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Impacts of hot climatic conditions on work, health, and safety in Australia: A case study of policies in practice in the construction industry

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ABSTRACT

Workers in many industries are frequently exposed to hot weather conditions. To protect workers' health and safety, it is important to evaluate the existing heat-related policies practiced in workplaces in accordance with national guidelines. We used a case study design to evaluate the existing heat-related policies of a large construction company and five of its subcontractors according to the guidelines provided by safe work Australia (SWA). We used snowball sampling to acquire documents from the companies. The retrieved documents were analysed thematically using the framework approach. The main guidance themes and categories were developed deductively based on *"the guide for working in heat"* provided by SWA. The data was interpreted and summarized. Our results suggest that all policies advised on some administrative control measures, safe work practices for workers, use of personal protective equipment, and emergency response plans. The majority of policies focus on administrative control measures, which may not be practicable at all times and are not a high level of health and safety control if implemented alone. The policies do not comprehensively cover some most important aspects of heat stress management such as consultation with workers, risk assessment of heat hazard, promoting training and awareness programs among workers, and reviewing and evaluating control measures and heat stress incidents. Priorities for heat-related policy development include an increased emphasis on preparation and planning for hot weather in consultation with workers, along with considering location-specific, workplace, and individual risk factors in assessing the heat hazard at the workplace.

1. Introduction

In Australia, workers in many outdoor industries are frequently exposed to hot ambient conditions, as most parts of the country experience hot summers and frequent heatwaves that can last for a week or longer (Coates et al., 2014). Exposure to hot temperatures leads to a reduction in physical capacity, impaired mental alertness, and altered behaviour among workers (Varghese et al., 2018; Fatima et al., 2021; Parsons, 2014), which compromises work, health, and safety (WHS), labour productivity, and economic yield in occupational settings (Kjellstrom et al., 2009, Zander et al., 2015). Australian studies focusing on heat-related health impacts have found a significant association between the rate of occupational injury claims and higher ambient temperatures and heatwaves (Fatima et al., 2022; Mcinnes et al., 2017a; Varghese et al., 2019; Xiang et al., 2015a). For example; Xiang et al., found that the risk of occupational heat illnesses increased by 12.7% with each one-degree increase in maximum temperature above 35.5 °C (Xiang et al., 2015a). The risk of all occupational injuries and illnesses was estimated to increase by 16% above 32.3 °C in Adelaide (Fatima et al., 2022), and 14% at 38.9 °C in Melbourne (Varghese et al., 2019). Loss of productivity is also a major consequence of heat stress. In the 2013–2014 financial year, productivity loss in Australia due to climate-related heat stress was estimated at 6 billion dollars (0.33 to 0.47% of GDP) (Zander et al., 2015). In 2019, Australians working outdoors in the construction industry lost over 67,500 potential work hours due to heat stress, which was more than double the 1991–2000 average of 25,240 h (Beggs et al., 2021).

Increasing global temperatures and frequent, longer, and more intense heatwaves (Trancoso et al., 2020) will further jeopardize WHS, especially in high-risk outdoor industries (Humphrys et al., 2020; Levy and Roelofs, 2019; Moda et al., 2019). Other factors such as the aging workforce and increasing obesity may also contribute to the future burden of heat strain (Kenny et al., 2010; Mcinnes et al., 2017b). Without adequate interventions, climate change will exacerbate the

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burden of heat-related occupational injuries and illnesses, loss of productivity, and economic losses in vulnerable industries (Moda et al., 2019).

1.1. Heat risk in the construction industry

Among vulnerable working populations, those employed in the construction industry are the most susceptible to heat impacts because of the dynamic and informal nature of the industry (Rowlinson et al., 2014). Safe Work Australia (SWA), the Australian national WHS regulator has identified the construction industry as a national priority to reduce the number and rate of fatalities and serious claims in the *Australian Work Health and Safety Strategy 2023–2033* (Safe Work Australia, 2023). Exposure to heat in the construction industry varies greatly with the geographic location, nature of work, and stage of the project life-cycle (Rowlinson et al., 2014). For example, construction work is often performed outdoors with direct sunlight exposure on roofs and roadways, during the hottest times of the year (Acharya et al., 2018) or indoors in non-climate-controlled spaces, such as attics and crawlspaces. Other construction jobs may expose workers to process-generated heat, for example from welding and cutting torches or hot asphalt and paving machines, etc. (Echt et al., 2020). In addition to hot temperatures, high humidity, and low air movement may limit the body's heat loss (Hanna et al., 2011). Construction work also involves heavy physical labour work and the use of personal protective equipment (PPE). The most commonly used PPE in construction industries such as safety helmets, reflective vests, and hard boots, often increase workers' heat strain (Rowlinson et al., 2014). A study found that when the environmental temperature was 32.2 °C, the air temperature inside the workers' helmets was 43.7 °C (Jia et al., 2016). In these circumstances, workers will naturally get rid of PPE from time to time to reduce thermal discomfort but will be exposed to other workplace hazards as a result (Rowlinson et al., 2014). Furthermore, personal risk factors such as underlying medical conditions, lack of acclimatization, age, body weight, socio-economic status, use of alcohol and recreational drugs, and restricted fluid intake may also increase heat risk (Cramer & Jay, 2016; Nerbass et al., 2017; Taylor & Cotter, 2006).

1.2. Heat risk management in the construction industry

Previous studies have reviewed the methods of heat risk management in construction industries (Edirisinghe & Andamon, 2019; Rowlinson et al., 2014). Various heat indices have been suggested for environmental heat identification, including air temperature, heat index, Wet Bulb Globe Temperature (WBGT), physiological strain index, perceptual heat strain, thermal work limit, etc (American Conference of Governmental Industrial Hygienists, 2017; Al-Bouwarthan et al., 2019; Bates & Miller, 2002; Chan et al., 2013; Miller & Bates, 2007; Occupational Safety and Health Administration, 2017; Parsons, 2006; Australian Institute of Occupational Hygienists, 2013). However, there is little consensus on which index best fits the observed injuries and illnesses data in selected conditions and locations (Epstein & Moran, 2006; Goldie et al., 2017; Edirisinghe & Andamon, 2019). The American Conference of Governmental Industrial Hygienists (ACGIH) provides international guidelines for heat risk management at workplaces. ACGIH specifies the thresholds for heat stress based on a combination of environmental heat (measured as WBGT) and metabolic heat (i.e. workload) (American Conference of Governmental Industrial Hygienists, 2017). Workers with predisposing personal risk factors, or are unacclimatized or those who wear PPE have lowered exposure limits (American Conference of Governmental Industrial Hygienists, 2017).

Based on these indices, various strategies are recommended for workplace heat risk management globally, including engineering and administrative controls (Edirisinghe & Andamon, 2019). Some of the most effective strategies as suggested by previous research include mandatory work-rest arrangements and self-pacing, increased fluid intake, enhancing heat tolerance (acclimatization), ensuring regular screening of workers, setting up heat alerts, and supervision and training (Edirisinghe & Andamon, 2019; Morrissey et al., 2021; Morris et al., 2021; Rowlinson et al., 2014).

A few countries have also proposed heat-related labour protection guidelines. For example, SWA has developed its guidelines for managing the risk of working in heat, and the US National Institute for Occupational Safety and Health (NIOSH) has also developed heat standards for managing occupational heat stress and provides recommendations for employers on how to prevent heat-related illness (Safe Work Australia, 2020a, National Institute for Occupational Safety and Health, 2016). Similarly, the Chinese government also issued the first national regulation "Administrative Measures for Heatstroke Prevention and Cooling" (AMHP 2012) on the prevention of heatstroke in outdoor and indoor labourers in 2012 (Zhao et al., 2016). According to this policy outdoor work activities will halt when the temperature exceeds 40 °C (Han et al., 2021). Furthermore, some hot weather policies have been implemented in the construction industry. For example, the Enterprise Bargaining Agreement (EBA) of the Australian Construction, Forestry, Mining, and Energy Union (also known as CFMEU) states that workers will stop work and leave the site at 35 °C (Construction, Forestry, Mining, and Energy Union, 2016).

1.3. Overview of Australia's current WHS legislation and protection of workers from heat exposure

The Australian WHS legislation framework consists of legislated acts that set out health and safety principles in occupational settings, supported by WHS regulations that prescribe mandatory requirements. Codes of practice further explain the practical measures required for compliance with laws (Safe Work Australia, 2022a; Mcinnes et al., 2017b). Approved codes of practice are not mandatory but can be used in a court of law as evidence for reasonable workplace practices. For WHS acts, regulations, and codes of practice to have effect in jurisdictions they must be implemented in that jurisdiction. Australian standards, New Zealand standards, International standards, and other industry standards guide many workplace activities, processes, and procedures relating to health and safety issues (Mining and Quarrying Occupational Health and Safety Committee, 2017). Standards are not mandatory, however, if there is a law that refers to a specific standard for the performance of particular activities in the industry then the duty holder must conform to those standards (Safe Work Australia, 2020b). Other types of non-mandatory guidance materials and resources are also available to assist with the management of hazards in workplaces (Mining and Quarrying Occupational Health and Safety Committee, 2017). SWA is the national WHS regulator, responsible for the development and evaluation of the model WHS legislation to achieve nationwide consistent WHS laws in Australia. The Commonwealth, States, and Territories are responsible for implementing, regulating, and enforcing WHS legislation in their jurisdictions. Model WHS legislation has been implemented by the Commonwealth government and all Australian states and territories except Victoria, which has its legislation in practice (Safe Work Australia, 2022a).

Australian WHS laws require *"the working environment to be safe and without risks to health and safety of workers, so far as is reasonably practicable"* (Safe Work Australia, 2022b). This applies to health and safety risks, including occupational injuries and illnesses arising from working in non-optimum temperatures. Model WHS regulations given by SWA also specified "working in extreme heat or cold" as a workplace hazard. Thirteen out of twenty-six model codes of practice given by SWA identified heat as a potential hazard in workplaces, however, none of these specifically addressed the management of risks associated with working in the heat.

SWA has developed detailed guidelines for managing the risk of working in heat, which is based on the risk management framework for managing WHS risks (Safe Work Australia, 2018; Safe Work Australia, 2020a). All Australian state and territory regulators also provide detailed guidelines and resources regarding the hazard of working in heat on their websites (Northern Territory WorkSafe, 2022; SafeWork South Australia, 2023; WorkCover New South Wales, 2023; Workplace health and safety Queensland, 2018; WorkSafe Australian Capital Authority, 2023; WorkSafe Tasmania, 2012; WorkSafe Victoria, 2012; WorkSafe Western Australia, 2020). The guidelines provided by the states and territories broadly correspond with the "Guide for Managing the Risks of Working in Heat" provided by SWA (Mcinnes et al., 2017b). Risk management of heat in workplaces is a holistic process (Singh et al., 2015) and involves various steps to control and manage the risk of working in heat (Safe Work Australia, 2020a). The workers and their health and safety representatives (HSRs) must be consulted when managing the risks of working in the heat. The risk management framework includes steps such as: identifying the hazard, risk assessment, controlling risk using the hierarchy of controls (Safe Work Australia, 2020a), and reviewing controls (Safe Work Australia, 2020a; WorkCover New South Wales, 2023). The SWA guidelines also provide information on preparedness for working in heat and response to heat-related incidents. SWA suggests that the most effective control measures that are reasonably practicable in the circumstances should be implemented. Examples of control measures include eliminating the risk by stopping the work or by removing workers from the hot environment based on preliminary risk assessment; using mechanical equipment and automation of processes to reduce the need for strenuous physical work. Engineering controls such as the provision of fans or air misters, where possible, air-conditioned sheds or rest areas for outdoor workers; maintaining thermal comfort in an indoor office environment where practicable, provision of cool drinking water can be adapted. Administrative controls can be established further to minimize remaining risks and examples of these include: reorganizing work, rotating jobs, and relocating work to cooler areas, etc with adequate supervision, awareness, and training, encouraging safe work behaviour, and the use of PPE.

1.4. Organizational-level issues in the implementation of heat-related standards

Despite the existence of heat-related safety standards, programs, and regulatory requirements that have been developed for the protection of workers (American Conference of Governmental Industrial Hygienists, 2017; National Institute for Occupational Safety and Health, 2016; Safe Work Australia, 2020a; Australian Institute of Occupational Hygienists, 2013), there has been a reported increase in heat-related morbidity and mortality in workplaces (Gubernot et al., 2015). Various studies have identified organizational-level issues contributing to heat-related health impacts in different industries and occupations (Jia et al., 2019; Rowlinson & Jia, 2015; Varghese et al., 2020a; Varghese et al., 2020b; Lao et al., 2016; Oswald et al., 2018; Weber et al., 2018). An investigation of Occupational Safety and Health Administration (OSHA) heat enforcement cases found that 80% of employers do not comply with national guidelines for heat illness prevention (Arbury et al., 2014). They are usually perceived as a regulative burden to many businesses that affect productivity rather than effective tools to improve safety (Hale et al., 2015). A case study assessing the institutional factors contributing to heat stress in mega-construction project in Australia found that senior management is often reported to be unaware of the heat risk and does not change productivity expectations (Jia et al., 2019). Various exploratory studies suggested that informal rules and practices such as self-pacing are almost always overshadowed by progress pressure (Jia et al., 2019; Singh et al., 2015; Rowlinson et al., 2014). One study exploring workers' experiences with heat stress suggested that workers' heat perceptions vary from person to person. The reluctance of many workers to undertake protective behaviour may be related to peer pressure and accultured stereotypical attitudes due to lack of awareness and training (Lao et al., 2016). It has also been suggested that heat safety in the construction industry is not the responsibility of one person or the organization at an isolated level rather it involves the participation of all those who work and interact across all levels of the system (Woolley et al., 2020). Furthermore, evidence-based studies suggested that heat impacts may aggravate at moderately hot weather conditions before the onset of extremely hot weather (Fatima et al., 2022), but there is little focus on heat stress prevention in moderately hot weather conditions in occupational settings (Varghese et al., 2018). One study reviewed the Australian WHS acts, regulations, and other relevant material available to protect workers from the impacts of heat and suggested that location-specific research is required to quantify health impacts in occupational settings to determine what is actually happening in workplaces (Mcinnes et al., 2017b).

In the light of existing literature, it is also crucial to assess the effectiveness of existing heat-related policies implemented at the organizational level and how well they are aligned with the national standards. To the best of our knowledge, there is no study that has assessed the efficacy of heat-related policies that are in place in organizations for heat risk prevention. Such assessments will help to identify impediments in the implementation of heat management programs within the organizations and provide recommendations to enhance organizations' WHS actions and performance. Such assessments will also help to inform areas for improvement and will guide future research into heat hazards and the best practices to manage heat hazards.

In this study, we aimed to evaluate the existing policies of a large construction company and five of its subcontractors in Australia in accordance with the national guidelines provided by SWA, identify the existing gaps in the heat-related policies implemented by the construction companies, and propose recommendations.

2. Methods

Using a case study design (Yin, 2009), this analysis focused on a large construction company to assess its existing heat-related policies in accordance with the national standards of Australia. A snowball sampling (Ishak & Abu Bakar, 2014) was adopted to acquire the policy documents from the company and its subcontractors. The company provided us with its heat-related policy documents and the heat-related policy documents of five of its existing subcontractors, such as civil contractor, electrical contractor, structural steel contractor, mechanical contractor, and height safety contractor. As per the company's policy, all subcontractors should have their hot weather policy, which covers the workers under their control. However, regardless of subcontractors' policies, the company has the authority to change activities at its discretion to ensure the safety of workers. We acquired six heat-related policies, two sun protection policies, and one Quality, WHS, and environmental systems integrated management plan from the construction company and its subcontractors (Table 1). All these documents provide information on practical measures or standards that are adopted by the companies for heat risk management.

We analysed all policy documents thematically using the "framework analysis approach" (Pope et al., 2000; Goldsmith, 2021). Framework analysis is a commonly used qualitative research approach in applied policy (Srivastava and Thomson, 2009). SWA provides the model WHS framework and the state regulatory authorities that enforce WHS laws in their respective states, follow the guidelines given by SWA. It is the responsibility of State/Territory regulatory authorities to ensure that the practical measures translated in the industry are in accordance with the national guidelines. Therefore, we have assessed the heat-related policies of the construction company and its subcontractors in accordance with the guidelines for managing the risks of working in heat provided by SWA. Framework analysis consists of two main components: developing the framework of analysis and charting, sorting, and interpreting the data according to the developed framework. The main guidance themes and categories in the framework of analysis were identified deductively based on SWA's guidelines for working in the heat. To ensure the inclusion of all guidance and recommendation

Table 1
Policy/procedures document characteristics.

Industry type	Type of work	Document Type
Construction Company	*Commercial builders*	*Hot Weather Policy*
		Sun Protection Policy
Subcontractors		
Civil Contractor	*Civil works, demolition work*	*Working in Heat Policy*
Electrical Contractor	*Industrial electrical installation*	*Hot works Policy*
		Quality, WHS, and Environmental Systems Integrated Management Plan
Structural Steel Contractor	*Structural steel fabrication and erection works*	*Extreme Temperature Policy*
Mechanical Contractor	*Mechanical construction and services*	*Fatigue and Working in Heat Management Policy*
Height Safety Contractor	*Height safety solutions*	*Working in heat and cold*
		Sun safety

themes, six main categories were identified from the guidelines given by SWA. They are "preparedness", "identify hazards", "assess risks", "control risks" (by elimination, substitution, isolation, engineering, administrative, and PPE) "review control measures" and "response".

All policy documents were read thoroughly and the relevant data was extracted into the matrix of our predefined framework of analysis. To identify key patterns and gaps and to allow comparisons, all textual data in categories and themes were interpreted and summarized (Goldsmith, 2021). To give a descriptive overview of the existing policies, the frequency of recommended actions in each category was counted and presented in a summary table.

3. Results

Table 2 presents the summary of recommendations given in the hot weather policies of the construction company and its subcontractors against the set criteria of SWA's guidelines for working in the heat. The contents of the documents were summarized in terms of six main categories based on guidelines from SWA: "preparedness", "identification of heat hazard", "risk assessment", "control measures", "review controls", and "response plan".

Preparedness: Quantitative distribution of content in each category reveals that four policies suggested preparing for the minimization of heat-related risk at workplaces for example by *"arranging toolbox meetings"* and *"by informing the work plan at the beginning of each work shift where excessive heat is likely to be a problem"*. Only one policy suggested consultation with workers in the risk management process. No policy suggested the use of checklists or other supporting documents to assist preparedness.

Identification of heat hazard: Four policies identified heat as a hazard at workplaces such as *"Working outside on day of extreme heat is a safety issue recognized by the management team"* and *"…environmental conditions that may affect the health of the individual workers; working in high temperatures, minimal air movement, humidity, and around hot machinery"*. Although three policies explicitly defined extreme heat or hot weather conditions as a WHS risk for their businesses, there are discrepancies in the temperature threshold. For example, one policy identified temperatures over 35 °C as hot while one used 36 °C as their threshold, and one identified 38 °C as extreme temperature. Other climatic factors (such as humidity or air flow) were not used in any of the hot weather definitions. In terms of the hazard identification process, one policy suggested the involvement of stakeholders.

Risk assessment: Three policies suggested carrying out a risk assessment for undertaking work in hot weather conditions and identified the risk factors associated with heat stress such as; climatic factors, personal factors, and workplace factors. One document further explained the risk assessment process which will be carried out by identifying the seriousness of the hazard and how likely it is to cause harm and the type of control measures required to minimize the risk. No policy suggested the use of a heat stress calculator or expert advice for carrying out a risk assessment.

Control measures: Among controls, two policies suggested stopping work during hot weather conditions and one policy suggested eliminating workers from extreme temperatures. One policy suggested stopping work at a defined temperature i.e. 36 °C. Further, two policies explicitly discussed the financial implications of stopping work. One policy stated that salaried workers will be paid for the remainder of the day if they stop work during a hot day (when the temperature is above 36 °C). However, the policy does not apply to office and depot workers. Casual workers will only be paid for hours worked. The other policy states that *"if the employee feels unable to continue with his/her work duties he/she must notify supervisors prior to leaving workplace. Any lost work hours can be paid from employee's available annual leave entitlements"*.

Recommendations on using isolation or substitution as a control for reducing harm from the heat were usually lacking in the documents, only one policy recommended the use of mechanical aids to reduce physical exertion during hot weather.

Engineering controls such as the installation of cooling equipment and provision of rest areas and shades were mentioned in two to three policies. One policy provided further details advising that *"if there is no natural shade, physical barriers should be provided by installing temporary shade structures (awnings and shade cloths), if reasonably practicable"*. Four policies advised on the provision of cool drinking water for employees.

All policies provided some advice on using administrative controls such as *"rescheduling work to cooler parts of the day"* and *"job rotation"* (four policies), *"involving more people"*, *"providing frequent rest breaks"*, and *"reducing work load"* (two policies). Five policies advised on encouraging workers to keep hydrated. None of the policies advised the supervision of workers particularly new or young workers during hot weather conditions. Further, the policies did not advise acclimatization to hot working conditions. Only two policies explicitly mentioned the provision of training and information to workers about working in the heat. Four policies advised on some generic safe work practices for employees for example *"employees should take regular breaks"*, *"avoid heavy exertion"*, *"work at a sensible pace"*, *"avoid drinking coffee, tea, alcohol, and caffeinated soft drinks"* *"workers will Be responsible for their own sun protective practices at work"* and *"employees working in direct sunlight should ensure they are wearing the appropriate PPE"*.

All policies provided information on PPE and advised on the use of appropriate PPE to protect workers from heat-related risks such as loose clothing, covering arms and legs, wide-brimmed hats, and sunblock. However, most of the policies did not advise on assessing the heat-related risks associated with heavy protective gear used in many industrial operations. Only one policy mentioned that government-mandated instructions on wearing masks in close contact with others may increase the risk of heat stress and should be discussed with operation managers before making any decision.

Review controls: Two policies suggested, reviewing the control measures or the related policy documents on annual basis or when for example introducing new plants, equipment, or high-risk activities at the workplace. Only one policy suggested reporting and reviewing heat stress incidents.

Response plan: All policies suggested that if a worker reports symptoms of heat illness, immediate medical attention should be sought and first aid should be performed.

4. Discussion

This study reviews and assesses the existing policies in place in the construction industry and its subcontractors in accordance with

Table 2
Recommendations of the six hot weather policies against the set criteria of working in heat guidelines provided by SWA.

SWA Guidelines	Construction Company	Civil Contractor	Electrical Contractor	Structural Steel Contractor	Mechanical Contractor	Height safety Contractor	Summary
Preparedness							
deciding on how to manage the risks/consultation with workers or HSRs/preparing checklists	1	1	1	1	–	–	4
Identification of heat hazard							
monitoring weather conditions/involving stakeholders	1	1	1	1	–	–	4
Risk assessment							
Carrying out risk assessment/Identifying and assessing the risk factors/considering the impacts of hazards and the likelihood of causing harm	1	1	1	–	–	–	3
use of heat stress calculator/seeking expert advice for risk assessment	–	–	–	–	–	–	0
Control measures							
Elimination							
stopping work/eliminating workers from high-risk locations	1	1	1	–	–	–	3
Substitution and mechanical aids							
replacing manual work with automated tasks	–	–	–	–	–	1	1
Isolation							
separating workers from hot sources	–	–	–	–	–	–	0
Engineering							
Installation of cooling equipment and maintaining thermal comfort/shades/rest areas	1	1	1	–	–	–	3
Installation of insulation/ventilation	–	–	–	–	–	–	0
Reducing radiant heat	–	–	–	–	–	–	0
Availability of cool and clean drinking water	1	1	1	1	–	–	4
Administrative							
modifying targets and reorganizing work: regular breaks, relocation, rotation, avoid physical work during hot parts of the day	1	1	1	1	1	1	6
adequate supervision	–	–	–	–	–	–	0
allowing acclimatization	–	–	–	–	–	–	0
monitoring dehydration and hydration advice	–	1	1	1	1	1	5
information and training of workers	1	–	1	–	–	–	2
Advice for employees on safe work practices: take regular breaks and avoid exertion, prevent heat illness, call for assistance, look out for each other, avoid diuretic drinks, understand individual risk factors, avoid working alone	–	1	1	–	1	1	4
Use of PPE	1	1	1	1	1	1	6
assessing the risk of using PPE in extreme weather conditions	–	1	–	–	–	–	1
Review controls							
Review the control measures in consultation with workers	–	–	1	1	–	–	2
Review and report heat-related incidents	–	–	–	–	1	–	1
Response plan							
immediate medical assistance	1	1	1	1	1	1	6
ease of access to support services (Provision of the first aid fact sheet, which is easily accessible and understood by all workers)	1	–	1	–	–	–	2

Australia's national guidelines and recommendations for managing the risks of working in the heat. Our results identified the most common gaps in the existing heat-related policy framework, implemented in the construction company and its subcontractors. Such assessment will help to develop consistent and effective heat-related policies, which is crucial to protect workers from the growing impacts of working in the heat.

We found that the construction company and its five subcontractors have hot weather policies in place, and each policy provided recommendations on heat controls. However, the policies do not comprehensively cover some of the most important aspects of heat risk management. Consultation with workers or their HSRs about heat-related risk management is not reflected in a majority of policies. Many policies do not provide adequate information about carrying out risk assessments. Among control measures, stop work has been recommended with a majority of policies relying on administrative controls such as rescheduling work to cooler parts of the day, rotating jobs during hot weather, and use of PPE. The provision of training and information to workers, acclimatization, and reviewing and reporting of heat stress incidents are some of the important components of heat risk management, which are absent in the policy documents.

The majority of the policies broadly suggested preparing for working in heat. However, the policies do not suggest a consultation with workers or their HSRs when deciding on how to manage the risks of working in the heat. The guidelines from SWA and the regulatory bodies from Australian states and territories suggest that the employer must consult with workers who are likely to be directly impacted by heat hazards, when possible. To effectively manage the risks of heat stress in workers exposed to hot weather conditions, heat risk management plans should be discussed, developed, and implemented in consultation with workers and their HSRs (Safe Work Australia, 2020a). Toolbox meetings are a good forum to get workers' feedback in the decision-making process (WorkSafe Western Australia, 2020; WorkCover New South Wales, 2023).

The risk assessment should be carried out where necessary by considering the impacts of heat and how likely it is to cause harm (Safe Work Australia, 2020a). Occupational hygienists can be engaged when required. Information on formal workplace risk assessment during hot weather conditions is not adequate in the reviewed policy documents. Some policies relied only on predetermined 'stop work' temperatures to enforce controls. The guidelines by SWA or other jurisdictions do not specify a 'stop work' temperature. It is important to understand that the prevention of heat-related injuries/illnesses is a complex process and there is no workplace exposure standard or limit for heat stress (SafeWork South Australia, 2023). Setting a safe/unsafe limit based only on temperature metrics is not appropriate and has been criticized previously (Workplace Health and Safety Queensland, 2017; Bates & Miller, 2002; Montazer et al., 2013; Edirisinghe & Andamon, 2019). Further, it is not a practical control measure when several hot days with temperatures above the threshold are forecasted.

Some of the important location-specific, workplace, and personal factors that should be considered when implementing heat controls include climatic factors such as humidity, wind speed, and solar radiation, in addition to air temperature, the nature of work i.e. physical workload and use of PPE, radiant heat from other sources, and individual factors such as acclimatization and physical fitness (Morrissey et al., 2021; Rowlinson et al., 2014). Heat indices can be used to assess the physiological strain associated with heat in construction industries (National Institute for Occupational Safety and Health, 2016; American Conference of Governmental Industrial Hygienists, 2017). Work Safe Queensland provides extensive details on the risk assessment process and suggests the use of a heat stress calculator, which can potentially provide a good start to assess the location-specific risk of heat stress at the workplace. A heat stress calculator considers many of the above-mentioned risk factors and can be used for preliminary assessment by people with limited technical expertise (WorkSafe Western Australia, 2020; Workplace Health and Safety Queensland, 2017). If the calculator determines an unacceptable level of heat stress and the work involves physical labour and the use of PPE then heat indices such as predicted heat strain, thermal work limit, and physiological monitoring can be used. These assessment procedures require a range of measuring equipment and expertise (Australian Institute of Occupational Hygienists, 2013; WorkSafe Western Australia, 2020; Workplace Health and Safety Queensland, 2017; WorkSafe Victoria, 2012). Due to frequent changes in working environments in the construction industry, site supervision staff needs to make instant managerial decisions to mitigate heat risks. It is, therefore, crucial to have a set of localized, simplified, and realistic thresholds to implement heat controls for heat risk management (Rowlinson et al., 2014).

Further, stopping work has financial implications. Although employers and employees are often motivated to combat heat stress in workplaces, potential conflicts of interest can arise in desired outcomes (Singh et al., 2015). For example, stopping work at a certain temperature can impact the progress of the planned activities and increase the overall cost and payments involved. A common WHS barrier reported in previous studies is that employers tend to prioritize their project goals over the health and safety of workers and therefore would not want to stop work even when the heat stress risk is very high (Jia et al., 2019; Morris et al., 2021; Singh et al., 2015; Weber et al., 2018; Williams et al., 2020; Xiang et al., 2015b). Workers who are employed on a casual basis may wish to keep working irrespective of heat conditions to preserve their income. Not paying workers for the lost hours will push them to work even in heat-stress conditions, which can potentially increase the risk of occupational heat stress (Varghese et al., 2020a).

The majority of policies advised administrative controls for the management of heat risks. However, some of the administrative controls may not be practical at all times (Morris et al., 2021; Singh et al., 2015). For example, rescheduling work to cooler parts of the day and providing shades can potentially help in reducing injuries but may not be practicable in all instances due to the nature and requirements of job tasks (Varghese et al., 2020a; Uejio et al., 2018). Further research is required to investigate the feasibility and trade-offs of shifting tasks to reduce heat exposure (Uejio et al., 2018).

Previous studies have also argued that some safety rules lead to counter-safety behaviours and outcomes (Singh et al., 2015). For example, PPE standards to protect workers from sun and heat require workers to use long-sleeved PPE, however, employees sometimes do not comply with PPE requirements stating that it is too hot to wear long-sleeved shirts in summer, resulting in more heat-related complaints (Singh et al., 2015). Moreover, heavy protective gear, certain fabrics, hard hats and materials frequently used in construction industries block airflow and can make workers feel hotter and lead to an increased risk of heat stress (Rowlinson & Jia, 2015; Rowlinson et al., 2014; Safe Work Australia, 2020a). Exploratory studies also suggested that workers want safety rules related to PPE to be more flexible so that their actions are not perceived as unsafe violations (Oswald et al., 2018). While all policies advised on using PPE, it is also important to assess the risks involved in using PPE in tasks being performed. We found that there is a lack of information on the assessment of PPE used for certain tasks in the majority of policy documents. Previous studies have also highlighted this issue (Lao et al., 2016; Williams et al., 2020). It is necessary to find a practical solution to deal with this challenge which may need multi-sectoral collaboration. For example, PPE with new fabric and technology for better airflow might be welcomed by workers in construction industries.

Many administrative control strategies are effective, economically viable for organizations to adopt, and feasible for workers to implement to manage heat stress, but require adequate planning, supervision, and training (Safe Work Australia, 2020a). For example; job rotation, self-hydration, and adequate work-rest periods are found to be quite effective in managing heat stress (Rowlinson et al., 2014; Yi & Chan, 2013; Varghese et al., 2020b). Job rotation accommodates work-rest periods and the use of cooling strategies to expedite heat dissipation. A work schedule is required for rotating duties, with the allocation of adequate time and sufficient workers to allow the completion of tasks (Urban Utilities, 2022). Physically demanding tasks should be regularly rotated among workers to prevent heat illness. Job rotation can also help workers in developing acclimatization (Urban Utilities, 2022). Studies suggested that adequate work-rest schedules optimize productivity and safeguard the health and safety of construction workers (Acharya et al., 2018; Yi & Chan, 2013). However, they should be formally mandated in heat risk management policies and must be carried out under adequate supervision and training (Rowlinson et al., 2014). Self-pacing is also reported to be an effective way of preventing heat illness in the construction industry (Bates & Schneider, 2008). Previous studies suggested that although workers are generally aware of protective measures such as work-rest schedules and self-pacing, pressure for work progress imposed by supervisors does not allow workers to reduce their work rate (Williams et al., 2020; Xiang et al., 2016). The employer's perception of the so-called reduction in productivity associated with regular rest breaks and self-pacing may be fallacious (Rowlinson et al., 2014). It is likely that a fatigued worker makes more mistakes and has to redo work or is vulnerable to an accident, which will involve more costs (Rowlinson et al., 2014). Indeed, it is employers' responsibility to consider environmental conditions in planning and costing work.

We found that the policies we reviewed from the construction company and its subcontractors lack information on adequate supervision of employers and training and information for workers. Effective implementation of heat management controls requires supervision, effective communication and information, and appropriate training of workers to ensure workers are adequately prepared, particularly inexperienced and young workers (Safe Work Australia, 2020a). Training and information would provide workers with the necessary understanding of the risks of heat exposure, potential risk factors and predisposing factors, acclimatization, safe work practices, and work-rest regulation which are critical elements of managing heat risk (Workplace Health and Safety Queensland, 2017, Purohit et al., 2018). Trained and educated workers will be well aware of the heat impacts and will be able to adopt safe work practices such as self-pacing and hydration without excessive peer pressure, task completion pressure, and monetary incentives (Rowlinson et al., 2014).

Acclimatization is an important aspect of heat risk management which was missing from all policies. Acclimatization is the physiological adaptation of the human body to heat (National Institute for Occupational Safety and Health, 2016). Human populations are naturally acclimatized to their local climates, in physiological, behavioural, and cultural terms (Edirisinghe & Andamon, 2019). In occupational settings, excessive exposure to hot conditions can significantly increase the risk of heat stress, particularly in new, young, migrant, fly-in/fly-out workers and those returning from long leaves as their body is not acclimatized to hot environments (Safe Work Australia, 2020a). Evidence from previous studies suggests that around 73% of heat-related incidents occur in the first week of work (Tustin et al., 2018). An analysis of OSHA heat-related illness reports in the US suggests that 99% of employers failed to: develop heat tolerance among workers, monitor environmental conditions, enforce mandatory rest breaks during hot weather, and provide shade, and fluid replacement strategies (Tustin et al., 2018). Acclimatization can be achieved by gradually increasing controlled exposure to heat over 3–7 days (Rowlinson et al., 2014). The NIOSH standards also emphasize the importance of enhancing heat tolerance, which has been successfully implemented in other industries (Edirisinghe & Andamon, 2019). Acclimatization protocols can be practically and feasibly adapted in the construction industry and can be incorporated as mandatory programs in existing heat prevention policies. It should be noted that there is a limit to the body's physiological adaptation to heat, therefore acclimatization programs should be developed in consultation with occupational hygienists (Safe Work Australia, 2020a).

The policies broadly encouraged some safe work practices, but most of the policies did not articulate how employers can ensure that workers are complying with these safe work practices. The text in the majority of policies relies on advising employees rather than setting strict measures, which suggests that the locus of responsibility for coping with heat lies with the individuals, rather than the employers. It is noteworthy that occupational health risk associated with heat is not only the responsibility of individual workers but should be implemented as a systematic WHS intervention, where the principal responsibility lies with the employers (Safe Work Australia, 2020a; Singh et al., 2015).

Reviewing the control measures is a fundamental step in the heat management process but is missing from the policies (Safe Work Australia, 2020a). Reporting and reviewing hazards are important processes to assist in assessing the effectiveness of control measures and maintaining a safe working environment. They provide baseline data essential to develop evidence-based prevention strategies. Previous studies suggested that under-reporting of heat incidents is widespread in workplaces (Singh et al., 2015). SWA also advises that workers should be able to identify and report hazards and employers should review near misses, incidents, and injury records (Safe Work Australia, 2020a). Our study has shown that while heat-related policies were in place at the organizational-level in the construction industry that we were able to access, there were important omissions in the policies in terms of managing heat risks. As well, a unified framework to assess such policies was lacking. Policy assessments will improve implementation of heat management programs within organizations and could also be of benefit in enhancing organizations' WHS culture and performance. Such assessments will also help to inform areas for improvement and shape best practices to manage heat hazards in organizations.

4.1. Limitations

Limitations of this study include a small sample size of policy documents gathered from one company and its subcontractors in one industry, so we advise caution in the generalizability of results. While the documents were gathered from different types of contractors (for example civil works, height safety, electrical workers, etc.), it is likely that only those companies who have heat stress policies in place provided the documents. The policy documents were acquired from one construction company and its subcontractors so we cannot compare the findings across different companies, different industries, or different jurisdictions in Australia. We focused on policy documents only and these documents do not generally provide details on operational procedures and how the issue is being managed in the workplace. Finally, this review does not comment on how the policies are being enforced in workplaces and their effectiveness.

5. Conclusions

Hot weather conditions present a serious hazard for WHS. As we are transitioning to a hotter and more intense climate, it is important to have well-developed and readily accessible heat-related policies at workplaces. This review of existing policy documents from a construction company suggests that the development and implementation of heat-related policies is still in its infancy and needs further improvements. SWA guidelines serve as a good reference model for companies to structure their heat-related policies. Priorities for heat-related policy development include an increased emphasis on preparation and planning for hot weather in consultation with workers, along with considering location-specific, workplace, and individual risk factors in assessing the heat hazards at the workplace. Pursuing these priorities could lead to the implementation of practical control measures in a timely and effective manner. Mandating work-rest regimens and self-pacing, promoting awareness, and introducing training, acclimatization, and fitness programs among workers may also mitigate some of the risks of heat stress. Adequate supervision, review, and evaluation of control measures, heat stress incidents, and near misses at the workplace, and the development of practical and effective response plans must be prioritized in the development and revision of policy documents.

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CRediT authorship contribution statement

Syeda Hira Fatima: Conceptualization, Formal analysis, Methodology, Writing – original draft. **Paul Rothmore:** Conceptualization, Writing – review & editing, Supervision. **Lynne C. Giles:** Conceptualization, Writing – review & editing, Supervision. **Peng Bi:** Conceptualization, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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