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Policy recommendations to increase urban heat stress resilience

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ABSTRACT

As the frequency and intensity of heatwaves are growing, strategies to improve our resilience are becoming more vital. Policies to increase heat stress resilience are mostly isolated across different disciplines and government departments. A holistic approach would be necessary that mitigates the numerous negative impacts of heatwaves on public health, urban infrastructure and services through adaptation to heatwaves in the realm of public health, building and construction industry, and urban planning and infrastructure.

This paper reviews the research on heat stress adaptation measures, before presenting recommendations for a range of integrated policy measures to increase the heat stress resilience of urban populations in Australian cities. The recommended policy measures include information dissemination, incentives and disincentives, promotion, demonstration and regulations. The paper concludes by identifying directions for further research and reinforcing the multiple benefits that can result from the implementation of heat stress resilience policies and strategies.

1. Urban heatwaves and their negative impacts

Heatwaves have become a growing concern primarily due to their significant negative impact on public health and well-being (Zaidi and Pelling, 2015), in addition to impacts on urban infrastructure and economic activity (Zuo et al., 2014). The most extensively studied heatwave event, with regard to its death toll, was the European series of heatwaves in 2003. During that summer, the deaths of 70,000 people were associated with excess heat stress (Robine et al., 2008).

The alarming danger of heatwaves has catalysed further research on the topic, creating the evidence-base for the first heatwave management and response plans (Fernandez Milan and Creutzig, 2015). These plans have included threshold temperatures to trigger heat health alerts and heat health messages about different 'adaptation techniques' for the most vulnerable members of the population, such as older people and those with pre-existing health conditions (Lowe et al., 2011). 'Adaptation techniques' focus on behavioural changes to decrease individuals' levels of exposure to heat stress (Nikolopoulou and Steemers, 2003), such as drinking more water or staying in the coolest room of the house.

Most heatwave response plans encourage the use of air conditioning (Lowe et al., 2011), as air conditioning is widely accepted as a preventive tool for heat-related health issues (Bouchama et al., 2007; Davis et al., 2003; Gosling et al., 2009; Ostro et al., 2010; Patz et al., 2014). Fewer heatwave response plans have included recommendations on building design and retrofitting to minimise indoor overheating (Lowe et al., 2011). Nevertheless, air conditioning can have several negative impacts compared to the adoption of

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retrofitting techniques and the appropriate design of new buildings.

Air conditioning, through the process of heat rejection, as it pumps heat into the ambient air, contributes to the urban heat island (UHI) effect by raising outdoor air temperatures (Salamanca et al., 2014). The UHI effect is defined as a discernible temperature difference between urban and rural areas caused by the excess heat emitted and the solar gain trapped by the urbanised environment (Gartland, 2008). Urban citizens are therefore exposed to urban heatwaves, which are heatwaves exacerbated by UHI effects (Fernandez Milan and Creutzig, 2015; Hatvani-Kovacs and Boland, 2015). Consueqently, citizens are not just victims of but also contributors to climate change (Ruth and Franklin, 2014). As well as the alarming death tolls, electricity blackouts triggered by the extensive use of air conditioning during heatwaves have attracted more attention from the public, particularly as these power blackouts deprive the population of the use of air conditioning (Maller and Strengers, 2011) and can trigger a cascade failure including other critical infrastructures, such as transport and communication (Chapman et al., 2013).

Recent studies have argued that air conditioning can decrease the use of other adaptation techniques (Hatvani-Kovacs et al., 2016c; Kim et al., 2017; Pisello et al., 2017) and, overall, might even lack preventive capability in dealing with heat-related health problems (Bélanger et al., 2015). The demand for air conditioning has been dramatically increasing worldwide (Santamouris, 2016) and the equipment is regarded as the ultimate solution to indoor heat stress in the public's eye (Amos, 2015; Ferguson, 2016; Stein, 2016).

Recent studies have highlighted that a significant proportion of the population is exposed to heat stress indoors (Coates et al., 2014; Salagnac, 2007). Indoor conditions can be even worse during heatwaves than the outdoor environment (Chan et al., 2001). Energy-efficient new buildings can become more overheated than old constructions as a result of the high level of airtightness and the level of insulation (Dengel and Swainson, 2012; Pyrgou et al., 2017; Ren et al., 2014; Sameni et al., 2015). Projections show that climate change will decrease heating consumption and increase cooling consumption with the risk of overheating (Dodoo and Gustavsson, 2016; Jenkins et al., 2013; Karimpour et al., 2015; Mavrogianni et al., 2015; McLeod et al., 2013; Peacock et al., 2010; Wang et al., 2010). These findings call for more research on building design and retrofitting to increase occupants' capacity to cope with heatwaves (Maller and Strengers, 2011; Zuo et al., 2014).

Indoor overheating is still mostly unaddressed or under-regulated in building standards (Mulville and Stravoravdis, 2016). Current knowledge is incomplete about the means through which to develop a policy to implement heat stress resistance in building regulations (Dengel and Swainson, 2012). Note that a more heat stress resistant building denotes lower risk of indoor overheating without air conditioning during heatwaves. Buildings that are being constructed in compliance with the current building regulations will be affecting the energy use and indoor wellbeing of the built environment for the next 20–30 years' time (Roaf et al., 2015). The lack of adequate regulations addressing indoor overheating during heatwaves encourages the use of air conditioning.

Beyond the extensive use of air conditioning and thus electricity, water consumption also peaks during heatwaves (Andrews, 1994; Hatvani-Kovacs et al., 2016a; Reeves et al., 2010). The increased use of water, such as extra garden watering and having more cold showers, is a dominant means of adaptation to heatwaves besides air conditioning. This interplay shows that water scarcity or restrictions on its use can potentially be detrimental to public health during heatwaves. Climate change is likely to increase future droughts in already arid regions (Intergovernmental Panel on Climate Change, 2013), with this being of particular concern for Australia, the driest continent.

1.1. Heat stress in Australian cities

Australia has always been exposed to severe heat stress thanks to its climates that vary from an equatorial climate in northern Australia to a warm temperate climate in southern Australia (Peel et al., 2007). The risk of climate extremes has been growing as a consequence of increased greenhouse gas emissions caused by human activities (Frich et al., 2002). These emissions will potentially raise the overall temperature in Australian cities by up to 1.2 °C by 2030, up to 2.2 °C by 2050 and up to 3.4 °C or more by 2070 (Watterson et al., 2007).

A further aggravating factor during heatwaves is the UHI effect. In Australian cities, the intensity of the UHI effect is relatively high. In a recent global literature review, Santamouris (2015) found Adelaide and Melbourne, both located in south-east Australia, to be in the upper and middle range of cities according to the intensity of UHIs. Moreover, UHIs have been traced in Australian towns even with populations as small as 1500 residents (Torok et al., 2001). Considering that nearly 90% of the Australian population lived in urbanised areas in 2011 (Australian Bureau of Statistics, 2013), potential exposure to UHI effects and urban heatwaves is experienced by most Australians.

Heatwaves are Australia's most lethal natural hazard (Coates, 1996; Coates et al., 2014). Australia is ranked within the top one-third of countries in a global assessment of heat-related morbidity risks (Fang et al., 2015). Beyond morbidity, heatwaves are a broader health and well-being problem causing a substantial productivity loss at work (Zander et al., 2015).

During the severe heatwave of early 2009 in southern Australia, disruptions in transport and power were widely reported by the local media in both Adelaide and Melbourne (Reeves et al., 2010). Cooling-driven peak electricity demand during heatwaves can contribute to power blackouts. The normalised peak electricity demand is highest in South Australia of the Australian states, where the top 30% of electricity demand occurs in less than 2% of the time (Australian Electricity Market Operator, 2011; Energy Networks Association, 2008). Higher peak loads drive the demand for the extension of the electricity grid, thus directly increasing electricity prices. Heatwave-induced electricity demand is the dominant factor in soaring retail electricity prices (SA Power Networks, 2012). In SA, 2% of the annual energy demand was responsible for 65% of the yearly cumulative power generation costs in 2009–2010 (Dickinson et al., 2010). Rising electricity prices lead to energy poverty (Chester and Morris, 2011; Maller and Strengers, 2011; Santamouris and Kolokotsa, 2015), referring to people who cannot afford to cool down or heat up their homes to an appropriate level.