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# Climate Change and Rising Heat: Population Health Implications for Working People in Australia

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**Abstract**

The rapid rise in extreme heat events in Australia recently is already taking a health toll. Climate change scenarios predict increases in the frequency and intensity of extreme heat events in the future, and population health may be significantly compromised for people who cannot reduce their heat exposure. Exposure to extreme heat presents a health hazard to all who are physically active, particularly outdoor workers and indoor workers with minimal access to cooling systems while working. At air temperatures close to (or beyond) the core body temperature of 37°C, body cooling via sweating is essential, and this mechanism is hampered by high air humidity. Heat exposure among elite athletes and the military has been investigated, whereas the impacts on workers remain largely unexplored, particularly in relation to future climate change. Workers span all age groups and diverse levels of fitness and health status, including people with higher than "normal" sensitivity to heat. In a hotter world, workers are likely to experience more heat stress and find it increasingly difficult to maintain productivity. Modeling of future climate change in Australia shows a substantial increase in the number of very hot days (>35°C) across the country. In this article, the authors characterize the health risks associated with heat exposure on working people and discuss future exposure risks as temperatures rise. Progress toward developing occupational health and safety guidelines for heat in Australia are summarized.

**Keywords**

climate change, heat exposure, population health, worker health, public policy

## Introduction

Climate change threats facing Australia are significant. With a large land mass covering several latitudinal bands, Australia has climates that range from a tropical north to a temperate south.

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Rain falls primarily on the coastal fringes, leaving much of the inland continent as desert and northerly winds in summer push hot, dry, desert air over the cooler southern states, resulting in extreme summer heat waves. Few places in Australia are, therefore, free from the potential for extreme heat exposure, and in a warming world, this presents a significant and increasing threat to public health, especially among working people.[1] Predicted warming by 2070 of perhaps 6°C has profound implications; it would mean that the days where physical labor in parts of Australia of being unsafe increase from 31 to 94 days per year.[2]

Australia's natural climate is highly variable. Droughts, cyclones, bushfires, and extreme heat events occur regularly enough to feature in the folklore that characterizes the nation and its resilient spirit. However, over recent decades, an unprecedented strong drying trend and widespread warming has been observed across southern Australia that falls significantly beyond the bounds of this naturally variable climate. Across the continent, temperatures have risen by about 1°C (on average) since 1950, and parts of eastern Australia have warmed by 2°C.[3] Each decade since 1960 has recorded more days >35°C than the previous.[4] People living in naturally hot environments, such as the United Arab Emirates[5] and Australia, have developed a certain level of resilience to heat, but there are upper limits to human thermal tolerance,[6] and in a warming world, this resilience will not be sufficient. Physical activity produces surplus heat inside the human body, and this creates particular health risks among people working in hot environments.

Heat waves are the most underrated weather hazard in Australia and have killed more people than any other natural hazard experienced in this country.[7] The excess mortality resulting from more frequent and more intense heat waves is now being monitored, as described in the article by Bi et al in this issue. In this article, we examine the emerging risk for working people, and develop the case for carefully considered, nationally adopted, policies on occupational health and safety as a part of the public health policy response to climate change.

## Clinical Effects of Extreme Heat

Humans must maintain body temperature within a narrow range under diverse environmental conditions. The deep body core temperature ($T_c$) at rest is between 36°C and 37.2°C. Clothing, shelter, and heating facilitate keeping warm when the outside air temperature ($T_a$) is below $T_c$. However, when $T_a$ exceeds $T_c$, cooling the body (in the absence of artificial cooling) is more difficult, especially during sustained physical activity. Only 20% to 25% of the energy produced by muscular activity manifests as mechanical work; the rest is generated as excess heat, which must be dissipated.[6]

The physiological basis for the clinical effects of heat is quite well understood.[8] Blood flows to working muscles, absorbs heat, and is then transported to the skin for cooling via sweating. Sweat rates can exceed 1.5 L/h.[9] Greater blood volumes circulate through working muscles than the skin, so when there is more heat generated than lost and the skin cannot shed sufficient heat through sweating, the core temperature rises. Signs of heat stress include fatigue, thirst, tiredness, mental confusion (poor decision making), and visual disturbances[6] and when these are ignored, disabling complications can ensue. A few hours of exertion in heat, with sustained sweating, may lead to dehydration, which further compromises cardiovascular function and hence work capacity. As dehydration progresses, sweating declines and thermoregulation of $T_c$ becomes even more difficult. The resulting circulatory failure causes further increases in core body temperature, which may be fatal.[10]

In eastern Australian cities, a maximum temperature threshold, above which mortality is observed to increase, is approximately 28°C to 30°C,[11] with a dramatic rise in mortality observed after a succession of hot days, particularly among the elderly. Annual heat-related death rates in Australia are relatively high compared with other countries,[12] and heat waves are becoming hotter and longer.[4] Severe heat waves occurred in Adelaide, Melbourne, and Sydney in 2009 and 2010,

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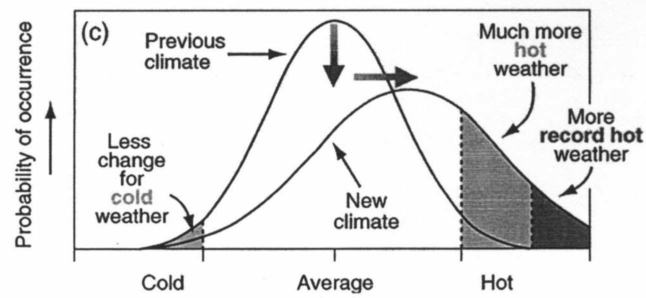


**Figure 1.** Climate change–induced shifts in hot days and extreme heat events
Source: IPCC Third Assessment Report. Synthesis Report, 2001; figure 4.1.[14]

and an increasing frequency of heat waves is consistent with the predicted amplification of extreme heat events by climate change.[13] An increase of the frequency of heat waves during climate change could be associated with a shift of the mean temperature or an increase of temperature variability (Figure 1), or both.

An increase of mortality during heat waves can also occur among young and middle-age adults. During the 2003 heat wave in France, more than 1000 additional deaths occurred in the age group of 35 to 64 years. In this age group, more men than women died, whereas in the older than 65 years age group, female deaths dominated.[15] Most research has focused on the aged, whereas the role of work-related heat exposures in these younger adult age groups was not analyzed in the French studies.

Public health attention should not be restricted to mortality, as most people who are affected by heat will not die. Heat-related illnesses cause a variety of symptoms, ranging from mild, transient effects to death. Extreme heat events have been linked to increased general practitioner visitations, ambulance callouts, presentations to emergency departments, and hospital admissions for conditions relating to heat stress and dehydration, or as a result of heat exacerbating a variety of preexisting conditions.[16] The toll on those who do not seek health services is unmeasured but likely to be substantial.

## Physiological Impacts on Working People From Heat Exposure

Humans experience heat as a combination of temperature, humidity, air movement (wind speed) and heat radiation.[6] Various heat indices have been developed,[17,18] and the most commonly used in occupational health settings is the wet bulb globe temperature (WBGT), which integrates the abovementioned 4 parameters. In Australian field situations, heat stress is commonly reported, but different indices are used.[17,18,19,20]

The international standard (ISO7243) for occupational heat exposure[21] uses WBGT to recommend maximum hourly work-to-rest ratios for different work intensities and clothing types. Increases in WBGT beyond thermal comfort exert a strongly negative influence on human capacity to perform intense physical activity. Figure 2 shows how theoretical work capacity, calculated from ISO7243, declines rapidly as WBGT increases above threshold temperatures for different hourly work intensity levels (ie, metabolic rates, measured in watts (heavy laboring work = 500 W); office work or light manufacturing work = 200 W). The capacity to produce high workload physical activity for an hour at a WBGT of 28°C is half of the capacity to work at 26°C, and work

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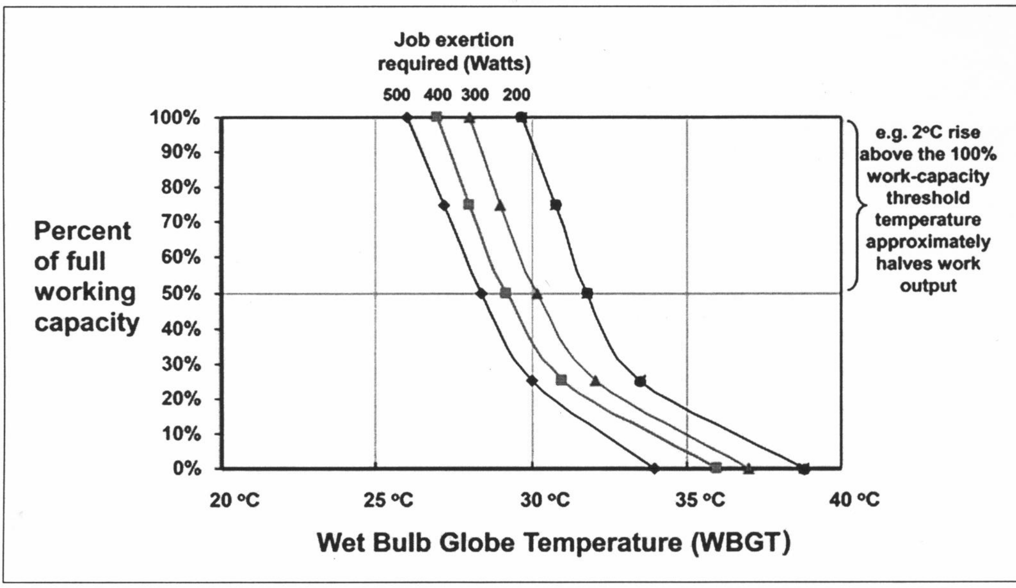


**Figure 2.** Theoretical work capacity (%) as a function of wet bulb globe temperature (WBGT; °C) at 4 work intensity levels (200-500 W); heat-acclimatized workers
Source: Kjellstrom et al.[22]

capacity reduces further to 25% at a WBGT of 30°C. Very light work intensity halves at a WBGT of 32°C.[22]

High heat exposure is subjectively perceived as unpleasant or dangerous. In real-life work situations, where people have freedom to self-manage their effort, they rarely work to their heat tolerance limit, but voluntarily start reducing activity prior to reaching the point of physical exhaustion. Heat-exposed workers therefore tend to "self-pace," that is, reduce physical workload by resting more and working less hard.[10] This compensatory *autonomous adaptation*[23] reduces work capacity, work output and, hence, economic productivity.[24] A study measuring daily work and leisure time use in the USA showed that working people carried out on average 1 hour less work per day when temperatures exceeded 37°C (compared with days <30°C), as workers self-paced to maintain thermal comfort.[25] Heat-related health risks increase when work is "externally paced," such as through production quotas, peer pressure, and remuneration by output. For example, if workers are remunerated by output, the potential loss of personal income may encourage a worker to push themselves beyond their safe limit. At most risk are those who are poorly hydrated, unacclimatized, or physically unfit.[26]

Hot working environments place tremendous strain on all workers, including the healthy. Workplaces with risks of extreme heat exposure include outdoor and maintenance work, mining,[17] shearing,[20] farmwork,[27] firefighting,[28] and other emergency and essential services. Indoor work near heat-generating equipment with poor ventilation is also potentially hazardous on hot days. The body's primary cooling mechanism in response to heat exposure is sweating, and its efficacy is greatly reduced by high humidity and slow air movement over the skin.[29] Many workers are required to wear protective clothing, which can interfere with evaporative heat loss and thus reduce one's ability to cool by reducing efficacy of sweating. Protective clothing can be unpopular as it reduces thermal comfort, and although it reduces exposure to flames, chemicals, and trauma, it also elevates the risk of heat exposure.[30]

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Individual tolerance to heat varies. Aerobic fitness and body fatness have a significant impact on tolerance to even low-intensity weight-bearing exercise in a hot environment. Those with high aerobic fitness can tolerate core temperatures 0.9°C higher than those who are less fit before succumbing to heat exhaustion.[31] Low heat tolerance can prejudice employers and generate peer pressure to work beyond individual safe limits, especially in male-dominated industries. The current national trend toward weight gain is another factor that is likely to reduce future population heat tolerance.

In Australia (and elsewhere), miners and other manual workers can be rostered to work 12-hour shifts in hot environments. Their sweat loss can exceed 12 L/d[32] (8 to 10 liters is common),[33] which needs to be replaced by drinking sufficient water and electrolytes during the work day. Insufficient fluid replacement results in dehydration, which reduces sweating and heat dissipation and may be accompanied by impairment of mental and physical performance. Poor decision making can increase the risks to themselves and fellow workers, and workplace accidents may increase in hot conditions. Thirst is not triggered until the body fluid is depleted by about 2%, and the above symptoms increase beyond this stage of early dehydration. Water deficits of 1% to 2% of body weight in a moderate environment results in a 6% to 7% reduction in physical work capacity, but water loss of 3% to 4% of body weight in the same environment causes a reduction of 22% physical work capacity. The additional cardiovascular strain imposed by a hot environment means that a 4% body water loss can cause a physical work capacity reduction of around 50%. Long-term effects from chronic dehydration include renal disease and premature death.[10]

The impacts of extreme heat are not restricted to physiological effects[34]; heat is oppressive, and results in cognitive impairment and psychological and behavioral effects.[35] Climate change has already been linked to increased suicide rates and other mental health concerns.[36] More work-related accidents,[37] and increased crime rates (particularly those related to aggressive behavior such as assaults and homicides) have also been reported.[38]

## Heat Tolerance and Acclimatization in Working People

Acclimatization is a physiological response mechanism to prolonged heat exposure and physical activity. It varies between individuals living in the same region, and also varies within the same individual in response to heat exposure.[33] Acclimatization is a function of current exposure, recent exposure, and other physiological factors operating at the time, such as level of fitness, current health and activity levels. Acclimatization typically requires 10 to 14 days in the warmer environment, although 75% of the response is believed to occur within 5 days.[39] Part of the acclimatization process is a reduction in the sodium concentration of sweat to conserve salt and other essential electrolytes and minerals. In outdoor workers, mean sweat sodium concentrations in summer have been measured at 44.7 mmol/L compared with 63.8 mmol/L in winter.[9]

Acclimatization dissipates in the absence of exposure to heat and needs to be reestablished when returning to hot environments. The impact on acclimatization of moving in and out of air-conditioned environments is unknown, and workers who "fly-in and fly-out" on a weekly/fortnightly basis to hot environments (as is common in the mining industry in Australia) are considered to be particularly at risk.[18]

## Future Health Risks for Working People

As the global climate continues to heat up, Australia can anticipate significant increases in heat exposure risks. Heating of the Earth is becoming increasingly apparent with long-standing temperature extreme records being broken, and by large margins. The National Aeronautics and Space

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**Table 1.** Average Number of Days per Year Above 35°C at Selected Sites for the "Current" Climate (Average for 1971-2000), and for 2030 and 2070 (Low and High Modeling Estimates)[a]

| | Current | 2030 A1B Low | 2030 A1B High | 2070 A1FI Low | 2070 A1FI High |
|---|---|---|---|---|---|
| Adelaide | 17 | 21 | 26 | 29 | 47 |
| Alice Springs | 90 | 102 | 118 | 132 | 182 |
| Brisbane Airport | 1.0 | 1.5 | 2.5 | 4.0 | 20.6 |
| Broome | 54 | 71 | 107 | 147 | 281 |
| Cairns | 3.8 | 5 | 9 | 19 | 96 |
| Canberra | 5 | 7 | 10 | 12 | 26 |
| Darwin | 11 | 28 | 69 | 141 | 308 |
| Dubbo | 25 | 31 | 39 | 44 | 87 |
| Hobart | 1.4 | 1.6 | 1.8 | 2.0 | 3.4 |
| Melbourne | 9 | 11 | 13 | 15 | 26 |
| Mildura | 32 | 36 | 43 | 48 | 76 |
| Perth | 28 | 33 | 39 | 44 | 67 |
| St George | 47 | 56 | 72 | 80 | 135 |
| Sydney | 3.5 | 4.1 | 5.1 | 6 | 12 |
| Wilcannia | 63 | 71 | 82 | 92 | 129 |

[a]Shaded areas are high-humidity locations, where thermoregulation via sweating is limited. Modified from Department of Climate Change. *Climate Change in Australia*, 2009.[44]

Administration reports that 2009 tied for the second warmest year in the modern record,[40] and 2010 (to July) is the warmest year since 1880. Unprecedented extreme heat waves are being felt across the globe. In May 2010, India recorded 48°C, and Pakistan exceeded 53°C,[41] causing thousands of deaths.[42]

Ongoing global heating will continue to generate more extreme heat and more hot days. In Australia, each decade since 1940 has experienced more days with temperatures >35°C and set more heat records than the previous decade, whereas there have been fewer record cold days each decade.[4] According to climate modeling carried out by the Commonwealth Scientific and Industrial Research Organisation, the mean Australian surface temperature will be between 0.4°C and 2.0°C higher in 2030 than in 1990. The models also predict that by 2070, the mean Australian temperature will be 1°C to 6°C above its 1990 value.[43] A climate shift in the lower range will mean more days with temperatures >35°C (see Table 1), but a shift nearer the higher range will create an Australia where it is difficult to carry out essential physical work without costly cooling systems, and in extreme situations "normal" daily life becomes impossible. Australian researchers[2] have predicted that the number of "dangerously hot" days (when core body temperatures may rise by 2°C or more and outdoor activity becomes impossible), will increase. For unacclimatized people this increase will be from the current 4 to 6 days per year, to 33 to 45 days per year by 2070, and from 1 day per 5 years at present to 5 to 14 days per year for acclimatized people. Such changes in our climate will pose serious threats to work capacity and productivity. Heat stress at work is increased by high humidity, heightening the risk for those in the subtropical northern regions of the country, such as Broome and Darwin, where changes in the normal daily temperature ranges will present distinct challenges for thermoregulation (Table 1). Southern parts of Australia will likely be most affected by periodic heat extremes.

The combined effects of heat and air pollution, especially ozone, may put additional strain on working people.[45] The synergistic effects of heat and poor air quality are now understood to contribute to heat-related mortality and morbidity in urban areas.[46] Work and other physical exertion activities raise the cardiorespiratory workload. Physical exertion outdoors on hot sunny days, when

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extreme ozone levels occur, further exacerbates the risk as the increased demand on cardiorespiratory function delivers higher doses of pollutants to the respiratory airways. No studies have dealt with this potential threat to health and productivity. This indicates a need for research to understand the impacts on working people, as well as the integration of air quality information into heat wave plans and heat warning alerts,

## Public Health Policy Responses

Public health responses to protect population health and working people in Australia are currently limited, as until recently, health impacts related to excessive heat exposure were not regarded as a significant public health or occupational health priority. The dramatic nature of recent heat waves, fires, deaths, and interruptions to transport and power attracted significant media attention and sparked community demand for action. Health departments and local governments are now responding to this emerging health hazard, and further intersectoral collaborations with the acute, community, and informal health care sectors are also required. In addition, collaborative approaches between industry, emergency and essential service sectors, and urban planning are needed to develop a national systematic approach to the prevention of climate change–related heat exposure and the associated adverse health effects. Urban planning and building design policies are also of importance to avoid exacerbation of the urban heat island effect and the poor heat resilience of indoor environments.

Development of a national heat strategy has been hampered by the low resource allocation to environmental health in Australia. The combined effects of expansion and intensification of hazardous environmental determinants of health have stretched response capacity of the states and territories to the absolute limit. Without serious investment in this area, future events are likely to significantly overwhelm the ability of Australian Government to respond adequately. Despite this surge in demand, environmental health expenditure dropped from 5.1% to 4.4% of the total public health budget in 2007-2008, which in Australia is a mere 2.2% of the total health expenditure. Total expenditure throughout Australia on environmental health in 2007-2008 equated to about $4.50 per person, with higher per capita expenditures in those jurisdictions with the smallest populations.[47] Substantial investment will be required to cater to the increasing climate related health demands. Australia's slow and tepid acknowledgement of climate change, and associated health risks have similarly hampered progress in this area.

When considered against the magnitude of health risk at stake, policy response from the Commonwealth Department of Health and Ageing (DoHA) to climate change to date has been limited. This is in part because of the portfolio arrangements; however, climate change should be considered a health issue, and this program area needs expanding, similarly at the state and territory level. An enHealth Council Working Group was tasked to devise a National Heatwave Framework; however, resource limitations have delayed its development. A key step in this framework involves the establishment of heat warning systems, and several states have initiated their own trial pilot programs with the aim of developing and incorporating programs into existing local government processes. Given the wide national variation in temperature patterns and heat tolerance, this task has been further hampered by a lack of regionally specific temperature threshold data, poor understanding of which parameters (such as maximum, minimum, mean or 3-day-average temperatures, humidity, and other climate variables), are most strongly linked to regional adverse health outcomes, and a lack of knowledge about what role is played by their interaction. Knowledge deficits also exist regarding heat impacts among subpopulations, including outdoor workers and rural communities.[48] Their high heat exposure means their health risks are significant, yet locally based research, necessary for the development of effective and well-targeted regional adaptive strategies, is yet to be undertaken.

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**Table 2.** Activity Restrictions for Outdoor Exercise in Hot Weather[a]

| WBGT (°C) | Flag Color | Guidance[b] |
|---|---|---|
| 25.0-26.9 | No flag | **Extreme exertion may precipitate heat illness**<br>*Normal activity* |
| 27.0-28.9 | Green | **Use discretion in planning intense physical activity**<br>*Normal activity* |
| 29.0-30.9 | Yellow | **Cancel intense physical activity; curtail other outside work**<br>*Use discretion in planning intense physical activity* |
| 31.0-31.9 | Red | **Stop work details and physical conditioning**<br>*Curtail strenuous exertion, limit outdoor work to 6 hours* |
| ≥32 | Black | **Cancel all outdoor work requiring physical exertion**<br>*Cancel all outdoor work involving physical exertion* |

Abbreviation: WBGT, wet bulb globe temperature.
[a]Source: Nunneley and Reardon.[49]
[b]Guidance for nonacclimatized personnel is given in boldface. Guidance for fully acclimatized personnel is given in italics.

This research is fraught with methodological challenges such as identifying heat exposure thresholds for specific health outcomes, and factors influencing admissions to hospital, and dealing with small sample sizes relative to the frequency of occurrence. Despite the obvious public health benefits to be gained, departments are reluctant to release data when study group numbers are small, arguing privacy infringements may occur. An additional problem faced by researchers is the 2-year time delay in accessing hospital-based data. The most significant heat events have occurred in the past few years, and without access to recent data, trend comparisons cannot be made. Research funding models evolved to assess biomedical research projects and have been slow to make the transition required to include research in climate change and health or policy development, or small-scale regional studies.

Although heat warning systems can provide significant benefit, they are not sufficient by themselves to prevent poor outcomes. These systems need to be associated with well-considered and locally feasible health protective actions across a range of sectors. Some actions involve national or state polices, and others can be enacted at the local scale, but national programs are needed to spearhead their adoption. For example, rationalization of work activities can reduce heat exposure. Work-related tasks can be rearranged to minimize the need for outdoor activity or intensive physical activity during the hottest part of the day. Prevention of heat-related illnesses and deaths among workers requires educating employers and workers to be aware of the hazards of working in hot environments, including recognition of heat-related illness symptoms and implementing appropriate heat stress management measures that do not cause significant income loss for the working people.

All heat-related public health activities need to incorporate occupational health considerations. With certain notable exceptions, such as the mining industry[50] and military,[51] occupational health and safety programs have given limited attention to protecting workers against excessive heat exposure. Sports[52] and the military publish recommended guidelines for exercise and rest according to WBGT (Table 2). To date, Australia has not released regulations specifying standards for maximum temperatures in the workplace,[53] leaving most employment sectors unprotected because of a lack of public health policies. Urgent consideration is particularly needed to protect the health of workers in the emergency and essential services during heat waves. Public health responses depend on the ability of firefighting, police, ambulance caring, and health sectors to function at maximum capacity and efficiency during the most adverse conditions for extended periods of time. Collapse of these sectors at a critical time could result in significant population health deterioration.

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Employers have a duty under various state Occupational Health and Safety Acts to provide and maintain a safe working environment with systems to minimize health risks among employees. This includes providing a safe system of work, information, training, supervision, and, where appropriate, personal protective equipment.[53] The international standard ISO 12894 (ISO, 2001) provides a method for screening workers who are potentially susceptible to an increased risk of heat stress prior to exposure.[21] The SafeWork Australia Web site neither provides standards, codes of practice, or guidance notes on heat hazards (as at June 2010) nor lists heat exposure under hazard and safety issues where advice is provided.[54] Furthermore, there is no classification code specifically relating to heat exposure in the Australian national workplace injury and disease recording standard.[55]

Some countries are better advanced at protecting worker health from heat. Legislation in most Canadian provinces requires employers to install engineering and administrative controls to reduce the heat stress risk of their working environment should it exceed the levels permissible under the WBGT system.[56] This has also resulted in some effective industry-based heat management programs such as measuring WBGT at strategically placed "hot spots" throughout the workplace. An extra minute of rest per hour is then given to all workers in a given area for every 0.1°C the local WBGT reading exceeds 26.3°C. For example, when the WBGT reading reaches 27.3°C workers receive an extra 10 minutes of rest per hour.[52] This is a relatively effective system that provides motivation for employers to ensure that working conditions remain acceptable to maintain a given level of productivity. A need exists for other countries, including Australia, to establish heat exposure thresholds for working environments to inform safety standards, and these must be accompanied by measures to ensure compliance. Procurement of protective clothing and policies for their adoption needs to accommodate thermal comfort to avoid worker heat stress and reduction in work capacity in hot environments. The contributing risks of air pollution should also be incorporated in health protection guidelines and policies.[57]

Effort is also required to educate employers, the health sector, and the public, to complement the development and testing of workable interventions and health protection strategies. Education about the need for adequate fluid replacement in hot conditions is vital to avoid dehydration, confusion (poor decision making), renal failure, and cardiac failure. It is also vital that appropriate fluids are selected to maintain adequate hydration. Soft drinks and cordials can exceed 10% sugar content and when used as a sole fluid replacement, the daily kilojoule intake is significantly increased.[9] When electrolytes need replacing, this can be achieved by maintaining a balanced diet. Many sports drinks are too concentrated to be regarded as safe for the average person, so intake of these should only occur in moderation, with water consumed as the primary rehydrating fluid. Caffeine and alcohol should also be avoided. Public education campaigns are also required to advise on the need to rest and to moderate exercise and outdoor activity during periods of extreme heat.

The potential for physical labor becoming hazardous for 3 months of the year presents an unequivocal imperative of the need for development of comprehensive public policy with regard to heat exposure, in addition to occupational health and safety guidelines. A balance must be found between the competing tensions of potential disruptions to key services, worker productivity, and health protection, for both the public and the workers involved. Finding this balance will be especially important as such a system will likely be accompanied by directives to ensure compliance with safety measures.

## Conclusions

Continued global heating will produce additional heat stress for populations living in hot climates. The recent rise in extreme heat events across Australia is particularly concerning and will place

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vulnerable populations at risk. Working people present a special case, yet have attracted little public policy attention to protect their health needs. There are upper limits to heat tolerance, and as the climate gets hotter, exercise tolerance will diminish and nonstrenuous work may become hazardous. The flow-on effects of diminished work capacity because of heat are many and significant, including reduced economic growth, slowed rates of production, reduced socioeconomic development, and increased demands on health care services. In addition, many workers experience particular pressures to continue working under extreme heat conditions, particularly when their work activities are controlled by quotas and remuneration by output. The use of personal protective clothing, such as firefighter uniforms, can also exacerbate the physiological strain experienced by workers in extreme conditions.

The demand on health care and emergency response sectors will increase during heat waves, yet there is little consideration for these workers who must try to function at maximum capacity during extreme events. As a matter of some urgency, adaptation strategies are required that include public education campaigns, the training of professionals to assist population adaptation, and the development of stringent occupational health and safety guidelines. Preventive actions for working people include working more slowly and taking more breaks, which reduces productivity for many people and needs to be considered as a key feature of future climate change in Australia. Essentially, a hotter Australia will require a cultural shift to accommodate the thermal constraints of the human body. This must be reflected in the expectations of the employment sector as well as permeate throughout society in all aspects of life.

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