

Risk Factors and Intervention Strategies of Heat Stress in Construction Workers: A Systematic Review

Nona Carolina, Oktomi Wijaya

FAhmad Dahlan University

Prof. Dr. Soepomo, S.H. Street Num. 21, Yogyakarta City, 55164, Indonesia

ABSTRACT

Introduction: One of the industries that contributes the most to deaths and work accidents during the summer is the construction industry. Heat stress among construction workers in several countries is a common health problem. Therefore, this study was conducted by the author to determine the risk factors and intervention strategies for heat stress among construction workers. **Methods:** The research method used is a Systematic Literature Review with reference to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) 2020 guidelines. A total of 2.073 articles were obtained from the Scopus and PubMed databases, and those that met the inclusion criteria were analysed using the Joanna Briggs Institute (JBI) Critical Appraisal and Mixed Methods Appraisal Tool (MMAT) to assess their quality. **Results:** A total of 13 articles were obtained and analysed qualitatively using a narrative synthesis approach. From these results, it is known that the risk factors for heat stress among construction workers include individual, economic, environmental, organisational, workload, history of chronic disease, and facility factors. Meanwhile, intervention strategies for heat stress among construction workers that can be implemented include acclimatisation, providing facilities for heat stress mitigation, work area engineering, arranging administrative support in the work environment, adjusting Personal Protective Equipment (PPE), and health promotion. **Conclusion:** The systematic review of included studies identified distinct risk factors and intervention strategies for heat stress among construction workers.

Keywords: construction workers, heat stress, intervention strategies, risk factors

Corresponding Author:

Nona Carolina

Email: nona2115029186@webmail.uad.ac.id

Telephone: +6282132139880

INTRODUCTION

Heat stress can affect workers in various industrial sectors. A study in Iran examining heat stress in the bakery industry found that it was higher in the traditional bakery industry than in the modern bakery industry using ovens, with the difference reaching 3,3% (Afshari *et al.*, 2019). A study in Indonesia examining heat stress among workers at a company found that 60% experienced moderate heat stress, while 40% experienced mild heat stress. Meanwhile, in the United States in 2016, at least 1.432 heat-stress incidents occurred in a single day, of which 6,36 occurred in the construction

industry, 5,01 in the mining industry, and 1,3 in other industries (Ramadhani *et al.*, 2023).

Another study in the United States that analysed deaths and injuries among workers stated that fatalities due to accidents in the summer were higher compared to the non-summer season (Morrissey *et al.*, 2023). Other data, according to the World Meteorological Organisation (WMO), also supports its findings in a very surprising temperature analysis, which claims 2023 was the warmest year. This is based on global surface temperature records compiled since 1850 (Lopez *et al.*, 2024).

A German study that analysed daily deaths and correlated them with average daily temperatures found that heat exposure in Germany in the summer of 2022 was responsible for 9,100 deaths. This is a much higher increase compared to the previous year, when 4.500 people died from heat exposure in Germany (Huber *et al.*, 2024). A study in Spain also stated that around 670.000 people per day are hampered in carrying out their work due to hot

Cite this as: Carolina, N., and Wijaya, O. (2025) 'Risk Factors and Intervention Strategies of Heat Stress in Construction Workers: A Systematic Review', *The Indonesian Journal of Occupational Safety and Health*, 14(3).

environmental temperatures. These findings show that high environmental temperatures can increase the risk of work accidents, worker health losses, and economic losses totalling 0,03% of Spain's Gross Domestic Product, or the equivalent of 370 million Euros (Martínez-Solanas *et al.*, 2018).

Another study in Australia explained that the natural disaster that is said to be the most dangerous in Australia is extreme heat, because this condition contributes to the death rate in Australia by 55%. Compared with other natural disasters, this figure is the highest. The results of research conducted on 1.726 workers in Australia found that this condition not only had an impact on the health and decreased performance of workers in Australia, but also resulted in a spike in economic burden reaching 0,47% of Australia's Gross Domestic Product or the equivalent of 6,2 billion US dollars (Zander *et al.*, 2015).

A study in Indonesia found that hot working conditions significantly contribute to heat stress in workers (Puspita, Kurniawidjaja and Ramdhan, 2018). Another study in the United States found that the main cause of weather-related deaths is heat stress. Heat stress can be broadly defined as the effect of environmental heat on body temperature. One measurement index that can be used is Wet Bulb Globe Temperature (WBGT) (Ennis and Milrad, 2024).

Increased risk of death in the human body is associated with higher environmental temperatures. A study reports that approximately 489,000 deaths occur each year due to heat (Kravets *et al.*, 2024). Research in Europe also states that hot weather lasting one week resulted in 11,000 deaths in 2022.

This is the highest case in Europe (Beck *et al.*, 2024).

Indonesia, as a tropical country in Asia, also experiences heat stress, which causes many residents to lose work hours. A study analysing heat stress trends in Indonesia from 1983 to 2016 found that the impact of population growth and increased urban heating led to heat exposure rising by 17.5 million people per year. So Indonesia is predicted to experience heat stress in greater numbers in the future (Kadihasanoglu, 2023).

Heat stress can occur across various industries, including construction. The International Labour Organisation (ILO) also stated that the industry most affected by heat exposure is the construction industry (Pal and Patel, 2021). Results from a study in Slovenia show that the percentage impact of heat waves in the construction industry can reach 33% (Pogačar *et al.*, 2017).

Based on this data, researchers identified risk factors and intervention strategies for heat stress among construction workers, aiming to provide solutions to cases of heat stress in the construction industry. The researcher chose the construction industry as the focus of the research because previous literature reviews indicated that heat stress cases often occur in the construction industry. It is hoped that this literature review will help minimise the number of work accidents and work-related diseases caused by heat stress in the construction industry.

METHODS

The research conducted by the author used the Systematic Literature Review method, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. PRISMA 2020 was created as a reference

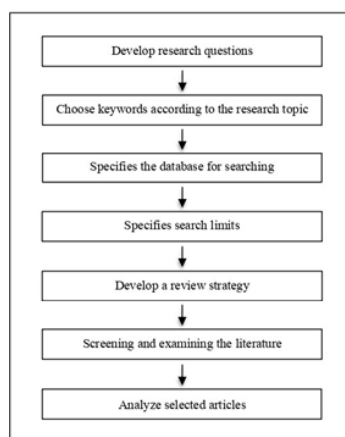


Figure 1. Seven Steps of the Research Process

Table 1. Research Questions Based on the PICO Framework

PICO Framework	Research Question
Population	Workers in the construction industry
Intervention	Risk factors and intervention strategies of heat stress in construction industry
Comparison	-
Outcome	Heat stress

for conducting systematic reviews in research that focuses on evaluating the impact of health interventions. However, PRISMA 2020 can also be used to evaluate problems in other fields. PRISMA 2020 is a development of PRISMA 2009. This development includes new reporting guidelines that describe progress in terms of ways to identify, select, assess, and synthesize studies (Page *et al.*, 2021).

This research process step is carried out systematically in seven steps, as shown in Figure 1. To answer the research questions, researchers

used the Population, Intervention, Comparison, and Outcome (PICO) framework. Researchers chose the PICO framework because it has three advantages, including focusing on the population as the problem to be solved, making it easier for researchers in the search process because it uses computerized keywords, and helping researchers in the process of identifying issues, ways to intervene, and results for conducting care for populations who have problems according to the research topic (Eriksen and Frandsen, 2018). The research questions structured

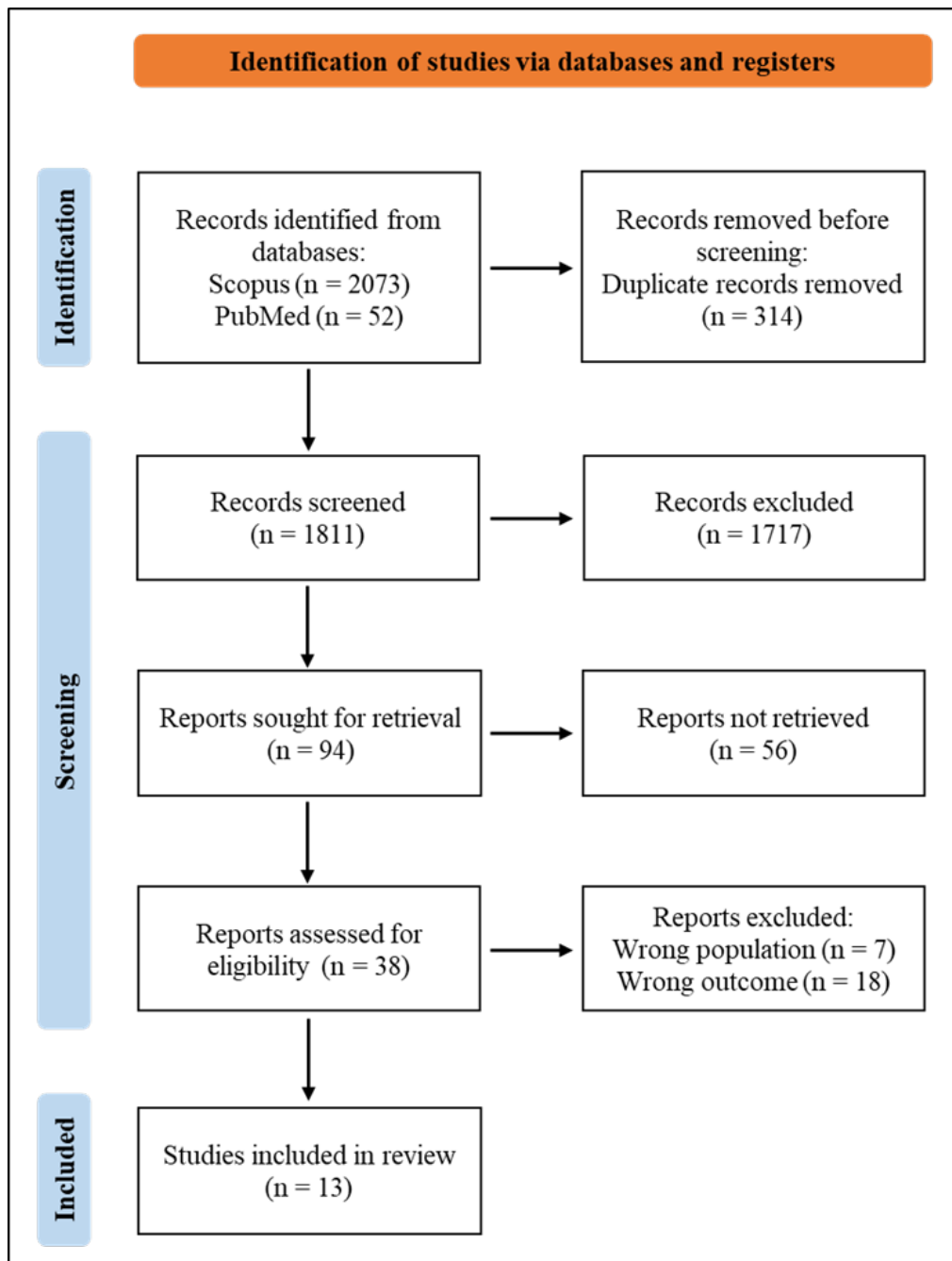


Figure 2. PRISMA Flowchart Selection of Relevant Study Article

based on the PICO framework could be seen in Table 1.

Medical terms used as keywords are searched through Medical Subject Headings (MeSH terms). Keywords are arranged and combined using Boolean Logic references, namely "OR" and "AND". The keywords for the risk factor variable are ("causes" OR "risk factors" OR "contributor" OR "associated factors") AND ("heat" OR "heat stress disorders" OR "work-related heat stress disorders") AND ("construction"). The keywords for the intervention strategies variable are ("intervention strategies" OR "management strategies") AND ("heat" OR "heat stress disorders" OR "work-related heat stress disorders") AND ("construction").

The database search sources used in this research are Scopus and PubMed. The selection of these two databases was based on the quality and scope of the articles. Scopus is one of the largest bibliographic indexes, covering a wide range of disciplines, including science, engineering, and the social sciences, and provides comprehensive citation information. PubMed, on the other hand, is a primary source for biomedical and health literature, managed by the United States (US) National Library of Medicine. PubMed is widely relied upon for research on human health, including occupational safety and health.

The author avoided publication bias by developing clear inclusion and exclusion criteria. He also conducted keyword searches and manual screening. Furthermore, he documented and reported the article selection process transparently, including the number of articles identified, screened, and included in the final review, as shown in the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) 2020 flowchart. Furthermore, he assessed the quality of articles using the Joanna Briggs Institute (JBI) Critical Appraisal and the Mixed Methods Appraisal Tool (MMAT) to avoid publication bias.

During the database search, inclusion and exclusion criteria were used to filter articles. The inclusion criteria were unpaid full-text articles published in the last 5 years (January 2020 to December 2024), in English, of the organic type, and with research subjects on workers in the construction industry. Articles that do not meet the inclusion criteria will be eliminated. Meanwhile, articles that meet the inclusion criteria will be further analyzed using the Joanna Briggs Institute (JBI) Critical

Appraisal and Mixed Methods Appraisal Tool (MMAT) to assess quality.

This systematic review uses the JBI Critical Appraisal to provide the best available evidence in a concise manner, not just randomized controlled trials. So the use of JBI Critical Appraisal can help researchers in assessing the quality of articles repeatedly and transparently against a series of research case studies included in the systematic review (Munn *et al.*, 2020). To support the completeness of the article quality assessment, researchers also use the MMAT. The use of MMAT can help researchers critically assess the quality of articles by combining quantitative and qualitative evidence. MMAT is the only tool that can be used to assess the quality of articles with mixed-method study designs and other study designs (Hong *et al.*, 2019).

High-quality articles will be used by researchers as the results of the Systematic Literature Review. The results of the study were then analyzed qualitatively using a narrative synthesis approach. The narrative approach can integrate research with storytelling, either by using storytelling as a data presentation or as a tool for data analysis/or by using storytelling as research data. The researcher chose the narrative synthesis approach to analyze the data because it is a good approach for reporting using stories as an analytical lens and for analyzing data in story form (Ghanbar *et al.*, 2024).

RESULT

The results of the flowchart for selecting relevant study articles can be seen in Figure 2. The PRISMA Flowchart is shown in Figure 2. Overall, the total number of unpaid full-text articles published in the last 5 years, from January 2020 to December 2024, and written in English, according to the Boolean Logic references, is 2.125 articles. The articles were obtained from the Scopus database (2,073 articles) and the PubMed database (52 articles). At the identification stage, the received articles are checked for duplication until 1.811 remain.

At the screening stage, articles that passed the duplication check were then checked against the title and abstract using the PICO framework, resulting in 94 articles. After re-screening, 38 articles were selected for re-search. At this stage, 25 articles did not meet the eligibility criteria. The final result of the selection of this article study is that only 13

Table 2. Result of Reviewed Articles

Reference	Title	Sample	Instrument	Main Result	
				Risk Factors	Intervention Strategies
Phanprasit <i>et al.</i> (2020)	Climate Warming and Occupational Heat and Hot Environment Standards in Thailand	n = 168	- Digital thermometer - Heat stress monitor - Testo Model 435 HVAC - IAQ meter - Questionnaire - Interview	- Work experience - Metabolic rate - Age and BMI - Peer pressure - Workload - Incentives - Working hours and continuous work - Employee non-compliance	- Regular health checks - Cold drinking water - Shaded rest areas - Work cycle arrangements - Work personnel to manage stress - Identification of heat hazards for outdoor work
Al-Bouwarthan <i>et al.</i> (2020)	Risk of Kidney Injury among Construction Workers Exposed to Heat Stress: A Longitudinal Study from Saudi Arabia	n = 65	- Questionnaire and Physical Exam - Digital scale - Sphygmomanometer - Abbott Architect c8000 instrument	- Obesity - Limited implementation of OSH - High job demands - Albuminuria - Additional working hours - Lack of sleep - Dehydration	- Healthy habits after work - Shade - Limiting or reducing daily work shifts ≤ 7 hours with 6 work shifts per week - Improving sleep quality - Health promotion - Hydration
Hansen <i>et al.</i> (2020)	Using a Qualitative Phenomenological Approach to Inform the Etiology and Prevention of Occupational Heat-Related Injuries in Australia	n = 22	- Informed consent - Interview guide	- Hot rooms in the workplace - Summer - Organizational factors in the work environment - Interpersonal factors (attitude) - Individual factors (age, fatigue, dehydration, and not acclimatized)	- Coolant clothing - Training on heat stress knowledge - Cold drinking water facilities - A cool and shady resting place - Acclimatization and breaks - Risk assessment and heat policy - First aid and PPE - Safety devices and systems - Hydration - Employer and worker awareness and support - Worker awareness of heat risks
Morris <i>et al.</i> (2021)	Health vs. wealth: Employer, employee and policy-maker perspectives on occupational heat stress across multiple European industries	Sample of qualitative is 64 and quantitative is 41	- Qualitative and quantitative questionnaire - Focus Group Discussion	-	- Heat Awareness - Extra cooling - Starting work early - Creating a cooling oasis - Allowing extra rest periods - Optimizing clothing - Keeping hydrated - Assessing risk - Paying attention to the weather - Making a work plan

Advancing Table 2. Result of Reviewed Articles

Reference	Title	Sample	Instrument	Main Result	
				Risk Factors	Intervention Strategies
Kakamu <i>et al.</i> (2021)	Heat related illness risk and associated personal and environmental factors of construction workers during work in summer	n = 61	• LW-360HR • C-BB-15 cm • HMP60 Humidity • Temperature Probe	• Fatigue and workload • Work on site • Young age and heart rate • Career duration and machinery • Skin temperature • Sun exposure • Daily work and work on high • Simple accommodation	• Water intake • Allocate rest time • Rest areas • Education for workers • Physiological monitoring sensors • Break schedules • Adjustment of work schedules and loads • Monitoring of heat and worker conditions
Ioannou <i>et al.</i> (2021)	Occupational Heat Stress: Multi-Country Observations and Interventions	n = 238	• Experimental protocol • Business as Usual (BAU) scenario • Refractometer	• Clothing • Work intensity settings	• Work-rest cycle • Using salt supplementation • Shaved ice and cold water • 2x breaks • Heat stress education • Rest area with AC • Water stations • Shaded area • Evaporative and ventilated clothing • Mechanization • Hydration • Work speed regulation
Lohrey <i>et al.</i> (2021)	Perceptions of heat-health impacts and the effects of knowledge and preventive actions by outdoor workers in Hanoi, Vietnam	n = 1.027	• KoBo Toolbox • Focus Group Discussion • In-Depth Interviews	• Working in the sun • Labor-intensive work • Poverty	• Cooled buses • Heat health information • Water, cold tea, and clean towels • Watering the roof and sleeping on wet sheets at night • Adapting to temperatures • Rest during extreme heat exposure • Ice slurry • Acclimatization and behavioral adaptations • Aerobic • Education and heat mitigation strategies • Weather forecasts and early warnings • Water intake • Longer breaks • Rescheduling outdoor activities • Cooler areas

Advancing Table 2. Result of Reviewed Articles

Reference	Title	Sample	Instrument	Main Result	
				Risk Factors	Intervention Strategies
Kakamu <i>et al.</i> (2022)	Heart rate increase from rest as an early sign of heat-related illness risk in construction workers	n = 79	• Youden's index • pROC package	• Environment and workload • Temperature • Intra-individual factors • Inter-individual factors • Metabolic heat • Clothing	• Physiological, objective, heat, and worker conditions monitoring • Task rotation • Adjustment of schedules, workloads, and rest periods
Flunker <i>et al.</i> (2022)	Potential Impacts of Different Occupational Outdoor Heat Exposure Thresholds among Washington State Crop and Construction Workers and Implications for Other Jurisdictions	-	• National Weather Service • AgWeatherNet (AWN) • Parameter-elevation Relationships on Independent Slopes Model (PRISM) data	• Workload • Solar radiation • Cumulative heat exposure • Summer • Workers not fully acclimatized • Inappropriate clothing • Total working days	• Cooling during breaks • Reduced work speed and shift work practices • Best practices for heat stress management • Time regulation of heat regimes according to the environment • Protection and adaptation to heat regimes • Acclimatization • Administrative and technical control • Hydration
Bonafede <i>et al.</i> (2022)	Workers' Perception Heat Stress: Results from a Pilot Study Conducted in Italy during the COVID-19 Pandemic in 2020	n = 345	Cronbach's Alpha calculation	• Chronic diseases and dehydration • Use of COVID-19 masks and chemicals • Physical activity • OSH education and knowledge level • Heat waves • Collective exposure • Personal exposure and fear of risk • Age > 35 years • Lack of training about heat stress • Hot surfaces • Steam and fire • Working indoors without adequate ventilation and cooling equipment • Working outdoors without access to a shaded area • Solar radiation • Use of PPE	• Develop heat health warning systems • Improve training • Improve prevention strategies • Heat wave warnings • Increase worker knowledge base and awareness of the impacts of heat stress
Santurtún <i>et al.</i> (2023)	Descriptive analysis of occupational accidents in Spain and their relationship with heatwaves	-	Generalized Cross-Validation (GCV) Criterion	• Heat exposure • PPE used • High radiation • Environmental heat • Task completion • Metabolic heat	Prohibition of carrying out certain work at certain hours during the day when bad weather events occur

Advancing Table 2. Result of Reviewed Articles

Reference	Title	Sample	Instrument	Main Result	
				Risk Factors	Intervention Strategies
Fatima <i>et al.</i> (2023)	Impacts of hot climatic conditions on work, health, and safety in Australia: A case study of policies in practice in the construction industry	-	• Framework analysis approach • Working in heat provided by Safe Work Australia (SWA) guide	• Water intake • Alcohol and drug use • Socioeconomic status • Age, weight, and obesity • Lack of acclimatization • Medical conditions • PPE • Physical work • Hot equipment • Confined spaces • Outdoor work • Project life cycle • Nature of work • Geographic location • Heat waves • Rising global temperatures	• Hydration and acclimatization • Administrative controls and preparedness • Heat warnings and emergency response plan • Periodic checks • Regulation of work pace and rest • Planning and preparation for hot weather • Heat stress management (incident response, review and evaluation of control measures, promotion of awareness and training programs among workers, hazard risk assessment, and worker consultation) • Use of PPE
Idris <i>et al.</i> (2024)	Examining Management and Employees' Perceptions of Occupational Heat Exposure and the Effectiveness of a Heat Stress Prevention Intervention on Safety and Well-Being among Natural Gas Construction Workers: A Qualitative Field-Based Study	n = 21	• Six focus groups • Two in-dept semi-structured key informant interviews • Study protocol • Focus group guide • Focus group and interview guide main questions	-	• Reduced working hours and heat conditions • Healthy lifestyle • Shaded area • Finishing work early • Heat stress prevention programs • Plans to prevent heat stress • Services and resources for heat stress mitigation • Written program policies • Improving overall worker health and well-being • Adjusting working hours using shifts

articles are included and can be studied and analyzed qualitatively using a narrative synthesis approach, as shown in Table 2.

DISCUSSION

Risk Factors of Heat Stress

Heat stress among construction workers can be triggered by several risk factors, including individual factors. Research (Phanprasit *et al.*, 2020) states that work experience and research (Kakamu *et al.*, 2021) state that career duration among workers in the

construction industry is a risk factor for heat stress. Research (Phanprasit *et al.*, 2020; Kakamu *et al.*, 2022; Santurtún *et al.*, 2023) indicates that metabolic rate is a risk factor for heat stress. Research (Phanprasit *et al.*, 2020; Fatima *et al.*, 2023) states that Body Mass Index (BMI) is a risk factor for heat stress. Research (Phanprasit *et al.*, 2020) (Hansen *et al.*, 2020) (Fatima *et al.*, 2023) states age, research (Kakamu *et al.*, 2021) states young age, and research (Bonafede *et al.*, 2022) states age > 35 years as a risk factor for heat stress.

In addition, many other individual factors contribute to heat stress among construction workers. Research (Phanprasit *et al.*, 2020) indicates that

workers' noncompliance with Occupational Safety and Health (OSH) standards is a risk factor for heat stress. Research (Al-Bouwarthan *et al.*, 2020; Fatima *et al.*, 2023) states that obesity is a risk factor for heat stress. Research (Al-Bouwarthan *et al.*, 2020) states that lack of sleep is a risk factor for heat stress. Research (Al-Bouwarthan *et al.*, 2020; Hansen *et al.*, 2020; Bonafede *et al.*, 2022) (Fatima *et al.*, 2023) states that dehydration or lack of water intake is a risk factor for heat stress. Research (Hansen *et al.*, 2020) states that interpersonal or attitudinal factors are risk factors for heat stress.

Researchers continue to identify additional individual factors that contribute to heat stress risk among construction workers. Research (Hansen *et al.*, 2020; Kakamu *et al.*, 2021) states that fatigue is a risk factor for heat stress. Research (Hansen *et al.*, 2020; Flunker *et al.*, 2022) indicates that unacclimatized workers are at increased risk of heat stress. Research (Kakamu *et al.*, 2021) states that heart rate and maximum skin temperature are risk factors for heat stress. Research (Kakamu *et al.*, 2022) states that intra- and inter-individual factors are risk factors for heat stress. Research (Bonafede *et al.*, 2022) states that physical activity, education level, and knowledge, lack of training regarding heat stress, personal exposure, and fear of risk are risk factors for heat stress. Research (Fatima *et al.*, 2023) states that the use of alcohol and illegal drugs is a risk factor for heat stress.

Another risk factor for heat stress in construction workers is economic factors. Research (Phanprasit *et al.*, 2020) states that incentives received by construction workers are a risk factor for heat stress. In addition, research by Lohrey *et al.* (2021) indicates that poverty is a risk factor for heat stress. Another study conducted by Fatima *et al.* (2023) states that the socioeconomic status of construction workers is also a risk factor for heat stress. Construction workers often work harder to earn wages that meet their needs, which increases the risk of heat stress.

Environmental factors in the workplace, as mentioned in the study (Kakamu *et al.*, 2022), are also risk factors for heat stress in construction workers. Research (Hansen *et al.*, 2020) states that hot rooms in the workplace and research (Bonafede *et al.*, 2022) state that hot surfaces near workers or workplaces close to steam and fire are risk factors for heat stress. Research (Hansen *et al.*, 2020; Flunker *et al.*, 2022) states that summer is a risk factor for heat stress. Research (Kakamu *et al.*, 2021) and

research on confined spaces (Fatima *et al.*, 2023) state that confined spaces are a risk factor for heat stress. Research (Kakamu *et al.*, 2021) states that exposure to sunlight and research (Lohrey *et al.*, 2021) (Bonafede *et al.*, 2022) state that working in the sun without a shaded area is a risk factor for heat stress. Research (Kakamu *et al.*, 2021) indicates that daily work and working at high altitudes are risk factors for heat stress. Research (Bonafede *et al.*, 2022; Fatima *et al.*, 2023) states that heat waves are a risk factor for heat stress. Research (Santurtún *et al.*, 2023) states that heat exposure is a risk factor for heat stress.

In addition, many other environmental factors can trigger heat stress in construction workers. Research (Kakamu *et al.*, 2022) (Fatima *et al.*, 2023) states that increasing global temperatures and research (Santurtún *et al.*, 2023) state that environmental heat is a risk factor for heat stress. Research (Flunker *et al.*, 2022; Bonafede *et al.*, 2022; Santurtún *et al.*, 2023) states that radiation and heat exposure are risk factors for heat stress. Research (Bonafede *et al.*, 2022) states that the use of chemicals and working indoors without ventilation or cooling equipment are risk factors for heat stress. Research (Fatima *et al.*, 2023) indicates that outdoor work and the workplace's geographic location are also risk factors for heat stress.

In line with research (Ismail *et al.*, 2020), one risk factor for heat stress is direct, constant exposure to sunlight. Other sources also explain that heat stress is caused by several external factors that affect the body's ability to respond sufficiently to accumulated heat. Stress is caused by heat in the workplace, exposure at work, and a combination of external factors, including metabolic and environmental heat. This makes it difficult for the body to stabilize normal temperature (Cheveldayoff *et al.*, 2023).

Organizational factors in the workplace, as mentioned in the study (Hansen *et al.*, 2020), are also risk factors for heat stress in construction workers. Research (Phanprasit *et al.*, 2020) states that peer pressure is a risk factor for heat stress. Research (Al-Bouwarthan *et al.*, 2020) states that the limited implementation of Occupational Safety and Health (OSH) in work organizations is a risk factor for heat stress. Research (Fatima *et al.*, 2023) states that the project life cycle stage is also a risk factor for heat stress.

Workload factors, as mentioned in the studies (Phanprasit *et al.*, 2020), (Kakamu *et al.*, 2021),

(Kakamu *et al.*, 2022), (Flunker *et al.*, 2022), are also risk factors for heat stress in construction workers. Research (Phanprasit *et al.*, 2020; Flunker *et al.*, 2022) states that working hours are a risk factor for heat stress. Research (Phanprasit *et al.*, 2020) indicates that continuous work is a risk factor for heat stress. Research conducted by Al-Bouwarthan *et al.* (2020) states that high job demands and additional working hours are risk factors for heat stress. Research (Ioannou *et al.*, 2021) states that work intensity settings are a risk factor for heat stress.

Workload factors that are risk factors for heat stress in construction workers are also reported in the literature (Lohrey *et al.*, 2021), such as labor-intensive work. Research (Santurtún *et al.*, 2023) indicates that how workers complete tasks is also a risk factor for heat stress. Research (Fatima *et al.*, 2023) states that physical work and the nature of the work done are risk factors for heat stress.

The history of disease factors, as explained in the study (Bonafede *et al.*, 2022), is also a risk factor for heat stress in construction workers. The study by Al-Bouwarthan *et al.* (2020) found that albuminuria is a risk factor for heat stress. In addition, research by Fatima *et al.* (2023) found that medical conditions among workers are a risk factor for heat stress.

Other risk factors for heat stress in construction workers are facility factors. Research (Kakamu *et al.*, 2021) indicates that simple accommodations and workplace machines are risk factors for heat stress. Research (Ioannou *et al.*, 2021) (Kakamu *et al.*, 2022) (Flunker *et al.*, 2022) states that clothing and research (Bonafede *et al.*, 2022) (Santurtún *et al.*, 2023) (Fatima *et al.*, 2023) state that Personal Protective Equipment (PPE) is a risk factor for heat stress. Research (Bonafede *et al.*, 2022) states that the use of COVID-19 masks is also a risk factor for heat stress. Meanwhile, research (Fatima *et al.*, 2023) states that hot equipment used by workers is a risk factor for heat stress.

Intervention Strategies of Heat Stress

A study in the United Arab Emirates (UAE) recommends several methods to control heat stress among construction industry workers. These methods include adjusting body condition to the work climate, or acclimatization, meaning that workers are prohibited from working and are not advised to work alone if their body condition cannot adapt to the work climate. Apart from that, other recommended methods are increasing the amount

of ventilation, adapting environmental conditions to the speed of work, providing a shady and cool place for workers to use during breaks, and scheduling later (after sunset) or earlier (before the sun shines hotter at noon) (Ahmed *et al.*, 2020). A study in Arizona found that, to reduce heat stress, workers in the construction industry and other industries can use cooling vests (Cordova, Lazaro, and Momayez, 2021).

One practical measure the construction industry can take to prevent heat stress among workers is acclimatization. Furthermore, providing facilities for heat-stress mitigation and engineering the workplace are necessary to prevent heat stress. Importantly, administrative arrangements within the work environment, such as work shifts and rest schedules, as well as adjustments to the Personal Protective Equipment worn by workers, are also crucial. Health promotion in the construction industry can be implemented to increase workers' knowledge and awareness regarding heat stress.

CONCLUSION

The final results yielded 13 articles, which were analyzed qualitatively using a narrative synthesis approach. From these results, it is known that the risk factors for heat stress among construction workers include individual, economic, environmental, organizational, workload, history of chronic disease, and facility factors. Meanwhile, intervention strategies for heat stress among construction workers that can be implemented include regulating and adjusting body temperature to the environment (acclimatization), providing facilities for heat stress mitigation, implementing work area engineering, arranging administration in the work environment, adjusting Personal Protective Equipment, and improving health.

If the prevalence of heat stress can be reduced, the likelihood of construction workers experiencing heat strain and heat-related illness will also decrease. Therefore, managing and preventing heat stress in the construction industry is crucial. This will reduce the high number of accidents and deaths caused by heat stress or extreme weather worldwide. This will ensure the safety, health, and well-being of workers in the construction industry and ensure their effective implementation through various proposed programs.

This study has limitations: the researcher's review spanned only 5 years, from 2020 to 2024.

In addition, another limitation of this study is that it used only 2 databases: Scopus and PubMed. Therefore, the author's suggestion for continuing this research is to develop a research strategy and expand the search for articles. Further research can increase the time span of the articles to be reviewed. In addition, further research can add to the article search database, thereby improving the results of the systematic study conducted.

ACKNOWLEDGEMENTS

The author would like to thank all parties who have prayed for the author and supported the author, both directly and indirectly, especially the parents and lecturers who have provided the author with much knowledge. Alhamdulillah, after a long journey, this research has been completed successfully. Hopefully, this research will be useful and serve as a reference for further research. May Allah always bless what has been done. Aamiin allahumma aamiin.

AUTHOR CONTRIBUTION

NC contributed fully to conducting this research starting from collecting articles from Scopus and PubMed databases, reviewing articles using the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) 2020 guidelines, assessing the quality of articles using Joanna Briggs Institute (JBI) Critical Appraisal and Mixed Methods Appraisal Tool (MMAT), analyzing and synthesizing the reviewed articles, to reporting this research as a whole. Meanwhile, OW contributed ideas, direction, suggestions, and constructive input throughout the research process. So that both researchers work together to refine this research until it is worthy of publication and read by the general public.

REFERENCES

- Afshari, D. *et al.* (2019) 'Estimation of Heat Stress and Maximum Acceptable Work Time Based on Physiological and Environmental Response in Hot-Dry Climate: A Case Study in Traditional Bakers', *International Journal of Occupational and Environmental Medicine*, 10(4), pp. 194–202. doi: 10.15171/ijoem.2019.1582.
- Ahmed, H. O. *et al.* (2020) 'Assessment of thermal exposure level among construction workers in UAE using WBGT, HSI and TWL indices', *Industrial Health*, 58(2), pp. 170–181. doi: 10.2486/indhealth.2018-0259.
- Al-Bouwarthan, M. *et al.* (2020) 'Risk of Kidney Injury among Construction Workers Exposed to Heat Stress: A Longitudinal Study from Saudi Arabia', *International Journal of Environmental Research and Public Health*, 17(11), pp. 1–16. doi: 10.3390/ijerph17113775.
- Beck, T. *et al.* (2024) 'Increasing likelihood of heat-related mortality events with global warming: a continental epidemiological extreme event attribution study', *Research Square*, pp. 1–27. doi: <https://doi.org/10.21203/rs.3.rs-5549732/v1>.
- Bonafede, M. *et al.* (2022) 'Workers' Perception Heat Stress: Results from a Pilot Study Conducted in Italy during the COVID-19 Pandemic in 2020', *International Journal of Environmental Research and Public Health*, 19(13), pp. 1–18. doi: 10.3390/ijerph19138196.
- Cheveldayoff, P. *et al.* (2023) 'Considerations for occupational heat exposure: A scoping review', *PLOS Climate*, 2(9), pp. 1–21. doi: 10.1371/journal.pclm.0000202.
- Cordova, V., Lazaro, P. and Momayez, M. (2021) The effects and perceptual responses of cooling technologies monitored during mining activity. University of Arizona.
- Ennis, K. E. and Milrad, S. M. (2024) 'Man, it's a hot one: Trends and extremes in Florida autumn heat stress', *International Journal of Climatology*, 44(5), pp. 1–35. doi: 10.1002/joc.8415.
- Eriksen, M. B. and Frandsen, T. F. (2018) 'The impact of patient, intervention, comparison, outcome (PICO) as a search strategy tool on literature search quality: a systematic review', *Journal of the Medical Library Association*, 106(4), pp. 420–431. doi: 10.5195/jmla.2018.345.
- Fatima, S. H. *et al.* (2023) 'Impacts of hot climatic conditions on work, health, and safety in Australia: A case study of policies in practice in the construction industry', *Safety Science*, 165(1), pp. 1–9. doi: 10.1016/j.ssci.2023.106197.
- Flunker, J. C. *et al.* (2022) 'Potential Impacts of Different Occupational Outdoor Heat Exposure Thresholds among Washington State Crop and Construction Workers and Implications for Other Jurisdictions', *International Journal of Environmental Research and Public Health*, 19(18), pp. 1–24. doi: 10.3390/ijerph191811583.
- Ghanbar, H. *et al.* (2024) 'A methodological synthesis of narrative inquiry research in applied linguistics: What's the story?', *International Journal of*

- Applied Linguistics (United Kingdom)*, 34(1), pp. 1629–1655. doi: 10.1111/ijal.12591.
- Hansen, A. L. *et al.* (2020) ‘Using a Qualitative Phenomenological Approach to Inform the Etiology and Prevention of Occupational Heat-Related Injuries in Australia’, *International Journal of Environmental Research and Public Health*, 17(3), pp. 1–16. doi: 10.3390/ijerph17030846.
- Hong, Q. N. *et al.* (2019) ‘Improving the content validity of the mixed methods appraisal tool: a modified e-Delphi study’, *Journal of Clinical Epidemiology*, 111(20), pp. 49–59. doi: 10.1016/j.jclinepi.2019.03.008.
- Huber, V. *et al.* (2024) ‘Heat-Related Mortality in the Extreme Summer of 2022’, *Deutsches Arzteblatt International*, 121(3), pp. 79–85. doi: 10.3238/arztebl.m2023.0254.
- Idris, M. A. *et al.* (2024) ‘Examining Management and Employees’ Perceptions of Occupational Heat Exposure and the Effectiveness of a Heat Stress Prevention Intervention on Safety and Well-Being among Natural Gas Construction Workers: A Qualitative Field-Based Study’, *International Journal of Environmental Research and Public Health*, 21(9), pp. 1–17. doi: 10.3390/ijerph21091255.
- Ioannou, L. G. *et al.* (2021) ‘Occupational Heat Stress: Multi-Country Observations and Interventions’, *International Journal of Environmental Research and Public Health*, 18(12), pp. 1–21. doi: 10.3390/ijerph18126303.
- Ismail, A. R. *et al.* (2020) ‘The factor affecting heat stress in industrial workers exposed to extreme heat: A case study of methodology’, *Journal of Physics*, 1630(012001), pp. 1–12. doi: 10.1088/1742-6596/1630/1/012001.
- Kadihasanoglu, A. (2023) ‘Urban heat stress in Indonesia’. *America: Global Disaster Preparedness Center*, pp. 1–10.
- Kakamu, T. *et al.* (2021) ‘Heat-related illness risk and associated personal and environmental factors of construction workers during work in summer’, *Nature Resesarch*, 11(1), pp. 1–6. doi: 10.1038/s41598-020-79876-w.
- Kakamu, T. *et al.* (2022) ‘Heart rate increase from rest as an early sign of heat-related illness risk in construction workers’, *International Journal of Industrial Ergonomics*, 89(1), pp. 1–5. doi: 10.1016/j.ergon.2022.103282.
- Kravets, O. V. *et al.* (2024) ‘Trigger factors of general body overheating (scientific review)’, *Emergency Medicine (Ukraine)*, 20(8), pp. 702–710. doi: 10.22141/2224-0586.20.8.2024.1805.
- Lohrey, S. *et al.* (2021) ‘Perceptions of heat-health impacts and the effects of knowledge and preventive actions by outdoor workers in Hanoi, Vietnam’, *Science of the Total Environment*, 794(1), pp. 1–10. doi: 10.1016/j.scitotenv.2021.148260.
- Lopez, H. *et al.* (2024) ‘The longest-lasting 2023 western North American heat wave was fueled by the record-warm Atlantic Ocean’, *Research Square*, pp. 1–30. doi: <https://doi.org/10.21203/rs.3.rs-5522259/v1>.
- Martínez-Solanas, È. *et al.* (2018) ‘Evaluation of the Impact of Ambient Temperatures on Occupational Injuries in Spain’, *Environmental Health Perspectives*, 126(6), pp. 1–10. doi: 10.1289/EHP2590.
- Morris, N. B. *et al.* (2021) ‘Health vs. wealth: Employer, employee and policy-maker perspectives on occupational heat stress across multiple European industries’, *Temperature*, 8(3), pp. 284–301. doi: 10.1080/23328940.2020.1852049.
- Morrissey, M. C. *et al.* (2023) ‘Analysis of Exertion-Related Injuries and Fatalities in Laborers in the United States’, *International Journal of Environmental Research and Public Health*, 20(3), pp. 1–14. doi: 10.3390/ijerph20032683.
- Munn, Z. *et al.* (2020) ‘Methodological quality of case series studies: an introduction to the JBI critical appraisal tool’, *JBI Evidence Synthesis*, 18(10), pp. 2127–2133. doi: 10.11124/JBISRIR-D-19-00099.
- Page, M. J. *et al.* (2021) ‘The PRISMA 2020 statement: an updated guideline for reporting systematic reviews’, *Medicina Fluminensis*, 57(4), pp. 1–11. doi: 10.21860/medflum2021_264903.
- Pal, G. and Patel, T. (2021) ‘Heat Stress’s Impact on Agricultural Worker’s Health, Productivity, and its Effective Prevention Measures: A Review and Meta- Analysis’, *International Journal of Agriculture System*, 9(2), pp. 51–79. doi: 10.20956/ijas.v9i2.3283.
- Phanprasit, W. *et al.* (2020) ‘Climate Warming and Occupational Heat and Hot Environment Standards in Thailand’, *Safety and Health at Work*, 12(1), pp. 119–126. doi: 10.1016/j.shaw.2020.09.008.
- Pogačar, T. *et al.* (2017) ‘Comprehension of climatic and occupational heat stress amongst agricultural advisers and workers in Slovenia’,

- Acta Agriculturae Slovenica*, 109(3), pp. 545–554. doi: 10.14720/aas.2017.109.3.06.
- Puspita, N., Kurniawidjaja, M. and Ramdhan, D. H. (2018) 'Health Effect Symptoms Due to Heat Stress Among Gong Factory Workers in Bogor, Indonesia', *KnE Life Sciences*, 4(4), pp. 469–475. doi: 10.18502/cls.v4i4.2308.
- Ramadhani, A. *et al.* (2023) 'Faktor-Faktor yang Berhubungan dengan Heat Stress pada Pekerja di PT. X Kota Cilegon Tahun 2023', *Health Publica Jurnal Kesehatan Masyarakat*, 4(2), pp. 73–80.
- Santurtún, A. *et al.* (2023) 'Descriptive analysis of occupational accidents in Spain and their relationship with heatwaves', *Preventive Medicine*, 175(1), pp. 1–9. doi: 10.1016/j.ypmed.2023.107697.
- Zander, K. K. *et al.* (2015) 'Heat stress causes substantial labour productivity loss in Australia', *Nature Climate Change*, 5(7), pp. 647–651. doi: 10.1038/nclimate2623.