duplication. 156 articles were excluded due to a lack of inclusion criteria. By examining the titles and abstracts of the articles, 758 articles were removed because they were unrelated. 51 articles were removed due to the non-availability of the full text, article type and irrelevant (after reading the full text of the article), and finally, 28 articles were reviewed and analyzed.

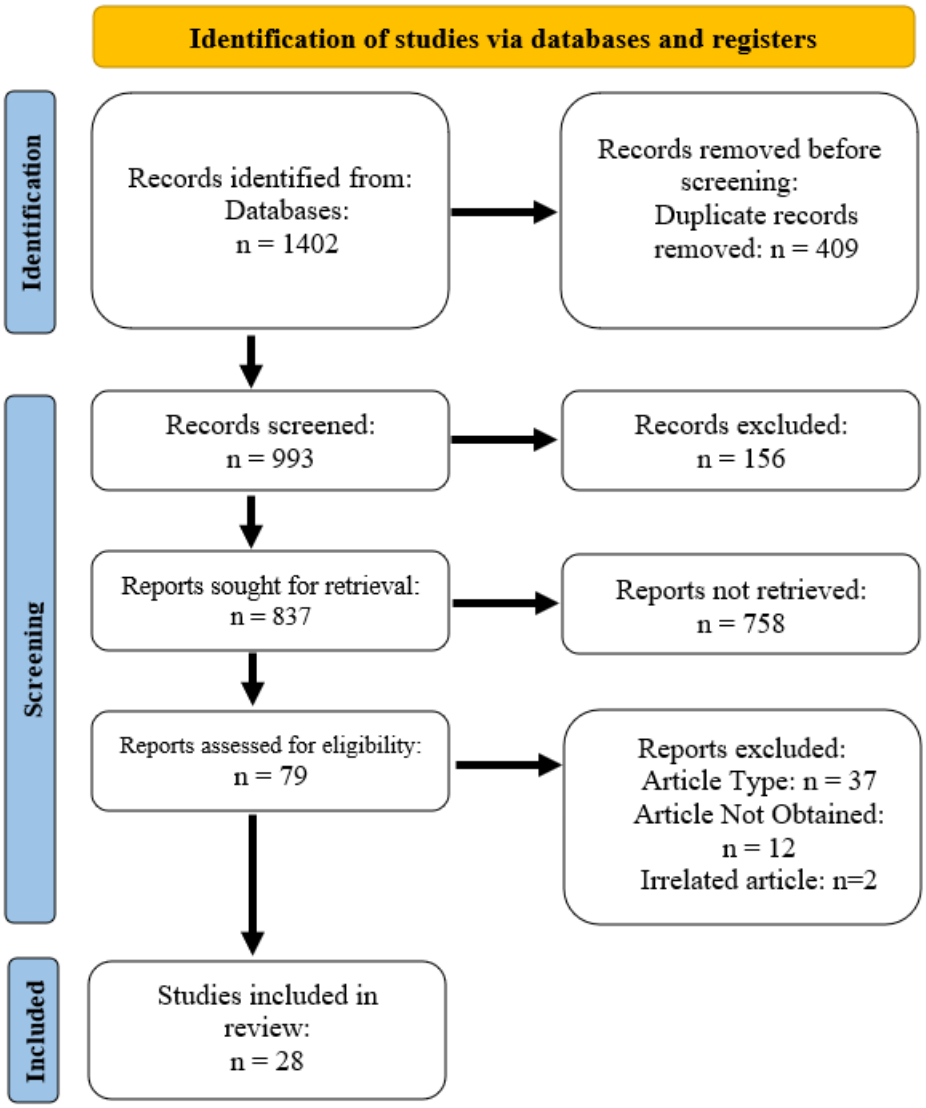

Figure 1. PRISMA flow diagram used in this study

Occupational health is a field concerned with addressing health issues in the workplace and promoting the well-being of employed individuals. Its goals include ensuring, maintaining, and enhancing the physical, mental, and social health of workers, as well as preventing work-related illnesses and accidents (25). Climate change can affect occupational health and safety from different aspects. This study examined the occupational health and safety risk factors linked to climate change.

Figure 2 shows the distribution of studies found (in percentage) across continents. The highest and lowest number of studies were from Asia and Africa, with 43% and 6%, respectively. 7% of studies were conducted in countries around the world.

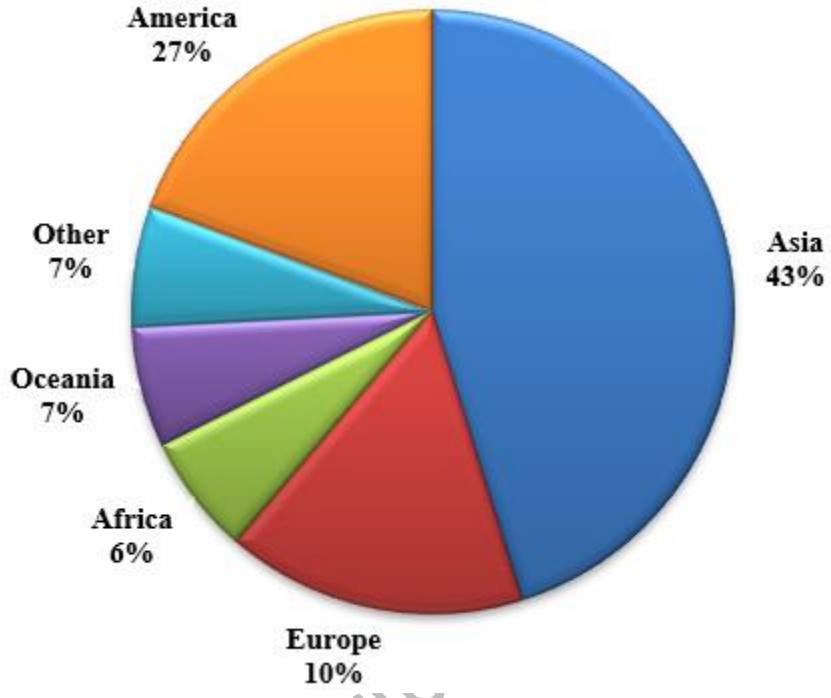

Figure 2. The Distribution of Studies Found in Each Continent

Impact of climate change on heat stress of workers

Heat stress is one of the most significant impacts of climate change on occupational health and safety (26-41). The results of Rahimi et al.'s study on Iran's workplaces showed that during 2021-2100, workers' exposure to heat stress increased 2.6 times in the studied provinces (42). Research carried out in Iran indicates that climate change is causing a rise in air temperatures, affecting both daily highs and lows across multiple months of the year. The findings suggest that the Wet Bulb Globe Temperature (WBGT) will continue to rise until 2099, with a particular concern for Pakdasht city, where the index is expected to enter the danger zone, especially between 2080 and 2099 (43). An additional study carried out in Iran forecasts an increase in air temperatures in the cities of Ahvaz, Dezful, and Dehdez in the coming years. The expected temperature rise is approximately 5 degrees Celsius between the periods of 2021-2040 and 2041-2070 (44). Liu et

al.'s research in China indicates that the WBGT will rise by more than 3-5 degrees Celsius by the century's end (45). Similarly, Sheffield et al.'s study in Nicaragua forecasts that excessively hot days will increase by over 15% by 2050 (46).

Impact of climate change on heat-related outcomes, symptoms, and illness in workers

Climate change leads to various consequences, symptoms, and diseases related to heat in workers. The most important consequence of climate change is heat-related death (29, 38, 47). The findings of Dong et al. indicate that rising summer heat from 1997 to 2016 contributed to higher mortality rates due to heat. Heat-related symptoms caused by climate change in workers include heat stroke (38). Symptoms caused by climate change in workers include heat stroke (32, 48), exhaustion (26, 31, 32), dehydration (26, 33), headache (26, 31), fatigue (29), thirst (29, 31), collapse (26), cramps (32), heat stress (33), excessive sweating (31) and visual disturbances (29). According to the results of various studies, heat-related diseases caused by climate change in workers include chronic kidney disease (30), skin cancer (30), and cardiovascular dysfunction (29).

Impact of climate change on worker work capacity and productivity

Various studies have shown that climate change negatively impacts employees' work ability and productivity (26, 27, 29, 31, 39, 41, 49-51). According to Hunt et al.'s study, the safe working duration (work capacity) will decline by over 50% in Port Macquarie and Griffith, and by 20-50% in northern Australia during the period of 2041-2080 (33). Additionally, Liu et al.'s research indicates that WBGT will rise by 3-5 degrees Celsius by the end of the century, leading to a reduction in labor capacity by more than 40% for both heavy and light work in major regions of southern and eastern China, which have large populations and advanced economies (45). Altinsoy et al.'s study anticipates a substantial decrease in labor productivity, particularly in the agricultural and construction sectors, in regions like Central Anatolia, Cyprus, and certain coastal areas of the Aegean and Eastern Mediterranean. It is projected that, between 2071 and 2100, some critical areas could experience a reduction of up to 52% in summer labor productivity (35). According to Kruse et al.'s study in Australia, workers in some areas will lose more than 12% of their productivity by 2099 (28). A study conducted in Thailand also revealed that climate change leads to a reduction in productivity ranging from 10% to 60% among workers in the construction and pottery industries (32). A study by Lee et al. in South Korea revealed that, as a result of climate change, labor productivity is projected to decline across most regions starting from the middle of

the 21st century (2041-2070). By the end of the century, productivity in strenuous outdoor jobs could drop by 26.1% compared to current levels (34). It is projected that climate change and heat exposure will result in a loss of 15-20% of annual working hours in Southeast Asia, with this percentage expected to double by 2050 as global climate conditions continue to worsen (36).

Impact of climate change on ultraviolet radiation exposure

Rahimi et al. analyzed the effects of climate change on occupational health indicators in Iran. They concluded that workers' exposure to ultraviolet (UV) radiation is expected to increase by 2.9 times during the period 2021–2100 (42). Additionally, according to the results of the study by Perkison et al. and Arjona et al., climate change increases the exposure of workers to UV rays and causes effects such as cataracts, malignant skin melanoma, and sunburn, and affects the immune system (30, 47).

Impact of climate change on workplace air pollution

Air pollution in the workplace, driven by climate change, can exacerbate conditions affecting the respiratory system, such as asthma, chronic obstructive pulmonary disease, allergic rhinitis, and bronchitis. It may also lead to premature, acute, and chronic cardiovascular deaths among workers (47).

Impact of climate change on infectious and contagious diseases among workers

Climate change affects the biological risks (infectious and contagious diseases through vectors) in workers. Various studies indicate that rising global temperatures are elevating the chances of workers contracting mosquito-borne illnesses such as dengue, malaria, and Zika, as well as tick-related diseases like Lyme. Additionally, the impact of climate change extends to foodborne illnesses, waterborne diseases (such as typhoid), asthma (due to molds and pollen), the release of toxic plants and their effects (such as skin and lung irritation), and a higher likelihood of workers being exposed to pesticides (47). Also, a 2022 study found that shifts in climate conditions influenced the spread of Sooty Bark disease and triggered sensitivity among woodworkers (52).

Impact of climate change on occupational accidents

According to the results of Ferrari et al.'s study in Brazil, occupational accidents show a direct correlation with weather variables (53). Research conducted by Athauda and colleagues indicated

that climate change can result in risks such as worker falls, scaffolding slippage, and lightning-related incidents among Sri Lankan workers (48). Meanwhile, research carried out in Australia revealed that climate change is linked to disturbances in both the mental and physical performance of workers. Ineffective decision-making can heighten both individual and collective risks, which in turn may lead to a rise in workplace accidents during hot weather conditions. (29).

Impact of climate change on cognitive, psychological, and behavioral disorders in workers

A study in North America also showed that climate change leads to mental, behavioral, and stress disorders in workers (47). Other related effects include mental confusion (impaired decision-making), higher suicide rates, and various other mental health issues (29).

Impact of climate change on extreme weather events

A study conducted in the United States indicated that climate change contributes to the intensification of extreme weather events like flooding, thereby increasing workers' exposure to various hazards such as drowning, physical injuries, skin infections, and diseases transmitted by vectors like mosquitoes and ticks (47).

Quality Assessment

The findings of the quality assessment of explored articles based on the JBI method are presented in Table 2. This quality assessment was conducted based on 8 questions related to the type of articles, and articles that met the desired criteria based on the designed questions were identified.

Table 2. Quality assessment of studies

Study	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6	Q_7	Q_8
Rahimi (2024)	Y	Y	Y	Y	NA	NA	Y	Y
Hunt (2023)	Y	Y	Y	Y	NA	NA	Y	Y
Cheng (2023)	Y	Y	Y	Y	NA	NA	Y	Y
Ferrari (2023)	Y	Y	Y	Y	NA	NA	Y	Y
Costabile (2023)	Y	Y	Y	Y	NA	NA	Y	Y
Dehaghi (2022)	Y	Y	Y	Y	NA	NA	Y	Y
Kespohl (2022)	Y	Y	Y	Y	Y	Y	Y	Y
Katopodis (2021)	Y	Y	Y	Y	NA	NA	Y	Y
Kruse (2021)	Y	Y	Y	Y	NA	NA	Y	Y
Nassiri (2020)	Y	Y	Y	Y	NA	NA	Y	Y
Kim (2020)	Y	Y	Y	Y	NA	NA	Y	Y
Liu (2020)	Y	Y	Y	Y	NA	NA	Y	Y
Pogačar (2019)	Y	Y	Y	Y	Y	Y	Y	Y
Takakura (2019)	Y	Y	Y	Y	NA	NA	Y	Y
Dong (2019)	Y	Y	Y	Y	NA	NA	Y	Y
Lee (2018)	Y	Y	Y	Y	NA	NA	Y	Y
Perkison (2018)	Y	Y	Y	Y	NA	NA	Y	Y
Pogačar (2018)	Y	Y	Y	Y	Y	Y	Y	Y
Arjona (2016)	Y	Y	Y	Y	NA	NA	Y	Y
Altinsoy (2015)	Y	Y	Y	Y	NA	NA	Y	Y
Kjellstrom (2014)	Y	Y	Y	Y	NA	NA	Y	Y
Sheffield (2013)	Y	Y	Y	Y	NA	NA	Y	Y
Hanna (2011)	Y	Y	Y	Y	Y	Y	Y	Y
Dash (2011)	Y	Y	Y	Y	NA	NA	Y	Y
Langkulsen (2010)	Y	Y	Y	Y	Y	Y	Y	Y
Kjellstrom (2009)	Y	Y	Y	Y	NA	NA	Y	Y

1. Were the criteria for inclusion in the sample clearly defined?
2. Were the study subjects and the setting described in detail?
3. Was the exposure measured in a valid and reliable way?
4. Were objective, standard criteria used for measurement of the condition?
5. Were confounding factors identified?
6. Were strategies to deal with confounding factors stated?
7. Were the outcomes measured in a valid and reliable way?
8. Was appropriate statistical analysis used?
Y=Yes, N=No,

Discussion

Climate change, as a global phenomenon, has significant and far-reaching impacts on the well-being and safety of diverse groups of workers. The findings of this review, which examine how climate change influences work environments, indicate that it can directly and indirectly affect multiple aspects of workers' health, safety, and overall working conditions across various sectors and settings. The risks to occupational health and safety associated with climate change and their possible impacts on both physical and mental (30, 35, 36, 54), productivity and work capacity (26-29, 32, 33, 35, 36), air pollution in the workplace (47), diseases related to heat stress and heat waves (26, 29, 31-33, 47), occupational accident rates (29, 48, 53) and the strategies for reducing risks that workers and their organizations implement are highlighted. However, a thorough and precise evaluation of the intricate risks and exposures linked to climate change is crucial for understanding its effects on workers' health and safety at various levels, as well as for developing and applying effective approaches for adaptation, minimizing risks, and implementing control measures.

One of the key findings of this study is the increase in thermal stress caused by climate change, especially in hot and dry areas (43-46). According to the results, workers' exposure to heat stress is expected to rise significantly by 2100 (42). This issue affects not only the physical health of workers but also various industrial and occupational aspects, potentially leading to decreased productivity and an increase in workplace accidents. However, it should be noted that these predictions and estimates are based on climate models and environmental conditions, and the actual results may differ due to local factors and management and engineering measures (26-29, 35, 45, 48, 53). In addition to heat stress, climate change can increase the exposure of people, especially workers, to UV. The findings show that this increase can lead to the occurrence of skin diseases and other health problems, especially in jobs such as farming and ranching, site workers, and road construction, which are directly exposed. However, many industries and businesses may adopt protective measures, such as the use of sunscreens and protective coatings, to reduce UV risks. In addition, in many covered industries, these exposures are close to their minimum levels. Therefore, examining control measures and exposure conditions during assessments is a key point (30, 42, 47).

Another important aspect of this issue is air pollution in the workplace. The results of the review of scientific sources show that climate change can lead to an increase in air pollution and the aggravation of respiratory diseases in workers of different occupations. However, it should be noted that air pollution is a multifactorial factor that is influenced by several factors, including environmental pollution caused by work processes and vehicle movement in work environments. Therefore, attributing air pollution in workplaces to climate change should be highlighted based on evidence, accurate measurements, and modeling of pollution sources based on environmental and climatic conditions (47).

With these new conditions in place, it is important to take measures to maintain the productivity of various industries. Finally, the findings of this study underscore the importance of addressing the research topic, particularly in subtropical and tropical regions. However, to achieve more accurate and reliable results and evidence, more comprehensive research is needed. By considering various environmental and occupational factors, it is possible to provide effective solutions to address these challenges based on the results.

First, it is essential to develop new guidelines for the protection of workers who work outdoors (29). Nations across the globe, regardless of their level of development, have enacted strategies to tackle the impacts of climate change within industrial settings and workplaces, placing special emphasis on those employed in outdoor occupations. Moreover, the implementation of educational initiatives is vital to raise awareness among both employers and employees about the potential for climate change to exacerbate occupational risks. The importance of this step lies in the fact that more than half of workers are still unaware of the potential effects and necessary actions during heatwaves (31). As a next step, actions should be taken to control and reduce the effects of climate change. These measures may include reducing shift lengths and work intensity (for example, substituting heavy tasks with electric and mechanical equipment), creating and developing specialized work break programs, and ensuring easy and adequate access to drinking water to replace fluids lost through sweating (29, 37). Approximately 70% of workers in Europe often arrive at work dehydrated and remain so by the end of their shifts (31). It is worth noting that implementing additional control measures is necessary given the diversity of climate change effects on employee health.

Limitations and future research

This study highlights the implications of climate change for workers' well-being and safety on a global scale. However, the distinction between developing and developed economies has been overlooked. The focus of this study is on the impact of climate change on workers' health and safety. Nonetheless, research that takes a multidisciplinary approach—encompassing disciplines like climatology, epidemiology, medicine, occupational health, and more—can provide valuable insights into the critical aspects and the complexity of the relationships between climate change and occupational health and safety. On the other hand, limited research has been conducted on vulnerable worker groups, including pregnant women, minors, older adults, individuals with disabilities, indigenous populations, and economically disadvantaged communities. Future research should prioritize longitudinal, evidence-based studies focusing on these populations.

Conclusion

Climate change presents considerable threats to the health and safety of workers in different contexts. Employees, particularly those in outdoor settings in tropical and subtropical areas, and also in economically developing nations, face heightened vulnerabilities to health and safety hazards. Moreover, as the implications of climate change continue to intensify, challenges related to employee health and safety are expected to escalate over time. Taking into account the results obtained in this study and the significance of the issue, the implementation of effective control measures by occupational health professionals, along with attention and support from policymakers, is essential. Furthermore, successful strategies for adapting to climate change should include cooperation between different government sectors, research institutions, various disciplines, and local communities.

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Appendix 1. Summary of reviewed articles

No.	Author(S) (Year) (Ref)	Title	Country or Location of Study	Finding	Design	Sample Size or Study Period	Tools Used to Collect Data
1	Rahimi (2024) (42)	Impacts of climate change on occupational health indicators in the three climatic regions of Iran	Iran	• Heat Stress • Increased Ultra Violet (UV) Radiation	Time series modeling	2005-2019 2020-2100	Meteorological Data - Modeling
2	Sverdlik (2024) (26)	Understanding the interplay of occupational, public health, and climate-related risks for informal workers: A new framework with findings from Zimbabwe and India	Zimbabwe And India	• Heat Stress • Heat-Related Consequences, Symptoms and Diseases: (exhaustion, headaches, collapse from dehydration) • Reduced Working Efficiency (Reduced Work Time)	Qualitative Study	735 Individuals	Qualitative Interviews - Focus Group Discussions -Quantitative Survey
3	Hunt (2023) (33)	Climate Change Effects on the Predicted Heat Strain and Labour Capacity of Outdoor Workers in Australia	Australia	• Heat-Related Consequences, Symptoms and Diseases: (heat strain) • Reduced Labour Capacity Of Outdoor Workers • Reduced Safe Work Durations (Labour Capacity)	Time series modeling	1986-2005 2041-2060 2061-2080	Meteorological Data - Modeling
4	Cheng (2023) (27)	Projecting future labor losses due to heat stress in China under climate change scenarios	China	• Heat Stress • Increase Heat-Induced Work Hours Lost	Ecological study	1986-2005 2021-2040 2051-2070 2081-2100	Meteorological Data - Modeling

5	Ferrari (2023) (53)	Impact of rising temperatures on occupational accidents in Brazil in the period 2006 to 2019: A multiple correspondence analysis	Brazil	• Increase Occupational Accidents	Ecological study	January 2006-December 2019 - 211396 Data	Meteorological Data - The Database of the Notifiable Diseases Information System
6	Costabile (2023) (40)	The effects of climate change on the health and safety of pasta industry workers: assessment of heat stress using wbgt index	Italy	• Heat Stress	Case Study	July 20 to July 27, 2023- October 20 to October 27, 2023	Measurement of the Wet Bulb Globe Temperature Index
7	Athauda (2023) (48)	Climate Change Impacts on Occupational Health and Safety of Façade Maintenance Workers: A Qualitative Study	Sri Lanka	• Risk Of Workers Falling • Risks Caused By Scaffoldings Becoming Slippery • Risks Caused By The Collision Of The Gondola Bucket With The Façade Due To The Vibration Of The Bucket • Heat-Related Consequences, Symptoms and Diseases: (risk of heatstroke) • Risk Of Employees Being Hit By Thunderstorms • Risks Caused By The Collision Of The Bucket With The Façade Due To Swaying • Risks Caused By The Swaying	Qualitative Study	12 Individuals	Semi-Structured Interviews - Open-Ended Questionnaires - Focus Group Discussions

				Or Ropes, Resulting In Workers Colliding With the Façade • Risks Caused by The Difficulty Of Working With Ropes for Hours			
8	Dehaghi (2022) (44)	Estimation of farmworkers' exposure to heat extremes in upcoming years in the southern part of Iran	Iran	• Heat Stress	Modeling Study	1986-2016 2011-2040 2041-2070	Meteorological Data - Modeling
9	Kespohl (2022) (52)	Impact of climate change on wood and woodworkers — Cryptostroma corticale (sooty bark disease): A risk factor for trees and exposed employees	Germany	• Cryptostroma Corticale (Sooty bark disease) • Hypersensitivity Pneumonitis (HP)	Analytical Cross Sectional Study	March 2018-March 2020 - 37 Individuals	Laboratory tests - Questionnaire
10	Kruse (2021) (28)	Occupational health impacts of climate change across different climate zones and elevations in sub-Saharan East Africa	Sub-Saharan East Africa	• Heat Stress • Reduced Productivity	Modeling Study	1981-2099	Meteorological Data - Modeling
11	Katopodis (2021) (37)	The impact of climate change to occupational safety and health: future projections of	West Attica Region	• Heat Stress	Ecological study	1980-2004 2021-2045	Meteorological Data - Modeling

		thermal discomfort (humidex index) in the West Attica region					
12	Nassiri (2020) (43)	Modeling heat stress changes based on wet-bulb globe temperature in respect to global warming	Iran	• Heat Stress	Modeling Study	1965-2015 2011-2030 2046-2065 2080-2099	Meteorological Data - Modeling
13	Liu (2020) (45)	Reductions in labor capacity from intensified heat stress in China under future climate change	China	• Heat Stress • Reduced Labor Capacity	Modeling Study	1981-2010 2021-2050 2071-2099	Meteorological Data - Modeling
14	Kim (2020) (49)	Spatial Changes in Work Capacity for Occupations Vulnerable to Heat Stress: Potential Regional Impacts From Global Climate Change	southwest Korea	• Heat Stress • Reduced Labour Capacity	Ecological study	1981-2010 2020s 2030s 2040s 2050s	Meteorological Data - Modeling
15	Takakura (2019) (50)	Site-specific hourly resolution wet bulb globe temperature reconstruction from gridded daily resolution climate variables for planning climate change adaptation measures	Japan	• Heat Stress • Reduced Labour Capacity	Prospective modeling study	1958-2013 2090s	Meteorological Data - Modeling

16	Dong (2019) (38)	Heat-related deaths among construction workers in the United States	United States	• Heat Stress • Heat-Related Consequences, Symptoms and Diseases: (death)	Cross Sectional epidemiological Study	1992-2016	Reliable databases, such as the Bureau of Labor Statistics (BLS) of the United States
17	Pogačar (2019) (31)	Heat waves occurrence and outdoor workers' self-assessment of heat stress in slovenia and greece	Slovenia and Greece	• Heat Stress • Reduced Productivity • Heat-Related Consequences, Symptoms and Diseases: (Thirst, excessive sweating, exhaustion, headache)	Analytical Cross Sectional Study	1981-2017 - 286 Individuals	Meteorological Data - Questionnaire
18	Pogačar (2018) (51)	The effect of hot days on occupational heat stress in the manufacturing industry: implications for workers' well-being and productivity	Slovenia	• Heat Stress • Reduced Labour Capacity	Analytical Cross-Sectional Study	1961-2011 1981-2010 2070-2099 2016	Meteorological Data - Modeling - Questionnaire - Direct Measurement
19	Lee (2018) (34)	Effects of climate change-related heat stress on labor productivity in South Korea	South Korea	• Heat Stress • Reduced Labor Productivity	Modeling Study	1981-2005 2001-2010 2011-2040 2041-2070 2071-2100	Meteorological Data - Modeling
20	Perkison (2018) (47)	Responsibilities of the Occupational and Environmental Medicine Provider in the Treatment	North American	• Heat-Related Consequences, Symptoms and Diseases: (death) • Solar Ultraviolet Radiation:	Analytical Cross Sectional Study	1980-2010	Meteorological Data - Questionnaire - Direct Measurement

		and Prevention of Climate Change-Related Health Problems		(Cataracts, cutaneous malignant melanoma, immune system and sunburn) • Air pollution in the Workplace: (Effects include respiratory disease exacerbation including asthma, COPD, allergic rhinitis, bronchitis, premature death, acute and chronic cardiovascular) • Extreme Weather Events Affecting Occupational Safety and Health: (the flood and its effects include drownings, injuries, skin infections, mosquito, tick and other vector borne diseases) • Vector- And Waterborne Disease: (mosquito, tick, and other vector-borne diseases, waterborne disease)			

				• Cognitive Impairment, Psychological and Behavioral Effects: (mental, behavioral health and stress disorders)			
21	Arjona (2016) (30)	Climate change and agricultural workers' health in Ecuador: occupational exposure to UV radiation and hot environments	Ecuador	• Heat Stress • Increase UV Index • Heat-Related Consequences, Symptoms and Diseases: (skin cancer, chronic kidney disease)	Analytical Cross Sectional Study	2006-2010 2014-2015	Meteorological Data
22	Altinsoy (2015) (35)	Labor productivity losses over western Turkey in the twenty-first century as a result of alteration in WBGT	Turkey	• Heat Stress • Reduced Labor Productivity	Modeling Study	1971-2000 2011-2040 2041-2070 2071-2100	Meteorological Data - Modeling
23	Kjellstrom (2014) (36)	Impact of Climate Conditions on Occupational Health and Related Economic Losses: A New Feature of Global and Urban Health in the Context of Climate Change	Different countries around the world	• Heat Stress • Reduced Labor Productivity	Modeling Study	2010 2030	Meteorological Data - Modeling
24	Sheffield (2013) (46)	Current and future heat stress in Nicaraguan work places under a changing climate	Nicaraguan	• Heat Stress	Ecological study	1980-2011 2030 2050	Meteorological Data - Measurement of the Wet Bulb Globe Temperature Index - Modeling

25	Dash (2011) (39)	Workplace heat stress in the context of rising temperature in India	India	• Heat Stress • Reductions Of Work Productivity	Modeling Study	1980-2010 2040 2070	Meteorological Data - Modeling
26	Hanna (2011) (29)	Climate change and rising heat: Population health implications for working people in Australia	Australia	• Heat Stress • Heat-Related Consequences, Symptoms and Diseases: (death, fatigue, thirst, dehydration, tiredness, visual disturbances, renal disease, compromises cardiovascular function) • Reduced Work Capacity • Increase Occupational Accidents • Cognitive Impairment, Psychological and Behavioral Effects: (mental confusion (poor decision making), increased suicide rates and other	Ecological study	1971-2000 2030 2070	Questionnaires - Interviews - Observations - Modeling

				mental health concerns)			
27	Langkulsen (2010) (32)	Health impact of climate change on occupational health and productivity in Thailand	Thailand	• Heat Stress • Loss Of Productivity • Heat-Related Consequences, Symptoms and Diseases: (cramp, exhaustion, heatstroke)	Analytical Cross Sectional Study	September and October of 2009 - 21 Individuals	Meteorological Data - Questionnaire - Wet Bulb Globe Temperature Monitor
28	Kjellstrom (2009) (41)	Workplace heat stress, health and productivity- an increasing challenge for low and middle-income countries during climate change	Different countries around the world	• Heat Stress • Reduced Work Capacity	Modeling Study	1980-2007	Meteorological Data - Modeling