Analysis of heatwave response plans and adaptation to cope with heatwaves now and in the future in aged care facilities

Benjamin Okwuofu-Thomas

MAgeHlth, RN

A thesis submitted in fulfilment of the requirement for the degree of

Doctor of Philosophy

Department of Environmental Sciences

Faculty of Science and Engineering

Macquarie University

April 2017

Table of Contents

ABSTRACT

Heatwaves result in significant excess mortality, particularly amongst the elderly, and increases in the frequency and duration of heatwaves are projected in the coming decades. This thesis examines heatwave response planning and adaptation with a focus on the health of the elderly in aged care facilities. Three related pieces of research were conducted to explore different aspects of this topic, these being a comparison of heatwave response plans from an aged care facility perspective, strategies for adaptation to climate change impacts in aged care facilities, and heatwave preparedness and planning in aged care facilities in Victoria, Australia. Selected heatwave response plans at national, state/provincial, and municipal levels were examined, with a particular focus on specific responses aimed at residents of aged care facilities. Heatwave response plans were sourced from several countries that are experiencing demographic transition that features growing ageing populations. A total of 23 heatwave response plans were obtained. Most of the plans were from Australia, with only three plans each available from Canada and the United Kingdom, and only two available from the United States. Key components found across the plans were analysis of temperature thresholds, heat stress prevention measures, and communication strategies. Only three heatwave response plans analysed included specific guidance for aged care facilities. These results underline the need for governments to implement effective guidelines that include specific provisions for aged care facilities.

The exploration of adaptation strategies focussed on potential adaptive categories of primary, secondary and tertiary preventions: divided into short-term and long-term adaptation measures. These measures include adaptations such as heat-alarm sensor detectors, client's care plan review schedule, increased staffing during heatwaves, families and carer's involvement, active and passive air-conditioning, and backup power supplies.

Victorian aged care facilities were invited to complete an online survey containing 50 questions on heatwave preparedness and planning. Thirty-nine surveys were completed. Eighty-seven percent had a heatwave policy in place, and 92% had a heatwave response plan. Chi squared (χ^2) test statistics found a strong statistically significant relationship between facilities having heatwave response plans and their healthcare assessment process including consideration of the risks and prevention of dehydration. The study found 92% of sampled aged care facilities use air-conditioning to cool residents during heatwaves. These and other results suggest living in the sampled Victorian aged care facilities is not a risk factor for direct heat-related illnesses during heatwaves. However, ongoing staff heatwave education, training, and communication must continue to reduce heat-related illnesses associated with residents of aged care facilities.

DECLARATION

This work has not been submitted for a higher degree to any other university or institution. The sources of information used and the extent to which the work of others has been utilised are indicated in the thesis. Macquarie University Human Research Ethics Committee approval has been obtained (Ethics Approval Number: 5201401035) (see Appendix 1).

ACKNOWLEDGMENTS

I am grateful to Macquarie University for the research training scheme opportunity to undertake this PhD program. I am also grateful to the Whiddon Group of NSW board of directors for their post graduate scholarship opportunity. Thanks to my principal supervisor Associate Professor Paul J. Beggs for the generosity of his wealth of knowledge, constant support and supervision during my candidature. It takes a benevolent heart of a professor to produce a doctorate holder. From the bottom of my heart I am once more saying a big thank you.

I would also like to thank my co-supervisor(s) Dr. Ross J. MacKenzie, for his dearly helpful supervision and Associate Professor Hilary Bambrick whom may not have directly supervised my candidature but was on standby. All supervisors' advice and support make this thesis a reality. Thanks to Dr. Wendy Noble for her teachings on 'Intensive Writing Course' organised by the Faculty of Science. My sincere thanks also go to Ms Lindie Clark, Mr Frank Siciliano and Dr. Elizabeth J. Latimer Hill, for their comments about my research potential during my master degree program. Their comments stimulated my interest in the PhD study. I will also like to thank Associate Professor Kristian Ruming for the opportunity to teach tutorial classes of the 'Geographies of Health' unit in 2013. Lastly, to God for life and good health, to my beautiful wife Oluremi Christiana, and children Ngozi and Amaka, and my parents Pa Abiamefune Thomas and Ezi-Nne Joannah.

LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
ACE	Angiotensin Converting Enzyme
ACFs	Aged Care Facilities
ACG	Australian Commonwealth Government
AIHW	Australian Institute of Health and Welfare
AMI	Acute Myocardial Infarction
AR4	Fourth Assessment Report (of the IPCC)
AR5	Fifth Assessment Report (of the IPCC)
ASGC	Australian Standard Geographical Classification
CATI	Computer Assisted Telephone Interview
CDC	Centers for Disease Control and Prevention (USA)
CO_2	Carbon Dioxide
COPD	Chronic Obstructive Pulmonary Disease
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
GCMs	Global Climate Models
GFDL-CM3	Geophysical Fluid Dynamics Laboratory–Coupled Physical Model
GHG	Greenhouse Gas
GJ	Gigajoules
GP	General Practitioner
HEWS	Heatwave Early Warning System
HHWS	Heatwave and Health Warning System
HRPs	Heatwave Response Plans

IHD	Ischemic Heart Disease
IPCC	Intergovernmental Panel on Climate Change
MIROC5	Model for Interdisciplinary Research on Climate
NCCARF	National Climate Change Adaptation Research Facility (Australia)
NOAA	National Oceanic and Atmospheric Administration (USA)
NSW	New South Wales
NZ	New Zealand
OECD	Organisation for Economic Co-operation and Development
O_3	Ozone
PEG	Percutaneous Endoscopic Gastrostomy
PM_{10}	Particulate Matter
ppm	parts per million
PV	Photovoltaic
RCM	Regional Climate Model
RCPs	Representative Concentration Pathways
RTI	Respiratory Tract Infection
SA	South Australia
UHI	Urban Heat Island
UK	United Kingdom
US	United States
USA	United States of America
WHO	World Health Organization
WMO	World Meteorological Organization
(χ^2)	Chi Squared

LIST OF FIGURES

Paper 2.

Paper 3.

LIST OF TABLES

CHAPTER 1

INTRODUCTION

This chapter provides an overview introduction to the thesis. It includes a short section on heatwaves, human health, and elderly health impacts in aged care facilities. The section also provides context for the thesis by introducing the ageing nature of the populations of the countries studied, climate change, and finally the concept of adaptation. This is followed by a section presenting the research aims of the thesis, and then a final section outlining the thesis structure.

1.1 Topic introduction

According to the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5), mortality due to extreme high temperatures will be one of the most significant climate-related health problems in the future in many countries, including Australia (Reisinger et al. 2014). Heatwaves are periods of abnormally and uncomfortably hot weather that can impact on human health, community infrastructure and services (World Health Organization (WHO) 2009).

The impacts of heatwaves on human health are many and varied, and include both morbidity and mortality (Carter et al. 2016; de' Donato et al. 2015; Lowe et al. 2011; Thomas et al. 2012; Zhang et al. 2015). Negative health impacts of heatwaves include cramps, fainting, heat exhaustion, heat stress, heat stroke, dehydration, sleep disturbance and death (Bross et al. 1994; Fuhrmann et al. 2016; Glazer 2005; Lowe et al. 2011; Phung et al. 2016; van Loenhout et al. 2016; WHO 2009).

Heatwave health impacts are found to increase with age (D'Ippolitiet al. 2010). The elderly (65 years and over) are identified as a particularly vulnerable population to the impacts of heatwaves (D'Ippoliti et al. 2010; Gamble et al. 2013). In Europe and North America, gender is also found to be associated with heatwave vulnerability, being more common in females (Alberini et al. 2011; Conti et al. 2005; Knowlton et al. 2009). Other vulnerable groups include the homeless, urban poor, those with pre-existing cardiovascular and respiratory illnesses (Alberini et al. 2011; Cusack et al. 2011; Kovats and Ebi 2006; Lowe et al. 2011; Smoyer-Tomic and Rainham 2001; Thomas et al. 2012), and those on certain medications that have psychotropic effects.

There is also a theory associated with where people live and heat-health susceptibility. Place of residence, such as type of homes, areas and cities are found to influence heat-health vulnerability (Alberini et al. 2011; White-Newsome et al. 2011; Xu et al. 2013). A study that explored heat-adaptive behaviours among older urban-dwelling adults in Detroit, USA, found that residence type influenced the percentage of time adaptive behaviours were recorded (White-Newsome et al. 2011). For example, residents of high-rise buildings had overall higher use of adaptive behaviours, followed by single family (i.e., stand alone) residences and those living in two-family flats (White-Newsome et al. 2011). Moreover, most adaptive behaviour recorded was in residences in high impervious areas (White-Newsome et al. 2011).

Residents of aged care facilities have been identified as a group susceptible to heatwaves (Foroni et al. 2007; Garssen et al. 2005; Hajat et al. 2007; Holstein et al. 2005; Klenk et al. 2010; WHO 2009). Aged care facilities and what were previously referred to as nursing homes include residential aged care where residents receive personal and/or nursing care as well as accommodation.

In the Netherlands, Germany, and United States of America (USA), there have been high heat-related morbidity and mortality reports about residents of aged care facilities (Garssen et al. 2005; Klenk et al. 2010; Marmor 1978). For example, a German study of ≥65 years of age residents of nursing homes in Baden-Württemberg between 2001 and 2005 found 444 excess deaths in 1 month due to the 2003 European heatwave, and 356 in the following 2 months (Klenk et al. 2010).

The social, cultural, institutional and infrastructural considerations of aged care facilities may contribute to creating heat vulnerability during heatwaves (Brown and Walker 2008). During the 2003 European heatwaves, approximately 40,000 heat-related elderly mortalities were recorded (WHO 2008). The mortalities considered resulted from inappropriate care and neglect (WHO 2008).

In many developed countries, such as Australia, Canada, New Zealand (NZ), United Kingdom (UK), and the USA, the proportion of 65 years of age and over population is increasing (Australian Bureau of Statistics (ABS) 2013; The World Bank Group 2016; WHO 2016a). For example, in Australia, in 2014, the 65 years of age and over population stood at 3.5 million (ABS 2015). By 2031, the 65 years of age and over population in Australia is projected to increase to between 5.7 million and 5.8 million (ABS 2013); meaning more elderly population will require more aged care facility placements assuming institutionalisation rates do not decrease over this period (Australian Institute of Health and Welfare (AIHW) 2007).

Due to climate change, heatwaves continue to increase in duration, frequency, and intensity (Kirtman et al. 2013); thereby influencing the risk of mortality during extreme high temperature events (D'Ippoliti et al. 2010). The annual maximum and minimum record hot days over the period 1950 to 2011 has increased by as much as 0.9°C (Climate Council of

Australia Limited 2014). Similarly, the number of heatwave days in the eastern and southern parts of Australia has also increased over the period 1950 to 2011 due to climate change (Climate Council of Australia Limited 2014).

There are urgent calls for measures to reduce current morbidity and mortality impacts of heatwaves (Hajat et al. 2010a; Lowe et al. 2011). Heatwave response plans are an approach to reducing the human health consequences of heatwaves. Heatwave response plan components can include heatwave events notification, heat-related health impacts, monitoring vulnerable populations, heat stress prevention strategies, communication of prevention responses and evaluation and revision of systems (Ebi et al. 2004; Ebi et al. 2006; Hajat et al. 2010a; Hajat et al. 2010b; Lowe et al. 2011).

The development and implementation of incremental, transitional and transformational adaptation options to reduce heatwave impacts should improve public health and health care services (Smith et al. 2014). Evidence suggests effective heatwave early warning systems with response plans are fundamental adaptation strategies to reduce heat-related morbidity and mortality during heatwaves (Fouillet et al. 2008; Lowe et al. 2011; Michelozzi et al. 2010; Palecki et al. 2001).

Palecki et al. (2001) highlight how effective heatwave response efforts in Chicago and St. Louis in 1999 helped save lives. For example, the Chicago heatwaves of July 1999 resulted in 114 deaths, compared to 700 recorded in the July 1995 Chicago heatwaves.

Heat stress prevention strategies include appropriate clothing, drinking more fluids to hydrate, refraining from excessive outdoor physical activities and knowing the signs and symptoms of heat-related illness during heatwaves (Alberini et al. 2011; Brown and Walker 2008; UK Department of Health 2010). Adaptation measures can be assigning municipal employees to check on the elderly and public housing residents, free bus services to cooling centres, setting up dedicated help lines, and broadcasting updated information through the media (Palecki et al. 2001).

Heatwaves have become a public health problem and require the attention of all governments, stakeholders and concerned citizens to ensure effective climate change adaptation (Akompab et al. 2013; Carter et al. 2016; de' Donato et al. 2015; Hanna and Spickett 2011). As the proportion of elderly population increases and heatwave conditions worsen into the future, the morbidity and mortality associated with heatwaves may become more prevalent and pervasive.

Our current knowledge about residents' vulnerability to heatwave impacts and adaptation against future heatwaves in aged care facilities is still in its infancy and very limited. This thesis attempts to extend this knowledge and focus on heatwave response plans and other adaptations to heatwaves to reduce heat-related morbidity and mortality before, during and after heatwaves in aged care facilities. In the light of previous research on heatwave adaptations and current knowledge of heat-related mortality in aged care facilities, the aims of this thesis are provided in the following section.

1.2 Research aims

The importance of heatwave adaptation to aged care facility residents, and the imperative necessity to increase knowledge in anticipation of projected changes in climate; the following are the four aims of this research:

1. To compare selected heatwave response plans sourced from Australia, Canada, NZ, UK and USA;

2. To specially examine the inclusion of aged care facilities in heatwave response plans sourced from Australia, Canada, NZ, UK and USA;
3. To explore heatwave awareness, preparedness and planning in aged care facilities in Victoria, Australia;
4. To develop aged care facility heatwave adaptation strategies.

1.3 Thesis structure

This thesis comprises a number of chapters, including three that are presented as papers. This chapter (Chapter 1) introduced the thesis topic and its aims. Chapter 2 presents the current knowledge of the topic and reviews the associated literature. Chapter 3 presents the methods of the research in the thesis. Chapter 4 is a paper assessing and comparing heatwave response plans from Australia, Canada, New Zealand, the UK and the USA. This analysis considers the inclusion of aged care facilities in plans.

Chapter 5 presents a study that explores different theoretical climate change adaptation frameworks and expands on heatwave adaptation strategies for aged care facilities. Chapter 6 is a study that examines heatwave awareness, preparedness and planning in aged care facilities in Victoria, Australia. Chapter 6 further evaluates health professionals' role in response to heatwaves. Chapter 7 discusses the thesis findings as an integral piece of work, makes general conclusions with respect to the thesis aims, states limitations of the thesis and makes recommendations for future work.

CHAPTER 2

LITERATURE REVIEW

This chapter presents a review of the literature and current knowledge on the topic of this thesis. Global scale records for temperature show that a number of regions have experienced warming trends and more frequent extreme high temperatures. Increasing temperatures are known to be the result of increases in greenhouse gas (GHG) concentrations in the atmosphere. In addition, world population in the 65 years and over age group is on the increase (WHO 2016). For example, between year 2000 and year 2050, 65 years and over age group world population is projected to double (WHO 2016). Whilst studies on heat-related morbidity and/or mortality in aged care facilities abound internationally, no such study exists in Australia, a country whose elderly population are susceptible to heatwaves (Black et al. 2013; Climate Council of Australia Limited 2014). The following sections of this chapter discuss heatwaves, climate change, human health impacts of heatwaves including in the elderly in aged care facilities, population ageing, and climate change adaptation for heatwaves. The final section provides a summary of this chapter.

2.1 Heatwaves

Heatwave may be defined as a period of abnormal and uncomfortable hot weather lasting several days within a local climate (Commonwealth of Australia, Bureau of Meteorology 2016; IPCC 2013a). There is no universal definition of heatwave (WHO 2009). However, heatwave is characterised by its intensity, duration and timing (Climate Council of Australia Limited 2014; Kirtman et al. 2013). Because a universal definition of heatwave is challenging, the possibility of developing a definition for similar climate regions with similar population characteristics may be explored (American Meteorological Society 2012; Climate

Council of Australia Limited 2014). For example, in Australia, a heatwave is defined operationally as a period of at least three days where the combined effect of high temperatures and excess heat is unusual within the local climate (Climate Council of Australia Limited 2014).

2.2 Climate Change

Climate change according to the Intergovernmental Panel on Climate Change (IPCC 2013a), is a change in the state of the climate that can be identified, for example, by using statistical tests, by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Global scale observations from instrumental records for temperatures since the mid 19th century reveal many regions have experienced warming trends and more frequent high temperature extremes (e.g., heatwaves) (IPCC 2013b). Continued increase in temperatures will result in further increases in future heatwave frequency, duration and severity (Kirtman et al. 2013).

Greenhouse gas such as carbon dioxide (CO_2) influences climate change (IPCC 2013a). According to the IPCC Fifth Assessment Report (AR5), since the pre-industrial era, CO_2 concentrations have increased by 40% primarily from fossil fuel emissions (IPCC 2013b). The US National Oceanic and Atmospheric Administration's (NOAA) CO_2 records, for example, show that global atmospheric concentration of CO_2 in 1959 was 315.97 parts per million (ppm) compared to 398.61 parts per million in 2014 (US Department of Commerce, NOAA 2015) an increase of 26% in just the last half century or so. Increase in the concentration of greenhouse gases increases the magnitude of its global warming potential (IPCC 2013a).

The global averaged combined land and ocean surface temperature data in a linear trend calculation over the period 1880 to 2012 shows warming of 0.85°C (IPCC 2013).

In the last century, observed warming has occurred in two phases: from the 1910s to the 1940s by 0.35°C, and more strongly from the 1970s to the present by 0.55°C (Hartmann et al. 2013). The confirmation of global warming comes from increased surface air temperature, warming of oceans, rising sea levels, glaciers melting, sea ice retreating in the Arctic, and diminished snow cover in the Northern Hemisphere (IPCC 2013b). Instrumental temperature records show each of the past three decades has been successively warmer at the Earth's surface than all the previous decades (Hartmann et al. 2013).

Under the current IPCC AR5, the scientific community defined a set of four new future scenarios called 'Representative Concentration Pathways' (RCPs) (2013b). These four RCPs include: a very low emission level mitigation scenario RCP2.6, two stabilisation scenarios RCP4.5 and RCP6.0, and one very high emission scenario RCP8.5. Projections of future temperatures under the low emission scenario RCP2.6 and the high emission scenario RCP8.5 are shown in Figure 2.1 (IPCC 2013b). These two scenarios both result in future increases in surface temperatures with these increases being far greater under the RCP8.5 scenario (IPCC 2013b).

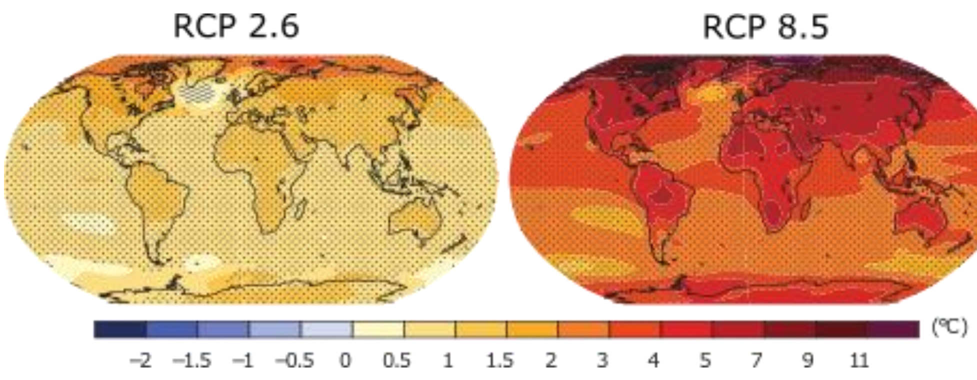

Figure 2. 1. Projections of future change (2081-2100 compared to 1986-2005) in average surface temperature under two scenarios (RCP2.6 and RCP8.5). Source: IPCC 2013

The anthropogenic warming of global surface air temperature is projected to proceed more rapidly over land by mid 21st century (Kirtman et al. 2013). By the year 2100, projected global average surface temperature would have increased between 0.3°C to 4.8°C compared to 1986-2005 (IPCC 2013b). Similarly, heatwave has been projected to increase in duration, intensity and spatial extent (Kirtman et al. 2013). For example, temperature extreme indices trends computed for Australia and the USA, using simulations and observations with nine GCMs (Global Climate Models) that include both anthropogenic and natural forcing found an increase in heatwave duration in the second half of the 20th century (IPCC 2013).

The water cycle describes the continuous movement of water through the climate system in its liquid, solid and vapours forms; and stored in reservoirs such as the atmosphere. As the saturation vapour pressure of air increases with temperature, it is expected that the amount of water vapour in air will increase with a warming climate (Stocker et al. 2013). Since 1950, the frequency and intensity of drought is likely to have increased in the Mediterranean and West Africa, and decreased in central North America and north-west Australia (Stocker et al. 2013). Globally, averaged mean water vapour, evaporation and precipitation are projected to increase (Stocker et al. 2013). As climate warms, extreme precipitation will very likely be more intense and more frequent (Stocker et al. 2013).

Changes in precipitation associated with climate change vary in space: increasing in some regions and decreasing in some others (IPCC 2013b). In the Northern Hemisphere (mid-latitude) land areas, there is a medium confidence of an overall increase in precipitation prior to 1951, and high confidence past 1951 being climate change related (Stocker et al. 2013). By the end of this century, the high latitudes and the equatorial Pacific Ocean are likely to experience increase in annual mean precipitation (IPCC 2013b). Also by the end of this century, in many mid-latitude and subtropical dry regions, mean precipitation will likely decrease, while in many mid-latitude wet regions, mean precipitation will likely increase (IPCC 2013b).

Further emissions of greenhouse gases will lead to more warming and additional changes in all components of the climate system (IPCC 2013). Therefore, limiting climate change would require sustained greenhouse gas emissions reduction (IPCC 2013).

2.2.1 Climate Change in Australia

Climate change in Australia is known to have resulted in extreme weather events including bushfires and heatwaves, change in the atmospheric pattern of daily weather and increased air temperatures (Commonwealth of Australia 2009). The Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) reports that, the mean surface air temperature since 1910 has warmed by 0.9°C (CSIRO 2014). This warming trend occurred against a background of year-to-year (and decade-to-decade) climate variability, mostly associated with El Niño and La Niña in the tropical Pacific (Figure 2.2). The year 2013 was Australia's warmest year on record, being 1.2°C above the 1961–1990 average of 21.8°C and 0.17°C above the previous warmest year in 2005 (CSIRO 2014).

In Australia a number of extreme heatwaves have occurred in the last 5 years (Climate Council of Australia Limited 2017). Major capital cities including Sydney and Melbourne are starting to experience heatwaves earlier in the year, and the heatwaves have become more frequent, hotter and longer in duration (Climate Council of Australia Limited 2017). In Melbourne, for example, heatwaves now start on average 17 days earlier, while in Sydney heatwaves now start 19 days earlier (Climate Council of Australia Limited 2017).

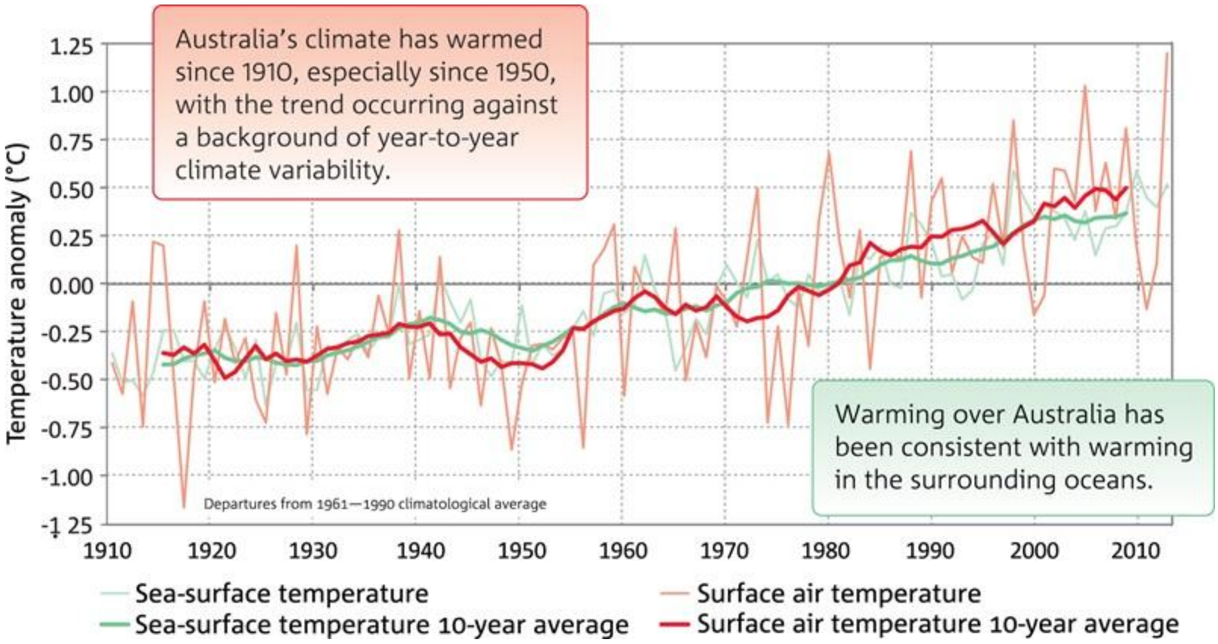

Figure 2. 2. Australia's temperature anomalies (departures from 1961-1990 climatological average) from 1910 to 2013. Source: CSIRO 2014

By 2030, Australia's temperatures are projected to continue to warm, rising by 0.6 to 1.5°C compared with the climate of 1980 to 1999: noting that 1910 to 1990 warmed by 0.6°C (CSIRO 2014). By 2070, Australia's warming is projected to be 1.0°C to 2.5°C for low greenhouse gas emissions and 2.2°C to 5.0°C for high emissions compared to 1980 to 1999 (CSIRO 2014). The projected changes in temperature will result in increase in the number of hot days and warm nights, and decrease in the number of cool days and cold nights (CSIRO 2014). Over the coming decades in Australia, it has been projected that extreme heat and heatwaves will continue to become even more frequent and severe (Climate Council of Australia Limited 2017).

Furthermore, it has been projected that northern Australia under low emissions will experience changes in rainfall ranging from 20% decrease to 10% increase by 2070, and 30% decrease to 20% increase under high emissions (CSIRO 2014). In southern Australia, droughts are expected to become more common and severe. For other regions, increase in the number and intensity of extreme rainfall events is projected (CSIRO 2014).

2.3 Climate, Heatwaves, and Human Health

The World Health Organization (WHO 2003) defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". This definition has three important health promotion implications; these being the physical, mental and social health promotion implications which cannot be separated from each other.

In many countries of the world, extreme high temperatures increased the risk of illness and death in humans (Sarofim et al. 2016; Smith et al. 2014). In the US, for example, observation of the relationship between daily high temperatures and average daily number of deaths has been reported during the 1995 Chicago heatwave (Sarofim et al. 2016; Figure 2.3a).

Anderson and Bell (2011) have recently described the physiology of heatwave human health impacts, stating that "When ambient temperature is high, the human body responds via thermoregulation: Blood vessels dilate near the skin to transfer heat from the body's core to the skin, and then sweat transfers heat from the skin by evaporation (Havenith 2005). Even when body temperature remains normal, thermoregulation strains the cardiovascular system (Havenith 2005). The higher the temperature or the longer the heat wave, the more work required of the cardiovascular system to maintain normal temperature; therefore, more intense or longer heat waves are likely to have greater health effects".

Exposure to severe hot climate can have a negative effect on cardiovascular diseases such as hypertension, myocardial infarct and chronic heart disease (Barnett 2007; Davido et al. 2006; Qian et al. 2008; Smith et al. 2014; US CDC 2002; Vandentorren et al. 2004; Vaneckova et al. 2008a; Vaneckova et al. 2008b; WHO 2003; WHO 2004; WHO 2010).

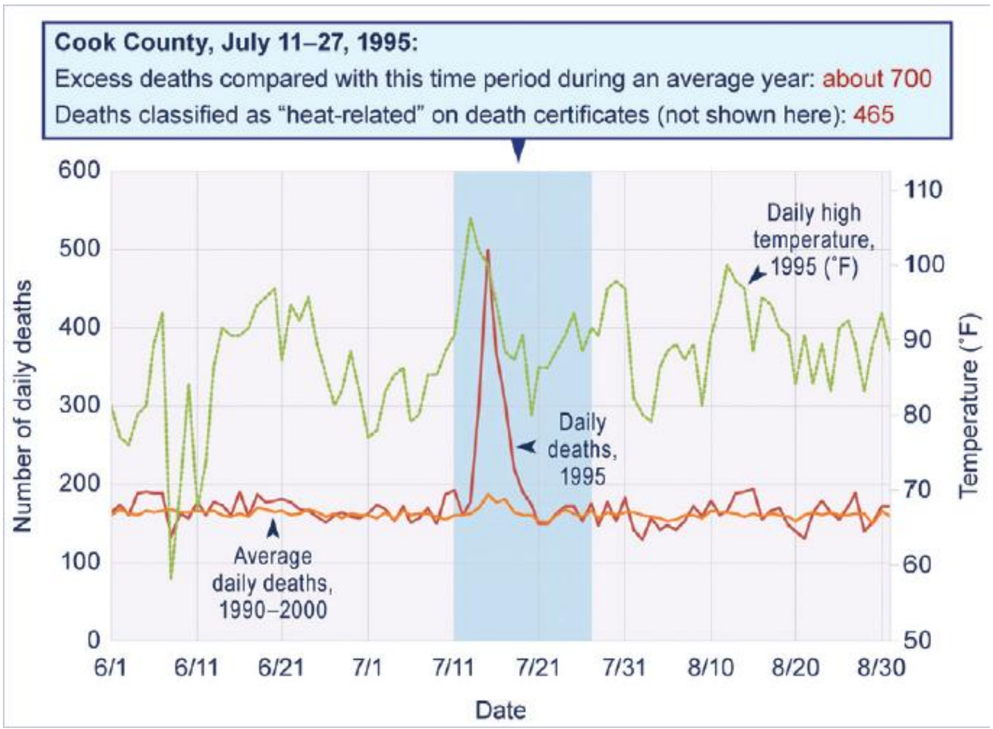

Figure 2. 3a. Daily high temperatures and daily number of deaths before, during, and after the July 1995 Chicago heatwave. Source: Sarofim et al. 2016

Hot weather exposure can result in heat stress illness (also known as heat-related illness) which comprises heat exhaustion, heat oedema, heat cramps, heat syncope, and heat stroke (Australian CSIRO 2014; Choudhary and Vaidyanathan 2014; Costello et al. 2009; Fuhrmann et al. 2016; Kim et al. 2014; Smith et al. 2014; WHO 2009; Younger et al. 2008). A variety of other adverse health conditions can also result and may include dizziness, nausea and vomiting, heavy sweating, rapid pulse, high body temperature and sleep disturbance (Mudarri 2010; van Loenhout et al. 2016). Heat stroke can be defined as a core human body temperature of 40.5°C or greater (Bross et al. 1994). Heatstroke can be either exertional or classic, and if not treated is capable of causing acute neurological inflammations, multi-organ failure or death (Bross et al. 1994; Glazer 2005). For example, thermal extremes contribute to death of approximately 1121 people a year in the Australian cities (Commonwealth of Australia 2003).

The impact of hot days on human health can be exacerbated by high humidity (IPCC 2014). According to the IPCC (2014), physical outdoor workers are at particular risk as such work produces substantial heat within the body, which cannot be released when outside temperature and humidity is above certain limits. Also in indoor thermal conditions, humidity influences the occurrence of thermal adverse events (IPCC 2014). Consequently, changes in the water cycle such as increasing precipitation and humidity can lead to greater heatwave health impacts (IPCC 2014).

Anderson and Bell (2011) provide an excellent summary of the many factors that might result in heterogeneity between communities in both heatwave effects and effect modification by heatwave characteristics, with these being: "a) physical acclimatization of residents of warmer communities, b) different levels of exposure in different communities (e.g., AC [air-conditioner] use, housing structure, clothing type), c) different community-level responses to extreme heat (e.g., heat wave warning systems), d) different demographics (e.g., population in high risk categories such as the elderly or less healthy), or e) different geographical, meteorological, or pollution factors within communities that might confound or modify temperature–mortality relationships".

In Adelaide, Australia, Nitschke et al.'s (2007) study investigated morbidity and mortality associated with heatwaves, comparing heatwave and non-heatwave periods using ambulance, hospital admission, and mortality data for 13 years, from July 1993 to June 2006. The study found that during heatwaves, total ambulance transports increased by 4% (Nitschke et al. 2007).

Dolney and Sheridan's (2005) study investigated the impacts of heatwave on human health in the city of Toronto, Ontario, Canada, by analysing ambulance calls for a 4-year period from

1999 to 2002. The study found 14% increase in weekday ambulance calls on heatwave days compared to non-heatwave days (Dolney and Sheridan 2005).

Davido et al.’s (2006) study was a retrospective analysis of comparisons between survivors and one month non-survivors of heatwaves of August 2003 in France. The study found pneumonia to be significantly more frequent in non-survivors particularly as it was associated with aspiration-pneumonia in the setting of altered mental status (Davido et al. 2006).

Vaneckova et al. (2008a) found maximum temperature has significant effect on mortality in Sydney, with particulate matter (PM_{10}) and ozone (O_3) confounding the association. Loughnan et al.’s (2010) study also identifies threshold temperatures above which acute myocardial infarct (AMI) admissions to hospital increase in metropolitan Melbourne.

Likewise in Italy, there was association between mean apparent temperature (lag 0-1) and all non-injury mortality (Fig. 2.3b). The study evaluated the effects of summertime high temperature on daily mortality amongst population subgroups defined by their demographic characteristics, socioeconomic status and episodes of hospitalisation for various conditions. The study found that during the preceding 2 years, place of death is an important effect modifier for temperature-related mortality (Stafoggia et al. 2006). Patient’s discharged from hospitals 2-28 days before their death had a reduced heat-related mortality while residents of nursing homes were more vulnerable (Stafoggia et al. 2006). The overall odds ratio increased with age and was higher among widows and widowers (Stafoggia et al. 2006).

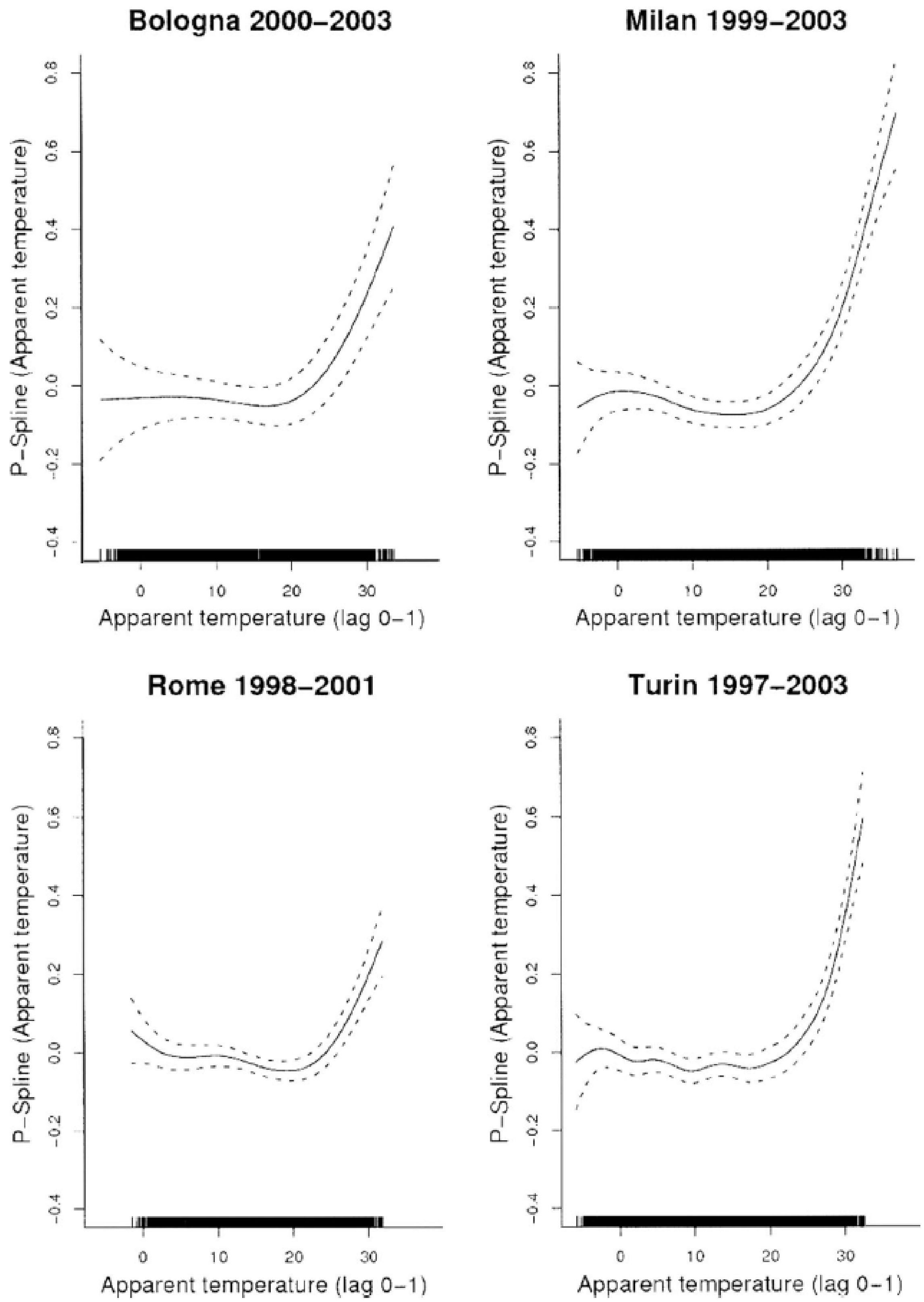

Figure 2.3b. Relationship between mean apparent temperature (lag 0–1) and all non-injury mortality, age 35+ years, 1997–2003, in the 4 Italian cities of Bologna, Milan, Rome and Turin. The y-axes represent the natural logarithms of risks of death centred at zero. Source: Stafoggia et al. 2006

In addition, among the pre-existing medical conditions investigated, effects modification was detected for previous psychiatric disorders. Depression, heart conduction disorders, circulatory disorders of the brain and previous cerebrovascular diseases are some of the pre-existing medical disorders identified (Stafoggia et al. 2006).

2.3.1 Climate Change, Heatwaves, and Human Health

Climate change is the biggest health threat in the 21st century. Its effects will impinge on present and future populations (Costello et al. 2009). Climate change affects human health in 3 basic pathways (Smith et al. 2014). The impacts may occur through direct exposure to climate and weather such as heat, floods and storms; the natural system such as air pollution and vector- and water-borne diseases; and through human institutions such as occupational impacts, mental stress and under-nutrition (Smith et al. 2014).

The health of human populations is sensitive to shifts in weather patterns and other aspects of climate change (Smith et al. 2014). Changes to the climate state or system may alter the dynamic state of the human health equilibrium (i.e., the physical, mental and social well-being). Variability in temperatures is a risk factor in its own right, and does influence heat-related deaths (Sarofim et al, 2016; Smith et al. 2014). For example, in the north-east of the US, heat-related mortality risks during heatwaves were higher for every extra day a heatwave lasted (Anderson and Bell 2011). A study of heatwave impacts on mortality in Shanghai found heatwave mortality in both summers of 1998 and 2003 was strongly associated with the duration of the heatwave (Tan et al. 2007). The duration (length in days) of heatwaves can have large human health impacts: heatwave intensity, and timing in season cofounding the association (Anderson and Bell 2011).

When the climate continues to warm, present and future generations will encounter environmental risk factors such as more heatwaves, higher rates of climate-related infectious diseases, and air pollution-related morbidity and mortality (Mudarri 2010; Shea et al. 2008). For example, the US Centers for Disease Control and Prevention (CDC) estimate 688 annual mean deaths are from climate change effects such as extreme heatwave events (Mudarri 2010). The public health cost of premature deaths from heat events each year was estimated to be $5.1 billion (Mudarri 2010).

Climate change impacts on human health are projected to affect future generations with more injuries, disease, and death related to natural disasters and heatwaves, widespread malnutrition, as well as more allergic and air pollution related morbidity and mortality if current emissions and land use trends continued unchecked (IPCC 2014a; Kim et al. 2014; Sarofim et al. 2016; Smith et al. 2014). Research studies found climate change experience of hot climate is associated with increased elderly heat-related morbidity and mortality (Fuhrmann et al. 2016; vanLoenhout et al. 2016; Zhang et al. 2015).

Climate change is projected to alter the spatial and temporal distribution of heatwaves and heat-related mortality (Kim et al. 2014). Recent research studies in Australia, Germany, Korea, and Spain found projected extreme temperatures will increase future health risks (Huang et al. 2011; Kim et al. 2016; Roldán et al. 2016; Zacharias et al. 2015).

One of the health risks includes increase in the incidence of Ischemic heart disease (IHD) (Zacharias et al. 2015). A Germany study investigated the impact of climate change on the occurrence of heatwaves based on 19 regional model stimulations (Zacharias et al. 2015). The study found that virtually all regional climate models (RCMs) demonstrate a positive climate change sign. Therefore, heatwave-related IHD mortality will significantly increase in future in Germany (Zacharias et al. 2015).

In the US, a similar approach was used to project future impact of heatwave on heat-related mortality between 2030 and 2100 (Figure 2.4). Future temperature projections were based on the RCP6.0 scenario from two climate models: the Geophysical Fluid Dynamics Laboratory–Coupled Physical Model 3 (GFDL–CM3) and the Model for Interdisciplinary Research on Climate (MIROC5) (Sarofim et al. 2016). Extreme high temperatures that will result from future changing climate are projected to increase mortality by thousands to tens of thousands across the US by the end of the century (Sarofim et al. 2016).

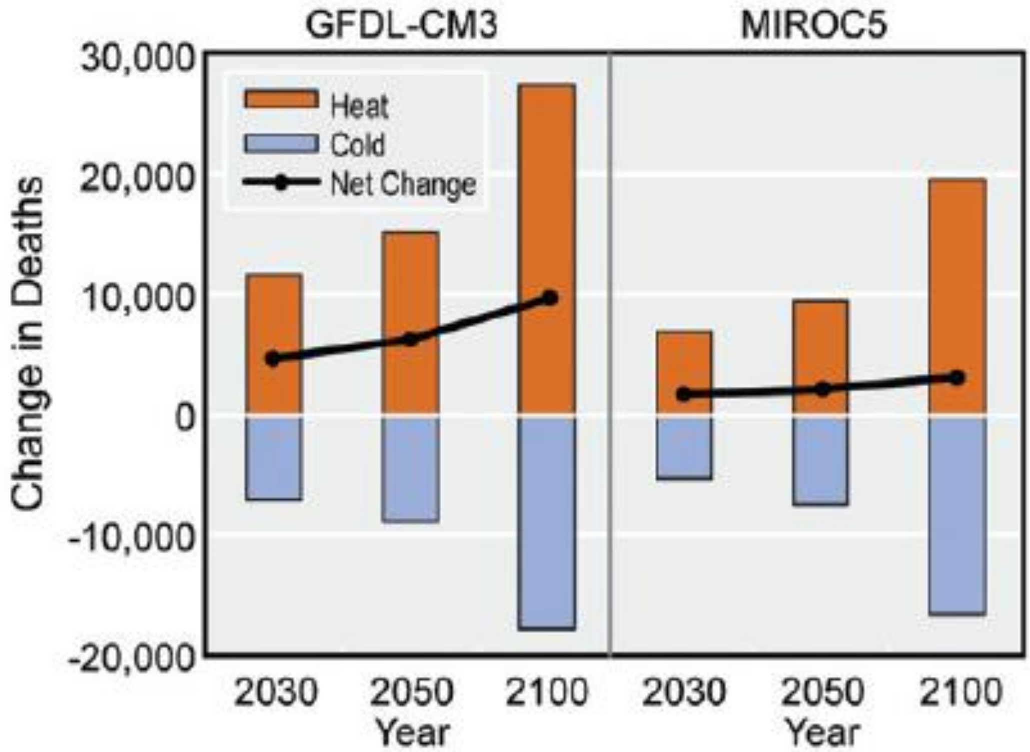

Figure 2.4. Projected change in heat- and cold-related deaths in the USA in 2030, 2050, and 2100 using two models. Source: Sarofim et al. 2016

2.4 Climate Change, Heatwave, and Human Health in the Elderly

The elderly will be one of the subgroups to be affected by future heatwaves (Costello et al. 2009). In an epidemiological review of how climate variations and trends affect various health outcomes, McMichael et al. (2006) found a positive association between climate change, heatwaves, and mortality in the elderly with pre-existing cardiovascular disease such as heart attack, stroke and chronic respiratory diseases. Gastrointestinal infections due to contamination of food and water; volume depletion, syncope, collapse and psychological stress are other negative effects which severe hot climate can have on elderly ≥65 years (Beggs and Vaneckova 2008; Hansen et al. 2008; Knowlton et al. 2009).

Beggs (2000) asserted in his study of the impacts of climate change on medications and human health that increased temperatures may lead to medication-related health impacts through deterioration of storage conditions thereby influencing pharmacokinetics. Beside age-related physiology, changes in the elderly could also be exacerbated by concomitant use of medication such as angiotensin converting enzyme (ACE) inhibitors, beta-blocker or other antihypertensive and diuretics (Flynn et al. 2005). In addition, elderly people with peripheral neuropathy and those taking anticholinergic drugs and phenothiazines are at increased risk of heat-related morbidity due to their inability to reflex and regulate body temperature and being able to sweat (Flynn et al. 2005).

Wang et al.'s (2010) review study of susceptibility of the ageing lung to environmental injury from high climatic temperature, found that those ≥65 years of age are more likely to have pre-existing medical conditions such as cardiovascular and respiratory illnesses which put them at greater risk of severe morbidity and mortality, or the onset of a completely new disease. As a result, the ageing population will become more vulnerable to environmental injuries (Wang et al. 2010).

Hansen et al.'s (2008) study established a positive association between ambient temperature and mortality rate in the 65 to 74 years age group. The study found that there were 4,629 admissions to Adelaide hospitals during heatwaves above a threshold of 26.7°C compared to non-heatwave periods in Adelaide, South Australia.

Flynn et al.'s (2005) study observed symptoms of altered consciousness and disseminated intravascular coagulopathy are frequently profound in the setting of hyperthermia. Elderly people have a lower threshold for the development of renal failure and diminished renal tubular conservation of sodium and water during periods of dehydration (Flynn et al. 2005). In the absence of renal disease, elderly people are at increased danger of hyperkalaemia as they typically have both impairment of glomerular filtration and renal tubular k+ secretion (Flynn et al. 2005; McGreevy et al. 2008).

Flynn et al. (2005) have suggested that a further contributor to risk in extreme hot weather is when elderly subjects are unable to obtain sufficient volume of water for themselves due to infirmity or impaired thirst during such periods of excessive insensitive loss of fluid (Flynn et al. 2005). Under the above mentioned circumstances, elderly people are prone to hypernatraemia. The authors then postulated that many elderly people who succumbed to death during heatwave periods usually were dehydrated, and experience hypernatraemia with indication of renal failure (Flynn et al. 2005).

Persistent heatwaves which are currently experienced as a result of climate change will expose ≥65 years elderly people to increased psychological and physiological stress (Hansen et al. 2008). Study on the effects of heatwaves on mental health in temperate South Australia found that mortalities attributed to mental and behavioural disorders increased during heatwaves particularly in the 65 to 75 years age group with schizophrenia, schizotypal, and delusional disorders (Hansen et al. 2008). Disruption to normal human life from heatwaves thus impacts on human health (Berry et al. 2010; Fritze et al. 2008; Molloy et al. 2008).

In Switzerland, Cerutti et al.'s (2006) study investigated whether the 2003 European heatwaves had a significant impact on mortality and on the demand for ambulance emergency services, particularly among the 65 years and 75 years age groups. The study found significant excess deaths for the first heatwave and a significant increase in ambulance callouts for all age groups.

Positive associations of ambient heat exposure mortality and climate change is now well established (Basu and Samet 2002; Vaneckova et al. 2008a). Elderly population with medical pre-existing and co-morbidity diseases have increased risk of death associated with ambient heat exposure.

2.5 Population Ageing

The global proportion of elderly people is increasing (WHO 2016). The number of people 65 years and over is projected to double from the current 900 million to 2 billion by 2050 (WHO 2016). This global trend is reflected in Australia (ABS 2013; ABS 2014), with the estimated 65 years and over population set to change in the next decades with around one in four Australians being 65 years or older (ABS 2013). In terms of absolute numbers, for example, those aged 65 years and over are projected to increase from 3.5 million in 2014 to 11.5 million by 2101 on a lower estimation value (Figure 2.5; ABS 2013).

In Victoria, estimated resident population as at June 2012 was 5.6 million people (ABS 2013). The estimated resident population in Victoria is projected to increase to 12.1 million in 2061 (ABS 2013). As at June 2012, there were 809,000 people aged 65 years and over living in Victoria. This age group number is projected to increase to 2.3 million in 2061 (ABS 2013).

Katz (2011) has recently compared the percentage of population 65 years and older in nursing homes in 15 post industrialised countries. Significant variation existed, with the percentage ranging from just 0.2% in Korea (with the next lowest being 2.4% in the Netherlands) to 7.0% in Switzerland and 7.9% in Sweden (Katz 2011). With respect to future need for aged care facility places, Katz (2011) states that the "increasing numbers of older adults worldwide, coupled with diminishing social supports, highlights the need for increased long-term care services", and that this need "may further increase depending on the prevalence of obesity, which has tempered recent gains in disability rates".

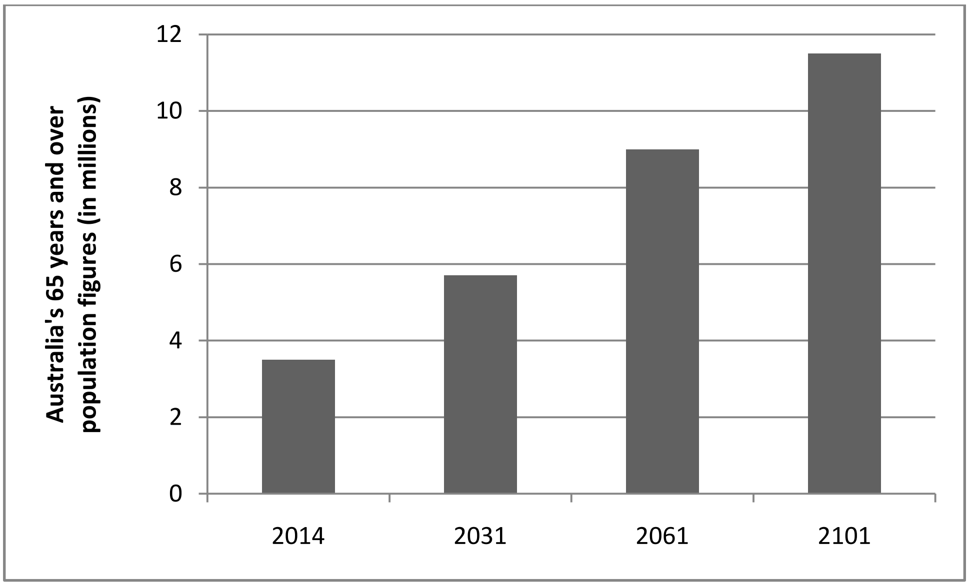

Figure 2.5. Australia’s 65 years and over population in 2014 and projected for 2031, 2061, and 2101. Source: ABS 2013; ABS 2015

2.6 Heatwaves and Human Health in The Elderly in Aged Care Facilities

In this section, studies of heat-related morbidity and mortality in aged care facilities are reviewed. Aged care facility heatwave studies in France, Germany, Italy, United Kingdom and the US found significant high heat-related mortality in residents of aged care facilities (Figures 2.6a-2.6c; Table 2.1). Heat-related mortality was much greater for residents living with one or more medical conditions (e.g., dementia), and for those residents needing assistance with activities of daily living (Garssen et al. 2005; Klenk et al. 2010; Stafoggia et al. 2006). Also, the associations between temperature-related mortality and gender, age, and level of care in residents of aged care facilities are well established (Figures 2.6a-2.6c).

Klenk et al. (2010) studied the relationship between maximum daily temperature and average daily mortality rate stratified by gender (Fig. 2.6a), age category (Fig. 2.6b) and level of care (Fig. 2.6c) in residents aged ≥65 years living in nursing homes in Baden-Württemberg, Germany, between 2001 and 2005. High ambient temperature increased mortality risk in males and females, all age categories, and all levels of care. However, as noted by the authors, there were no age or sex differences in mortality rate ratios associated with a 5°C increase in daily maximum temperature over the threshold of 26°C. (Klenk et al. 2010). On the other hand, "residents with the lowest degree of care need (level of care 1) were found to be less susceptible to heat-related mortality than those categorised within the medium degree of care need (level of care 2)" (Klenk et al. 2010). The study also found 444 excess deaths in 1 month due to the European heatwave of 2003, and 356 in the following 2 months (Klenk et al. 2010).

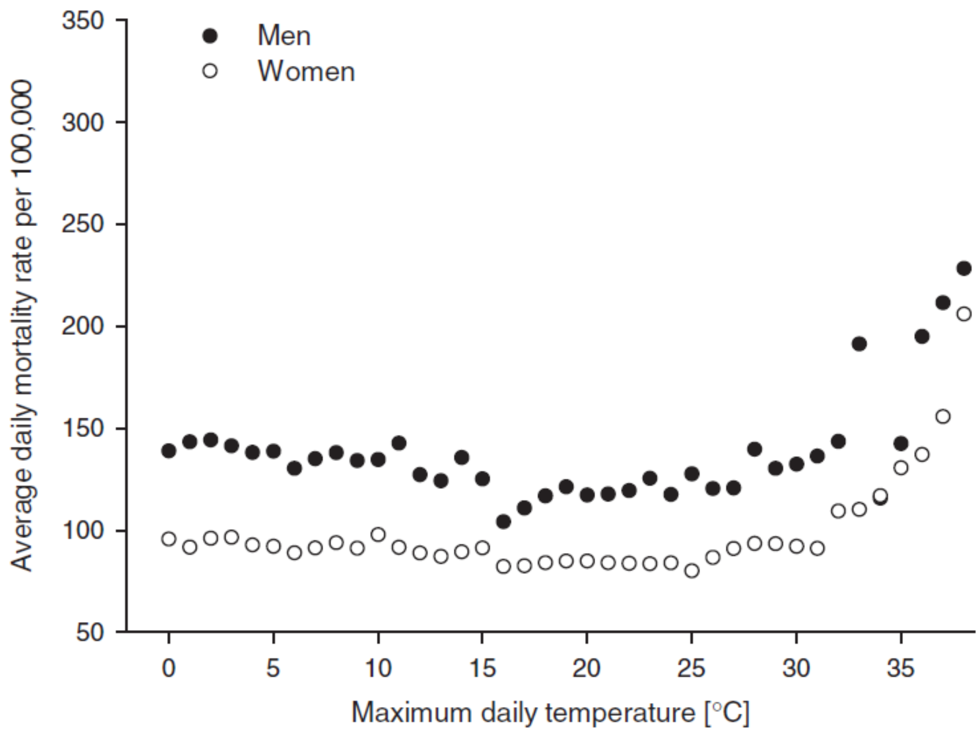

Figure 2.6a. The relationship between maximum daily temperature and average daily mortality rate stratified by gender in residents aged ≥65 years living in nursing homes in Baden-Württemberg, Germany, between 2001 and 2005. Source: Klenk et al. 2010

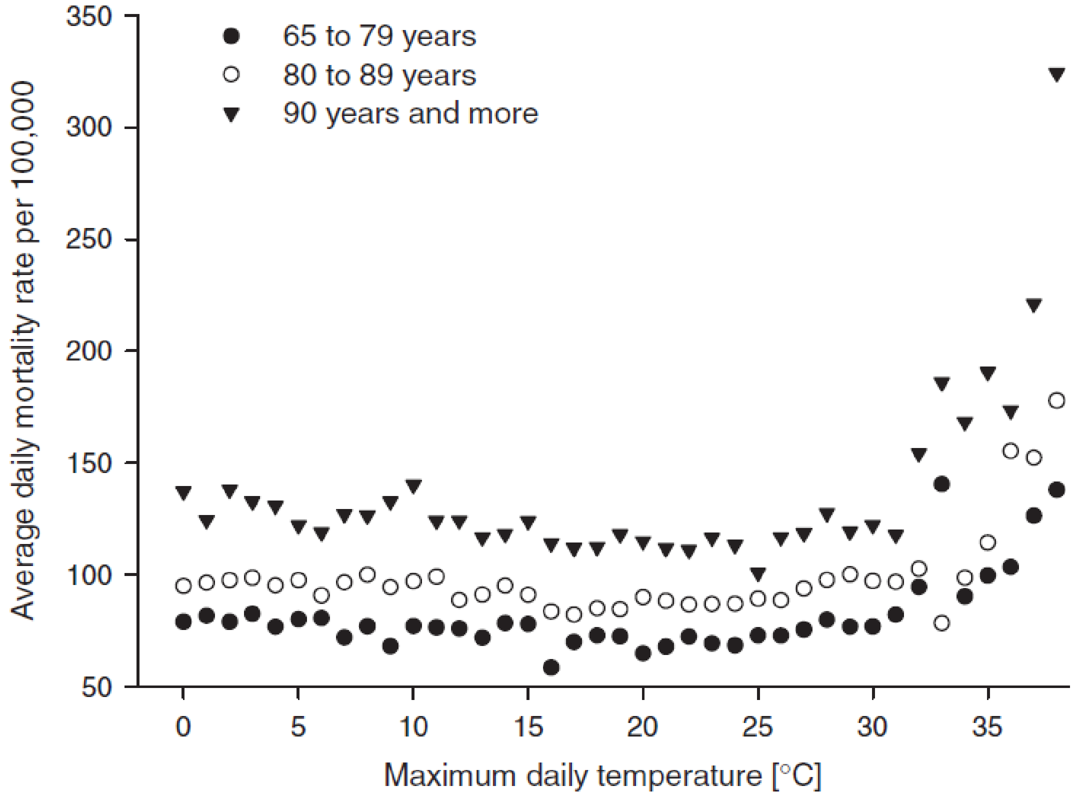

Figure 2.6b. The relationship between maximum daily temperature and average daily mortality rate stratified by elderly age groups in residents aged ≥65 years living in nursing homes in Baden-Württemberg, Germany, between 2001 and 2005. Source: Klenk et al. 2010

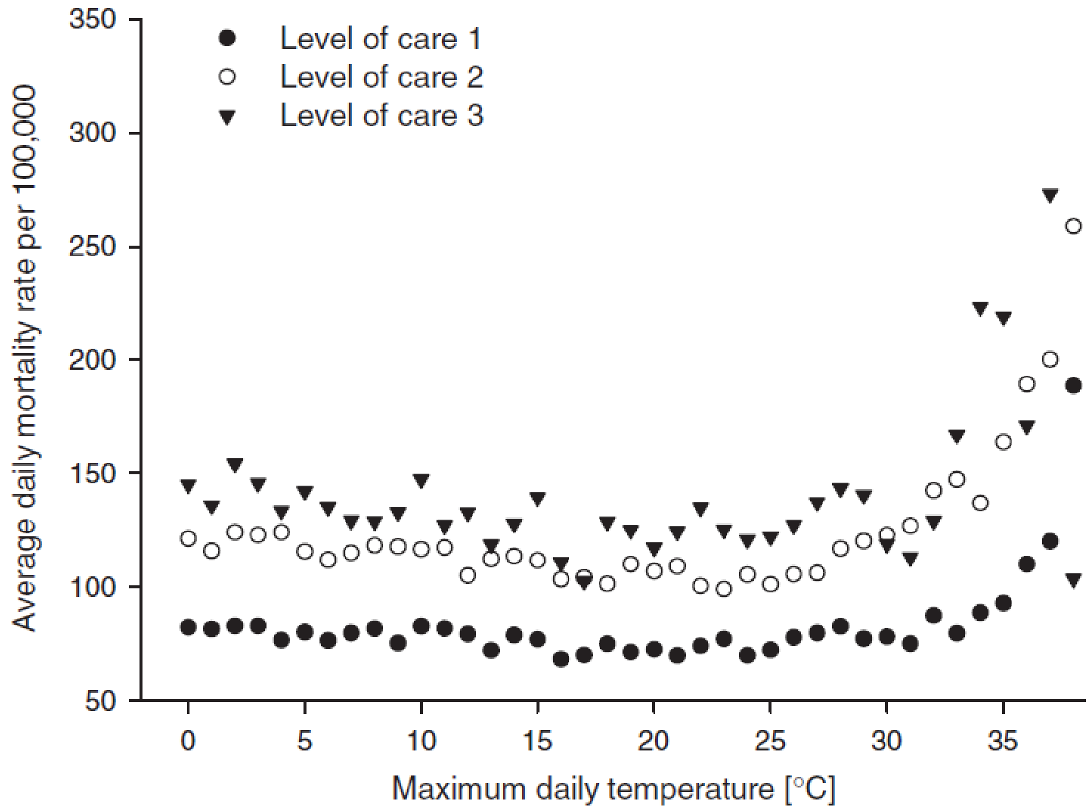

Figure 2.6c. The relationship between maximum daily temperature and average daily mortality rate stratified by level of care in residents aged ≥65 years living in nursing homes in Baden-Württemberg, Germany, between 2001 and 2005. Source: Klenk et al. 2010

Table 2. 1. Examples of studies of heat-related morbidity and mortality in aged care facilities. Studies are ordered chronologically from oldest at the top to newest at the bottom.

Study location	**Study period**	**Climate phenomenon studied**	**Reference**
New York City, USA.	1 May to 30 September 1972; and 1 May to 30 September 1973.	Heatwave.	Marmor 1978.
Louisiana, USA.	1992 to 1993.	High temperature.	Kohn 1995.
Paris, France.	12 to 18 May 2003.	Heatwave.	Holstein et al. 2005.
Bologna, Milan, Rome, and Turin, Italy.	1997 to 2003.	High temperature.	Stafoggia et al. 2006.
England and Wales.	1993 to 2003.	Hot and cold weather.	Hajat et al. 2007.
Modena, Italy.	1 to 31 August 2003.	Heatwave.	Foroni et al. 2007.
France.	25 June to 3 July 2005.	Heatwave.	Gaillat et al. 2008.
North-west England.	July to September 2007.	Heatwave.	Brown and Walker 2008.
Baden-Württemberg, Germany.	1 January 2001 to 31 December 2005.	Ambient maximum temperature.	Klenk et al. 2010.

An Italian study evaluated the effects of summertime high temperature on daily mortality amongst population subgroups defined by their demographic characteristics, socioeconomic status and episodes of hospitalisation for various conditions. The study found that residents of nursing homes were particularly vulnerable (Stafoggia et al. 2006).

Foroni et al.'s (2007) study, to define risk factors for heat-related death in Modena, Italy, during August the hottest month of the 2003 heatwave, established that mortality cases were more likely to be living in nursing homes and needing assistance. This retrospective case-control study found that individuals who died had a complex profile. They were more likely to have cognitive problems and a high degree of co-morbidity and dependence. In addition, the individuals took a higher number of drugs and had a greater number of hospital admissions and specialist visits in the year before death.

Marmor's (1978) study, in the USA, determine if excess mortality during heatwaves is less in air-conditioned nursing homes than in non-air-conditioned nursing homes: and estimated how many deaths in non-air-conditioned nursing homes could have been postponed if air-conditioning had been in operation. It was found that heatwaves cause severe increases in mortality rates in non-air-conditioned nursing homes and little impact on mortality rates in air-conditioned nursing homes. Therefore, excess deaths would have been prevented in non-air-conditioned nursing homes if air-conditioning had been installed (Marmor 1978).

In the Netherlands, Garssen et al.'s (2005) study of the effects of the 2003 heatwave on mortality found the elderly in nursing homes were more affected than the non-institutionalised elderly population. Reasons for this may have included that the institutionalised elderly population was older and had a much higher share of frail and demented persons than the non-institutionalised population.

In France, the effects of heatwave on nursing home residents' mortality and heat-related illness during the 2003 heatwave are well established. Between 12 May and 30 November 2003, there were 785 nursing home deaths (Holstein et al. 2005). Of this number, 245 occurred before the heatwave (mortality rate 2.2% persons month (CI 1.9-2.4)), 241 during heatwave (mortality rate 9.2% persons month (CI 8.0-10.4)), and 299 after heatwave (mortality rate 2.4% persons month (CI 2.2-2.7)) (Holstein et al. 2005). However, decreased mortality during heatwave was noted in patients with dementia and chronic conditions. This may be the result of targeted interventions at the most vulnerable patients at risk of dehydration and other deleterious effects of extreme heat.

Associations between heatwaves and climate-related infectious diseases such as summer influenza have been established by studies in the USA and France (Gaillat et al. 2008; Kohn et al. 1995). Kohn et al.'s study summarises investigations of three summertime outbreaks of acute respiratory illness caused by Influenza Type A (H3N2) in Louisiana, USA, two of which were among residents of nursing homes (Kohn et al. 1995). There were record-breaking high temperatures in southern Louisiana during the month of the outbreaks and the authors suggested this extremely hot weather may have resulted in indoor crowding which can enhance transmission of influenza virus.

Gaillat et al.'s (2008) study also reported on a summer Influenza Type A outbreak in a nursing home, in France, in which 39.5% (n=32/81) of residents were affected. The study found a case mortality rate of 16% (n=5/32) in residents of the nursing home. Diagnostic investigations revealed positive results for fever, shortness of breath, combined with cough and/or respiratory illnesses amongst tested nursing home residents (Gaillat et al. 2008).

This section has described the research on heat-related morbidity and mortality in aged care facilities. While this research comes from several countries, they are all in the Northern hemisphere, and in Australia such aged care facility research does not exist.

2.7 Climate Change Adaptation for Heatwaves

Managing the risks of climate change must involve adaptation and mitigation decisions; with implications for future generations, economies and environments (IPCC 2014a). According to the Intergovernmental Panel on Climate Change, adaptation is defined as the “process of adjustment to actual or expected climate and its effects”. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities (IPCC 2014b).

Adaptation has no single approach for reducing risks appropriate across all settings: it is place and context specific. The planning and implementation of adaptation can be enhanced through complementary actions across levels: for example, from individuals to governments (IPCC 2014a). Every effort to adapt to the health impacts of climate change can be categorised as incremental, transitional or transformational actions (Smith et al. 2014).

Incremental adaptation includes the improvement of public health and health care services for climate-related health outcomes in light of climate change. Transitional adaptation means shifts in attitudes and perceptions, leading to initiatives such as vulnerability mapping and improved surveillance systems that specifically integrate environmental factors (Smith et al. 2014).

Climate change will impact on human health mainly by exacerbating already existing health problems (IPCC 2014a). Climate change adaptation for heatwaves may include information technology systems, and heatwave and health warning systems (Noble et al. 2014). Early warning systems generally are critical to ensuring awareness of natural hazards and the promotion of timely responses including evacuation (Noble et al. 2014). Heatwave and health warning systems (HHWS) may be designed to prevent negative health impacts, predict possible health outcomes, identify triggers, and communicate prevention responses (Noble et al. 2014).

A study that evaluated the effectiveness of heatwave early warning systems using a Poisson regression model to estimate the daily expected number of deaths over the period 2004–2006 in France, found observed mortality during a 2006 heatwave markedly less than the expected mortality (Fouillet et al. 2008). The lower mortality may have been the result of increased awareness of the dangers of extreme high temperatures to human health, awareness of more preventive measures, and adequate heatwave communication by French institutions and health authorities (Fouillet et al. 2008).

Measures designed to minimise heat-health impacts in cities, to keep building internal environments cool, and to improve the general care of the elderly are adaptations likely to reduce future heatwave impacts (Costello et al. 2009; Hajat and Kosatky 2010). These measures have been suggested as incremental adaptation to improve public health and health care services in the face of climate change (Smith et al. 2014).

Lowe et al.'s (2011) study reviewed key characteristics of heatwave early warning systems (HEWS) in 33 European countries, to help inform modification of current and development of new systems and plans. It found 12 of the HEWS have heatwave action plans organised in phases of "forecasting", "monitoring", "warning", and "alert". A number of the countries health department's websites have heat-health advice, and their meteorological departments issue heatwave warnings (Lowe et al. 2011). Passive heat prevention measures are not sufficient to bring about change to heatwave protection. Thus, the need to actively raise awareness of potential health impacts and advise on protecting against, and recognising heat illnesses, including dehydration (Lowe et al. 2011).

The EuroHEAT project explored models of good practices for national/local heatwave preparedness and planning, and how to improve public health responses to weather extremes (e.g., heatwaves). The study found the elderly >65 and >75 years with pre-existing diseases and taking medication as heatwave target population groups (Matthies and Menne 2009).

Heatwave response plans set out what should happen before and during periods of severe heat (Public Health England 2015). They spell out what preparations both individuals and organisations can make to reduce health risks and include specific measures to protect at-risk groups (Public Health England 2015). Therefore, heatwave response plans are formalised measures to reduce heatwave impacts and improve population health in heatwave seasons. There is a need for further development of heatwave response plans, as well as the creation of them where they do not exist, and comparison and assessment of existing plans would be of benefit to this.

Review of the impacts of heatwaves on health, ecosystems and the built environment, and the corresponding mechanisms suggests a number of adaptation mechanisms for dealing with the effects of heatwaves. The mechanisms fall into 3 broad categories including structural/institutional, cultural/behavioural, and technology (Zuo et al. 2015). For example, impacts of heatwaves should be considered during the design of residential buildings (dwelling building adaptation). Nevertheless, effectiveness of these interventions will vary from place to place (Zuo et al. 2015).

Studies about heatwaves and aged care facilities that exist in Australia are community studies on health professionals' knowledge of heatwave awareness, preparation and planning. Black et al.'s (2013) report to the Australian National Climate Change Adaptation Research Facility (NCCARF) focussed on heatwave awareness, preparedness and adaptive capacity in aged care facilities in the three Australian states of New South Wales, Queensland, and South Australia. The report found almost 90% of all care facilities across the three states reported that their facility had an aged care facility emergency plan in place, however, not all included preparation for heat emergencies (Black et al. 2013). Other findings showed that in South Australia, 77% of care facilities had heatwave plans, 41% in Queensland, and 60% of care facilities in New South Wales had some form of informal or formal heatwave plans (Black et al. 2013). Equivalent research has not been conducted in other Australian states including Victoria where severe heatwaves have occurred in recent years and are projected into the future.

There exist some guiding principles about the preparations of Australian health services (e.g., aged care facilities) against climate change impacts such as heatwaves (Blashki et al. 2011). The four principles proposed include flexibility of health services to adjust to uncertain climate change projections, strategic allocation of resources to strengthen existing health services against heat-related illnesses that are expected with the projection of more frequent heatwaves, the robustness of health services to cope with increased climate change related emergencies, and the collaboration between government and non-government organisation response plans (Blashki et al. 2011).

In an electronic survey study that investigated the awareness, knowledge and practices of six different health professions regarding heatwaves and the health of Victorians aged 65 years and over living in the community, it was found that over 90% of respondents are aware heatwave is highly likely to cause the elderly who are already ill to become sicker, and that a heatwave is likely to be associated with an increased number of elderly deaths (Ibrahim et al. 2012). Other findings were that 62% of participants were aware of the problem of thermoregulation (e.g., changes to cutaneous blood flow), that responses to heatwaves were mostly reactive and opportunistic, and that fans are less effective on a very humid day (Ibrahim et al. 2012).

Challenges to heatwave preparations may include lack of heatwave training and coordination, air-conditioning equipment capacity due to restricted power supply, lack of air-conditioning for bedrooms and monitoring of indoor temperatures (McInnes and Ibrahim 2010; McInnes and Ibrahim 2013). Heatwave preparedness and planning is an important component of aged care, particularly in view of recent heatwaves in Australia (Black et al. 2013). Therefore, to have a written heatwave response plan is an important facilitator to heatwave planning (McInnes and Ibrahim 2013).

Health care professionals are being acknowledged as an important group to the success of climate change adaptation. The second Lancet Commission on Health and Climate Change (Lancet 2015), advised health professionals identify individuals susceptible to heat and educate them and their carers about how to stay healthy during heatwaves. Behaviour adaptations including giving guidance on storing and taking medication are other heat-health education health professionals can provide individuals vulnerable to heatwaves (Lancet 2015). Health professionals have the expertise to communicate the risks posed by heatwaves and the benefits of adaptation to the public. They should be the leading forces at promoting health threats from heatwaves by evidence-based health protection, to cut deaths and reduce harm as temperatures continue to rise (Lancet 2015).

Health care professional climate change adaptation capability to identify at-risk patients and tailor clinical care to protect the individuals will contribute to protect human health and the right to health (Sheffield et al. 2014). Knowlton et al.'s (2014) study of human heat-health threats in India, suggests capacity building that enables health care professionals to identify and respond to heat-related illnesses as an adaptation strategy.

Populations that lack good quality public health and health care services are likely to be affected by the changing climate state or system (Smith et al. 2014). Therefore, ongoing investments to advance information about the changing climate system (e.g., extreme high temperatures), and the management of population health are important adaptation to human health (Patz et al. 2000).

2.8 Climate Change Adaptation for Heatwaves in Aged Care Facilities

Adaptation to heatwaves in aged care facilities can be moderated through the understanding of the relationship between residents heat exposure, heat prevention strategies employed, health professionals and care providers heatwave knowledge, and everyday life activities (Brown and Walker 2008; Ibrahim et al. 2012). The heat-related morbidity and mortality impacts reported about residents has led to calls for heatwave adaptation in aged care facilities (Blashki et al. 2011; Brown and Walker 2008; McInnes and Ibrahim 2013).

A review of 12 European countries documented HEWS, suggest heatwave advice messages be directed towards the most vulnerable populations with an early warning of impending heatwave, and outline preventive strategies to minimise the negative effects of intense heat periods (Lowe et al. 2011). The majority of the reviewed HEWS documents suggest heat adaptation advice include daily monitoring of room temperatures and measures to cool environments and residents, heat-auditing rooms, and improving heat-health responses of residential staff and centres (Lowe et al. 2011).

A team of experts in Matthies and Menne's (2009) study developed heat-health action plans to reduce heatwave effects on vulnerable subgroups and it include the adaptation of individual behaviour, and short-, medium- and long-term modifications to buildings to reduce indoor temperatures. Behavioural and medical advisories are also launched through health services, general practitioners (GPs) and pharmacies.

Other heat-health action plans are that hospitals and care home managers, as well as their staff, ensure the implementation of heatwave adaptation measures in their facilities (Matthies and Menne 2009). According to Matthies and Menne (2009), ways to ensure the provisions of routine health and social care during heatwaves and adaptation of facilities and infrastructure to hot temperatures, is to develop heat-health action plans according to national and local needs and possibilities.

Oven et al.'s (2012) study aimed to identify areas of England where future extreme weather-related events and demographic trends may impact on infrastructure for older people's care, in order to develop resilience and adaptation strategies. The study suggested definitions of future weather-related hazards (e.g., heatwaves) be defined based on what, in future, will be the locally prevailing average conditions (projected temperature increases associated with climate change), and vulnerability of the populations exposed (Oven et al. 2012). Hence, the need for infrastructure redesign and adaptations that is more responsive to heatwave threats (Oven et al. 2012).

Training that focuses on diagnoses, surveillance, and reporting of heat-related illnesses and deaths is an essential component of capacity building among health care professionals (Knowlton et al. 2014). Health professionals' roles in climate change adaptations for heatwaves in aged care facilities may include regular maintaining of power back-up systems, information of patients about potential impacts and implemented prevention and coping measures, cooperation with other healthcare facilities, and monitoring of critical health infrastructures to prevent health services interruption and breakdowns (Hiete et al. 2011).

Despite the very considerable attention that has been paid to conducting research on climate change adaptation in some countries and some sectors, there remains an important need for such research focussed on potential future impacts of heatwaves on the elderly in aged care facilities.

2.9 Chapter Summary

This chapter discussed current knowledge and recent developments within the scope of climate change, heatwaves, and elderly human health impacts of heatwave in aged care facilities, population ageing, and adaptation to heatwaves in aged care facilities.

In summary, studies reveal high heat-related illnesses and deaths in residents of aged care facilities particularly in those residents needing assistance with activities of daily living, and having high degree of health co-morbidities. Having a written heatwave response plan is an important facilitator to heatwave planning; however, how it can be developed to communicate heatwave prevention and management strategies is essential in overseas and Australian aged care facilities.

Given that heatwaves have much greater health effects on aged care facility residents and are projected to become more frequent, more severe and long lasting in Australia and overseas, a range of adaptations for heatwaves may be particularly appropriate in aged care facilities, but this has been seldom studied. In Australia, there are studies of health professionals' knowledge on heatwave awareness, preparation and planning in the communities, nonetheless, this has been rarely studied in Australian aged care facilities.

The following chapters present the methods and results of three components of original research on heatwave response plans, adaptation to heatwaves in aged care facilities, and heatwave preparedness and planning in Victorian aged care facilities in order to address and fulfil the thesis aims. The next chapter will discuss the methods used for this thesis.

CHAPTER 3

METHODS

In order to address each thesis aim stated in the introductory chapter (Chapter 1), this thesis examines heatwave response planning and adaptation with a focus on the health of the elderly in aged care facilities. Three related pieces of research were conducted to explore different aspects of this topic, these being a comparison of heatwave response plans from an aged care facility perspective, strategies for adaptation to climate change impacts in aged care facilities, and heatwave preparedness and planning in aged care facilities in Victoria, Australia. The methods for each of these are described in the following three sections.

3.1 Comparison of Heatwave Response Plans

Chapter 4 assesses, compares and analyses heatwave response plans from an aged care facility perspective.

3.1.1 Study Selection

The five countries selected share English as at least one official language; are developed, high income nations that are members of the Organisation for Economic Co-operation and Development (OECD) (The World Bank Group 2016); and are experiencing demographic shifts that are marked by ageing populations (ABS 2013; The World Bank Group 2016; Wilmoth and Longino 2006). It is also noteworthy that these countries are located in a range of climatic zones.

3.1.2 Data Sources

Publicly available national and state/provincial heatwave response plans were initially sourced from government health department websites of Australia, Canada, NZ, UK, and US. The limited number of plans at these levels led to further searches at the municipal government level. Heatwave response plans referred to but not available through these websites were requested by email to the relevant departments. This resulted in acquisition of a total of 23 heatwave response plans, published between December 2004 and January 2013. Most (21) of these plans were obtained from the internet, with the other two obtained following a request by email to Health Canada and East Gippsland Shire Council.

Fifteen of the 23 plans reviewed were published by the Australian Commonwealth Government, state health departments, and municipalities. Eleven of these were from the Australian state of Victoria: two plans were produced by the state Department of Health and 9 were randomly selected from a total of 78 local councils divided into 9 administrative districts of the state of Victoria (the first council alphabetically for each administrative district with an available plan was selected) (State Government of Victoria 2016; State of Victoria Department of Health 2011).

Three plans each were obtained from Canada and the UK, and two from the US. No heatwave response plans were identified for NZ.

3.1.3 Data Extraction

The heatwave response plans obtained were analysed for inclusion of working definitions of temperature threshold warnings, heat stress prevention strategies, targeted organisations and individuals, communication strategies, scheduled updates and revisions, and for specific inclusion of aged care facility response plans.

3.2 Climate Change Adaptation Theoretical Frameworks

Chapter 5 assesses, compares and analyses different climate change adaptation theoretical frameworks on adaptation measures, and expand on them as a set of adaptation for heatwaves in aged care facilities.

These adaptation measures are in adaptive categories of primary, secondary and tertiary preventions that were further divided into short-term and long-term adaptation measures acknowledged.

3.3 Survey of Heatwave Preparedness and Planning in Victorian Aged Care Facilities

3.3.1 Survey setting

This is a cross-sectional survey questionnaire of heatwave preparedness and planning in Victorian aged care facilities. In Victoria, there are over 800 aged care facilities (Ibrahim et al. 2012). The Australian Government Department of Social Services' (2016) aged care service list for Victoria was used to obtain aged care facility information including name, physical address, organisation type, and Australian Bureau of Statistics (ABS) remoteness area class. The ABS Remoteness Structure is one of the seven structures that compose the Australian Standard Geographic Classification (ASGC), and its purpose is to "provide a classification for the release of statistics that inform policy development by classifying Australia into large regions that share common characteristics of remoteness" (ABS, 2014). A web-based search was then conducted for the e-mail address of the aged care facilities. Altogether, e-mail addresses were obtained for 525 aged care facilities. A letter of introduction to the research and a link to the survey were emailed to the directors and managers of these aged care facilities.

3.3.2 Survey design

The survey questions were a revised version of the study questionnaire by Black et al. (2013). Black et al.'s (2013) questionnaire contained approximately 74 questions on staff knowledge about heatwave policies and planning, and heatwave prevention strategies in aged care facilities. Our revised survey contained 50 questions on similar heatwave preparedness and planning (Appendix 2). There were additional response options to the survey questions beyond just the 'Yes' and 'No' options used by Black et al. (2013). Added response options were 'Currently under development', 'Not applicable', 'Not sure', and 'Other', as appropriate.

The included response options allowed participants to respond more accurately to the questions. Because our survey questionnaire was on aged care facilities in Victoria, Black et al.'s (2013) question on the NSW Health Department's 'Beat the Heat' was changed to question 50 in our survey about the Victorian Government Department of Health 'Residential Aged Care Services Heatwave Ready Resource' (Victorian Government Department of Health 2010). The meaning of a number of the questions in the Black et al. (2013) survey was not perfectly clear and such questions were modified slightly to clarify meaning and/or to use consistent terminology (e.g., consistently using the word "facility" rather than alternating between "facility' and "service").

Sampled Victorian aged care facilities were asked about heatwave response plans; annual in-service heatwave training; and process for communicating heatwave procedures to staff, residents and families. Other healthcare assessments and processes asked about included the risks and prevention of dehydration.

The survey was conducted using the online Qualtrics system for 4 weeks, between 28 July 2015 and 21 August 2015. Due to initial low response rates, two subsequent reminder emails were sent, one after the first 2 weeks and one in the last week of the survey. Ethical aspects of the study were approved by the Macquarie University Human Research Ethics Committee (Ethics Approval Number: 5201401035) (Appendix 1).

All data generated by this study was analysed using Chi squared test statistics. A p value less than 0.05 was considered statistically significant.

The following three chapters (Chapters 4-6) are presented as papers and include the results of these three studies, as well as discussion, in turn.

CHAPTER 4

PAPER 1

A COMPARISON OF HEATWAVE RESPONSE PLANS FROM AN AGED CARE FACILITY PERPECTIVE

Names of all authors:

Benjamin Okwuofu-Thomas, MAgeHlth

Department of Environmental Sciences, Faculty of Science and Engineering, Macquarie University, Sydney, New South Wales 2109, Australia

Paul J. Beggs, PhD

Department of Environmental Sciences, Faculty of Science and Engineering, Macquarie University, Sydney, New South Wales 2109, Australia

Ross J. MacKenzie, PhD

Department of Psychology, Faculty of Human Sciences, Macquarie University, Sydney, New South Wales 2109, Australia

Published April 2017: Okwuofu-Thomas B, Beggs PJ, MacKenzie RJ. A comparison of heat wave response plans from an aged care facility perspective. Journal of Environmental Health 2017; 79 (8): 28-37. http://www.neha.org/node/58996

Abstract accepted and presented at the 2014 National Climate Change Adaptation Research Facility conference in Gold Coast, Australia (see Appendix 3).

P1.1 Individual contributions

Discussions with my principal supervisor (Associate Professor Paul J Beggs) led to the initiative to review heatwave response plans for specific responses aimed at residents of aged care facilities during heatwave seasons. The conception, design and the acquisition of data for the manuscript were undertaken by the candidate, with frequent input from all supervisors (Associate Professor Paul J Beggs., Dr. Ross MacKenzie).

This paper is formatted as required by the *Journal of Environmental Health* (as detailed at: http://ecoanimal.com.brwww.neha.org/sites/default/files/publications/jeh/Instructions-JEH-Authors.pdf). This paper's content is exactly that submitted to and accepted by the *Journal of Environmental Health* for publication.

A Comparison of Heatwave Response Plans from an Aged Care Facility Perspective

Abstract

Heatwaves result in significant excess mortality, particularly amongst the elderly. This article examines selected heatwave response plans at national, state/provincial, and municipal levels, with a particular focus on specific responses aimed at residents of aged care facilities. Heatwave response plans were sourced from several countries that are experiencing demographic transition that features growing ageing populations. A total of 23 heatwave response plans were obtained. Most of the plans were from Australia, with only three plans each available from Canada and the UK, and only two available from the US. Key components found across the plans were analysis of temperature thresholds, heat stress prevention measures, and communication strategies. Only three heatwave response plans analysed included specific guidance for aged care facilities. Projected increases in frequency and duration of heatwaves in coming decades underline the need for governments to implement effective guidelines that include specific provisions for aged care facilities.

Keywords: aged care facilities; climate change; elderly; heatwave response plans

Introduction

Heatwaves are periods of abnormally and uncomfortably hot weather that can impact on human health and place demands on community infrastructure and services (World Health Organization (WHO), 2009). The main heat-related illnesses are heat cramps, heat exhaustion, and heat stroke, with the last of these able to cause death or permanent disability. The potential magnitude of such health impacts of heatwaves was demonstrated by the 70,000 excess deaths caused by the 2003 European heatwaves, with an estimated 14,802 excess deaths occurring in France alone during the first 3 weeks of August 2003 (Haines, Kovats, Campbell-Lendrum, & Corvalan, 2006; Hayhoe, Sheridan, Kalkstein, & Greene, 2010). Heatwaves represent an increasingly significant population health problem that must be addressed at multiple levels of government (Yardley, Sigal, & Kenny, 2011).

The impact of heatwaves is particularly severe amongst the elderly population (Conti et al., 2005; Foroni et al., 2007; Grize, Huss, Thommen, Schindler, & Braun-Fahrländer, 2005; Hajat, Kovats, & Lachowycz, 2007; Johnson et al., 2005; Simón, Lopez-Abente, Ballester, & Martínez, 2005; Stafoggiaet al., 2006; Vaneckova, Beggs, de Dear, & McCracken, 2008; Vaneckova, Beggs, & Jacobson, 2010). The relationship between heatwaves and illness in the elderly is determined by the level of exposure to outdoor temperature, and is influenced by the demographic profile of vulnerable groups and pre-existing health status (WHO, 2009). The combination of factors that impact on elderly thermoregulation and associated risk of heat-related illnesses includes lack of behavioural adaptation; cardiac output or reduced plasma volume; and factors that affect perspiration such as ageing, cystic fibrosis, dehydration, diabetes, scleroderma, and medication (WHO, 2009). Those 65 years of age and over residing in care institutions such as retirement villages, hostels, or nursing homes are likely to suffer from one or more of these conditions and diseases (Victorian Government Department of Health, 2010). There is also increasing evidence that those aged 75 years and over are the most vulnerable to health impacts from heatwaves (WHO, 2009).

Aged care facilities and what were previously referred to as nursing homes include residential aged care where the resident receives personal and/or nursing care in a residential facility, as well as accommodation. Several studies indicate that the impacts of heatwaves on the elderly are most pronounced among residents of aged care facilities (Foroniet al., 2007; Garssen, Harmsen, & de Beer, 2005; Hajat et al., 2007; Holstein, Canouï-Poitrine, Neumann, Lepage, & Spira, 2005; Klenk, Becker, & Rapp, 2010; Stafoggia et al., 2006). A study of the August 2003 heatwave in the Netherlands (Garssen et al., 2005), for instance, found there were 1/3 more deaths in residents of nursing homes than in the non-institutionalised elderly population. Klenk et al. (2010) also demonstrated the impact of the 2003 European heatwave on residents of nursing homes, showing that >400 additional deaths occurred in a south-western Germany sample of nursing home residents. An Italian study of vulnerability to temperature-related mortality during summer between 1997 and 2003 similarly found heat-related mortality to be higher among people residing in nursing homes and health care facilities than in the overall elderly population (Stafoggia et al., 2006).

A number of studies have shown that heatwave response plans are effective in reducing heat-related morbidity and mortality (Fouillet et al., 2008; Lowe, Ebi, & Forsberg, 2011; Michelozzi et al., 2010; Morabito et al., 2012; Palecki, Changnon, & Kunkel, 2001; Smoyer-Tomic, & Rainham, 2001; Weisskopf et al., 2002; WHO, 2009). Bassil & Cole (2010) have recently reviewed the effectiveness of public health interventions in reducing morbidity and mortality during heat episodes. Heatwave response plans per se received only limited attention in this broader review. This included the observation that there are usually several public health interventions included in a heatwave response plan that are implemented simultaneously and that this makes it difficult to attribute any beneficial effect to one intervention over another (Bassil, & Cole, 2010). The review also noted that many of the interventions are aimed at encouraging changes in individual practice (Bassil, & Cole, 2010). To date, there has been only one international review of heatwave response plans, focusing on those in European countries (Lowe et al., 2011). Its main findings included that an understanding of the similarities and differences in key characteristics of heatwave response plans from the different countries could inform improvements in these plans (Lowe et al., 2011). However, there is a need for further research on heatwave response plans, including research that includes other regions and/or countries, and research that places greater emphasis on particular characteristics of heatwave response plans, such as consideration of aged care facilities.

Population growth that will include proportionately larger elderly populations in Australia, Canada, New Zealand (NZ), the United Kingdom (UK), and the United States (US) has been projected for coming decades (Australian Bureau of Statistics (ABS), 2013; Oven et al., 2012; Wilmoth, & Longino, 2006). Australia's population of 22.7 million in 2012, for example, is projected to increase to between 36.8 and 48.3 million in 2061 (ABS, 2013). The estimated elderly population, 65 years of age and over, stood at 3.2 million in 2012 and is projected to increase to between 9.0 and 11.1 million in 2061 (ABS, 2013). Additional to these population changes are climate change projections that include both the frequency and duration of heatwaves increasing in coming decades (Intergovernmental Panel on Climate Change, 2013). These demographic and climate projections mean that well-developed heatwave response plans will become increasingly important.

This review will evaluate available plans from Australia, Canada, NZ, UK, and US, with particular focus on provisions for residents of aged care facilities. Comparison and evaluation, and identification of the key characteristics of heatwave response plans from different countries, may help inform modification of current, and development of new, heatwave response plans (Lowe et al., 2011).

Methods

Data Sources

Publically available national and state/provincial heatwave response plans were initially sourced from government health department websites of Australia, Canada, NZ, UK, and US. The limited number of plans at these levels led to further searches at the municipal government level. Heatwave response plans referred to but not available through these websites were requested by email to the relevant departments. This resulted in acquisition of a total of 23 heatwave response plans, published between December 2004-January 2013 (listed in online supplementary table). Most (21) of these plans were obtained from the internet, with the other two obtained following a request by email to Health Canada and East Gippsland Shire Council.

Fifteen of the 23 plans reviewed were published by the Australian Commonwealth Government, state health departments, and municipalities. Eleven of these were from the Australian state of Victoria: two plans were produced by the state Department of Health and 9 were randomly selected from a total of 78 local councils divided into 9 administrative districts of the state of Victoria (the first council alphabetically for each administrative district with an available plan was selected) (State Government of Victoria, 2016; State of Victoria, Department of Health, 2011).

The considerable number of documents available from Australian jurisdictions was in large part the result of the Victorian state government's initiative particularly over the period 2008-2009 to fund local councils to develop heatwave response plans (Victorian Government Department of Human Services, 2009). Three plans each were obtained from Canada and the UK, and two from the US. No heatwave response plans were identified for NZ. Four potentially related documents published by the NZ Ministry of Health (2000; 2002; 2015a;

2015b) contain no specific information on heatwave response or impacts other than very brief mention in the National Health Emergency Plan (NZ Ministry of Health, 2015b).

Study Selection

The five countries selected share English as at least one official language; are developed, high income nations that are members of the Organisation for Economic Co-operation and Development (The World Bank Group, 2016); and are experiencing demographic shifts that are marked by ageing populations (ABS, 2013; The World Bank Group, 2016; Wilmoth, & Longino, 2006). It is also noteworthy that these countries are located in a range of climatic zones.

Data Extraction

The heatwave response plans obtained were analysed for inclusion of working definitions of temperature threshold warnings, heat stress prevention strategies, targeted organisations and individuals, communication strategies, scheduled updates and revisions, and for specific inclusion of aged care facility response plans.

Results and Discussion

Heatwave Definition and Threshold Temperature

All the plans have either a technical or a descriptive definition of heatwaves. Twelve plans include a general written heatwave definition based on one or more days of abnormally and uncomfortably hot weather that could potentially impact population health, community infrastructure and services.

Sixteen of the 23 plans, these being the United Kingdom plans and most of the Australian plans, also include a threshold temperature. A threshold temperature (or temperature threshold) can be defined as the minimum temperature that is likely to impact on the health of a community, i.e., the temperature above which heat-related illness and mortality increases substantially (State of Victoria, Department of Health, 2011). The threshold daily mean temperature listed in the plans varied, ranging from 30°C to 36°C.

Despite at least some of the heatwave response plans referring explicitly to acclimatisation and acknowledging that the impacts of heatwaves can be more devastating early in summer, when populations have yet to become accustomed to high temperatures (Australian Commonwealth Government (ACG), 2011), all heatwave response plans use a single threshold temperature for the whole summer period.

Some level of correlation between temperature thresholds described in the heatwave response plans and their respective location latitudes was anticipated, i.e., countries in tropical and low temperate latitudes might have higher temperature thresholds that reflect their general climatic conditions. Temperature thresholds demonstrated some variation across climatic zones; the UK national plan's temperature threshold of ~30°C for the day/maximum alone (not the day-night mean) was similar to the mean temperature thresholds for most of the other (lower latitude) locations.

Heat Stress Prevention Strategies

The 23 response plans include a total of 13 different heat stress prevention strategies (Table1). The most common were related to hydration, minimising physical activities, avoiding sun exposure, and to knowing the signs and symptoms of heat (Table1). All three of the UK heatwave response plans (UK Department of Health, 2010; UK Department of Health, 2012; Welsh Government, 2012), for instance, underline the importance of maintaining hydration levels and avoiding sun exposure during heatwaves to prevent related illness and death (UK Department of Health, 2010).

One of the key clinical care management areas identified with lower quality of life in aged care facilities was hydration (Courtney, O'Reilly, Edwards, & Hassall, 2009). Leiper, Primrose, Primrose, Phillimore, & Maughan (2005) found that ageing adversely affects water homeostasis and urine output in physically inactive residents of aged care facilities to a greater degree than that amongst the physically active elderly population living in the community.

Canada's Extreme Heat Events Guidelines (Health Canada, 2011) is the only plan that listed all 13 heat stress prevention strategies found across the 23 heatwave response plans (Table 1). Almost all (n=22) of the plans include at least 5 different types of heat stress prevention strategies.

Across the 23 plans examined, strategies tended to reflect the characteristics of the areas they cover. Much of South Australia, and the Darebin and Central Goldfields regions in the adjoining state of Victoria (Central Goldfields Shire Council, 2010; Darebin City Council, 2009; Government of South Australia, SA Health, 2013), are manufacturing, mining and construction regions that share a combination of high mean temperatures and labour intensive economic activities which can have debilitating impact on workers' health. Plans for these areas commonly describe the need for "frequent rest breaks and wearing of protective clothing" for outdoor and construction site workers (Central Goldfields Shire Council, 2010; Darebin City Council, 2009).

A similar analysis was conducted of the 12 European heatwave response plans by Lowe et al. (2011). They also found hydration to be amongst the most frequently listed individual adaptation actions in these plans. One of the notable differences, however, was not only a difference in the frequency of the sun avoidance strategy (only 4 of the 12 European plans advising this), but also an apparent difference in focus, with the European plans presenting this as “protect against sunburn” rather than “stay out of the sun”. Importantly, the former may not protect against dangerous heat load from sun exposure, given some forms of sunburn protection (such as sunscreen) do not reduce heat load from the sun.

Targeted Organisations and Individuals

Identifying and alerting relevant organisations and stakeholders about the dangers of heatwave events, and directing implementation of strategies and guidelines is a particularly significant aspect of effective response. The Canadian national guidelines (Health Canada, 2011) and the Australian national framework (ACG, 2011) clearly identify their respective target audiences, but marked differences exist between the two plans in terms of the range of institutions and individuals targeted.

Canada’s national Guidelines are most explicitly directed at specific individuals, organisations, and stakeholders in health care delivery services. Key targets (listed in online supplementary table) include: medical health officers; retirement homes and long-term care facilities; medical helpline workers; nurse practitioners; nurses; paramedics; midwives; dieticians; pharmacists; and home care workers. It also explicitly recognises individual alternative/complementary practitioners such as traditional and indigenous healers (Health Canada, 2011), suggesting official awareness of the diversity of public responses to health issues, and their role in achieving the broadest possible dissemination. The Australian national framework, by contrast, is aimed at more established, typical stakeholders such as emergency services and government organisations (ACG, 2011).

Communication Strategies

Twelve distinct communication strategies were identified across the 23 plans (Table 2), and no single document contained all of these strategies. All response plans identify departments of health as the initial medium of heatwave warnings and interventions, and over 91% (n=21) of the response plans emphasise the role of media releases on radio and television in effective communication strategies aimed at local health administrators, hospitals, health agencies, community health centres and other key stakeholders (Table 2). Other means of communication include websites, posters, flyers, and brochures. Apart from the references to websites in the Australian (ACG, 2011) and Vancouver plans (City of Vancouver, 2010), there was little other mention of social media such as Twitter and Facebook.

Review Provisions

Bernard & McGeehin (2004) have highlighted the importance of revision of heatwave response plans, identifying this as one of six central principles around which heatwave planning should be organised. Ten of the 23 heatwave response plans recommend annual review to identify improvements to their procedures, policies, and planning to prepare the community for potential heatwaves. Australia's 2011 national framework for protecting human health and safety during severe and extreme heat events (ACG, 2011) is scheduled for review and update every 3 to 5 years, whilst England's heatwave plan for care homes (UK Department of Health, 2010) makes no mention of a review process.

Compliance with guidelines and recommendations for review that do exist appears to be generally poor. The 2004 Queensland heatwave response plan, for example, does not appear to have been updated since its original publication, despite recommendation that it be reviewed within three months of a heatwave season (Queensland Government, 2004) and Queensland having experienced heatwaves since 2004 (ACG, 2011).

Specific Inclusion of Aged Care Facility Response Plans

Only three plans contain specific provisions for aged care facilities: the Canadian technical guide for health care workers (Health Canada, 2011); the English national plan (UK Department of Health, 2010); and Residential Aged Care Services Heatwave Ready Resource for Victoria (Victorian Government Department of Health, 2010). The latter two plans are particularly substantial in this respect. The Victoria resource, for example, includes detailed sections on heatwave planning in residential aged care and a heatwave checklist for residential aged care, and heatwave information to assist development of brochures, flyers or posters including “ten common myths and misunderstandings”, information for residents, and information for carers and families.

Disaster preparedness for nursing homes without air-conditioning is also highlighted, with the Canadian technical guide including a section specifically on this topic. Noteworthy beyond these three plans is that the City of Toronto Hot Weather Response Plan (City of Toronto, 2012) also states that Toronto’s Homes for the Aged “provides six relief short-term stay beds for use by frail isolated seniors during an Extreme Heat Alert, as required”.

Given that the elderly (those aged ≥65 years of age) comprise one of the most vulnerable groups to the adverse health impacts of heatwaves, and that the most susceptible within this community tend to be concentrated in aged care facilities, the absence of explicit reference to such facilities in all but three of the documents reviewed represents a significant shortcoming that must be addressed in future heatwave response planning. Similarly, the review of heatwave response plans focusing on the 12 European countries (Lowe et al., 2011) indicated that aged care facilities were largely omitted from such plans, with just one of the plans making reference to the “institutionalized” being an at risk population, and carers of adults in nursing homes being identified in the French action plan which provided a tailored information brochure for this vulnerable group.

Limitations

This study has a number of limitations that may be addressed in future studies. It has included a focus on aged care facilities for reasons outlined in the Introduction. However, a broader examination of the inclusion of the elderly population generally in heatwave response plans requires serious attention by researchers. While this study has considered heatwave response plans from all levels of government and analysed them for a number of attributes, it has not explicitly considered the differences between heatwave response plans at each level of government. Similarly, this study has not examined and analysed the connectivity and interrelatedness of the heatwave response plans from each country, or the extent to which they may be hierarchical. Such analyses could be insightful and lead to further improvement in the integration of plans at different levels.

Conclusion

Based on examination of the 23 heatwave response plans, there is a broad range and variety of recommended responses to heatwaves. Given the growing ageing populations of the countries studied, the high vulnerability among residents of aged care facilities to heatwaves, and the absence of specific aged-care facility guidelines in the majority of heatwave response plans reviewed, the need for national and sub-national governments to address heatwave response for such facilities is clear.

A comprehensive heatwave response plan would ideally consider in its development all 13 heat stress prevention strategies and all 12 communication strategies found in the plans reviewed. However, not all heat stress prevention and communication strategies identified here will necessarily be relevant or appropriate for all heatwave response plans, and indeed there may be heat stress prevention and communication strategies not included in any of the 23 plans that are worthy of consideration for future plans. Similarly, all heatwave response plans should provide such basic information as a working definition of what constitutes a heatwave.

More broadly, a number of guides and templates are available for the development of heatwave response plans. For example, the Victorian Government guide for local government (Victorian Government, 2009) provides extensive information, guidance, actions, and advice to assist local councils address the risks associated with heatwaves at a community level. It makes brief mention of aged care facilities: in terms of interaction of municipal and aged care facility heatwave response plans; as potential stakeholders and partners to consider when local government is developing a heatwave plan; and as one of the establishments to which letters from local government about key heatwave-health messages can be disseminated. In the US, the Centers for Disease Control and Prevention (CDC) "works on guidelines to assist state and local health departments in their development of city-specific comprehensive heat emergency response plans" (US CDC, 2016).

Of particular concern is that New Zealand, where heatwaves are not uncommon (National Institute of Water and Atmospheric Research, 2010) seems to have no heatwave response plan at any level of government. Similarly, the small number of US heatwave response plans that could be accessed for this study is a significant vulnerability, given the enormous size of the US population and its great climatic and other heterogeneity.

Comprehensive public health emergency communication involves the interaction of government agencies, and intermediary responses such as the media and professional experts (Maxwell, 2003). In terms of heatwave response, communication will need to incorporate departments of health, hospitals, care home managers and staff; through the combination of traditional print and broadcast media; and more recent innovations such as Twitter, Facebook and other social media sites to disseminate heatwave warnings and response plans to the general public (ACG, 2011; City of Vancouver, 2010; Claessens et al., 2006; How, Chern, Wang, & Lee, 2000; Josseran et al., 2009; Sheridan, 2007).

Given projections that climate change will result in increased occurrence of heatwaves, comprehensive heatwave response plans will become of greater importance in coming decades. The Victorian Government's directive to local authorities to produce response plans suggests the value of proactive initiatives; and related funding provides one possible model that could be affordably adopted in other jurisdictions as a part of a broader preventative health agenda.

Acknowledgements

The authors wish to thank the National Ministries of Health in Canada and New Zealand, and state/provincial and municipal departments of health in Australia and Canada that replied to our request for their current heatwave response plans.

References

Arizona Department of Health Services. (2011). *Heat emergency response plan*. Arizona: Author.

Australian Bureau of Statistics. (2013). *Population projections, Australia, 2012 (base) to 2101: Projection results - Australia.* Retrieved from http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/3222.0main+features52012%20%28base%29%20to%202101

Australian Commonwealth Government. (2011). *Protecting human health and safety during severe and extreme heat events. A national framework.* PricewaterhouseCoopers Australia.

Bassil, K.L., & Cole, D.C. (2010). Effectiveness of public health interventions in reducing morbidity and mortality during heat episodes: a structured review. *International Journal of Environmental Research and Public Health, 7,* 991-1001.

Baw Baw Shire Council. (2009-2012). *Heatwave response & action plan 2009-2010.* Baw Baw Shire, Victoria: Author.

Bernard, S.M., & McGeehin, M.A. (2004). Municipal heat wave response plans. *American Journal of Public Health, 94,* 1520-1522.

Central Goldfields Shire Council. (2010). *Heat wave response plan.* Central Goldfields Shire, Victoria: Author.

City of Toronto. (2012). *Hot weather response plan.* Toronto, Ontario: City of Toronto Public Health.

City of Vancouver. (2010). *2010 extreme hot weather preparedness & response plan.* Vancouver, British Columbia: Author.

Claessens, Y.-E., Taupin, P., Kierzek, G., Pourriat, J.-L., Baud, M., Ginsburg, C., Jais, J.-P., Jougla, E., Riou, B., Dhainaut, J.-F., & Landais, P. (2006). How emergency departments might alert for prehospital heat-related excess mortality? *Critical Care, 10,* R156.

Conti, S., Meli, P., Minelli, G., Solimini, R., Toccaceli, V., Vichi, M., Beltrano, C., & Perini, L. (2005). Epidemiologic study of mortality during the Summer 2003 heat wave in Italy. *Environmental Research, 98,* 390-399.

Courtney, M., O'Reilly, M., Edwards, H., & Hassall, S. (2009). The relationship between clinical outcomes and quality of life for residents of aged care facilities. *Australian Journal of Advanced Nursing, 26(4),* 49-57.

Darebin City Council. (2009). *Darebin heatwave plan.* Darebin City, Victoria: Author.

East Gippsland Shire Council. (2010). *Heatwave plan.* East Gippsland Shire, Victoria: Author.

Foroni, M., Salvioli, G., Rielli, R., Goldoni, C.A., Orlandi, G., Sajani, S.Z., Guerzoni, A., Maccaferri, C., Daya, G., & Mussi, C. (2007). A retrospective study on heat-related mortality in an elderly population during the 2003 heat wave in Modena, Italy: the Argento Project. *Journal of Gerontology: Medical Sciences, 62A,* 647-651.

Fouillet, A., Rey, G., Wagner, V., Laaidi, K., Empereur-Bissonnet, P., Le Tertre, A., Frayssinet, P., Bessemoulin, P., Laurent, F., De Crouy-Chanel, P., Jougla, E., & Hémon, D.

(2008). Has the impact of heat waves on mortality changed in France since the European heat wave of summer 2003? A study of the 2006 heat wave. *International Journal of Epidemiology, 37,* 309-317.

Gannawarra Shire Council. (2012). *Heatwave plan.* Gannawarra Shire, Victoria: Author.

Garssen, J., Harmsen, C., & de Beer, J. (2005). The effect of the summer 2003 heat wave on mortality in the Netherlands. *Eurosurveillance, 10(7),* 165-167.

Government of South Australia, SA Health. (2013). *Extreme heat operational plan.* SA: Author.

Government of Western Australia Department of Health. (2010). *Operational directive: heatwave policy.* Perth, WA: Author.

Greater Shepparton City Council. (2009). *Greater Shepparton heatwave plan 2009.* Shepparton, Victoria: Author.

Grize, L., Huss, A., Thommen, O., Schindler, C., & Braun-Fahrländer, C. (2005). Heat wave 2003 and mortality in Switzerland. *Swiss Medical Weekly, 135(13),* 200-205.

Haines, A., Kovats, R.S., Campbell-Lendrum, D., & Corvalan, C. (2006). Climate change and human health: impacts, vulnerability and public health. *Public Health, 120,* 585-596.

Hajat, S., Kovats, R.S., & Lachowycz, K. (2007). Heat-related and cold-related deaths in England and Wales: who is at risk? *Occupational and Environmental Medicine, 64,* 93-100.

Hayhoe, K., Sheridan, S., Kalkstein, L., & Greene, S. (2010). Climate change, heat waves, and mortality projections for Chicago. *Journal of Great Lakes Research, 36*, 65-73.

Health Canada. (2011). Extreme heat events guidelines: Technical guide for health care workers. Ottawa, Ontario: Author.

Holstein, J., Canouï-Poitrine, F., Neumann, A., Lepage, E., & Spira, A. (2005). Were less disabled patients the most affected by 2003 heat wave in nursing homes in Paris, France? *Journal of Public Health, 27,* 359-365.

How, C.-K., Chern, C.-H., Wang, L.-M., & Lee, C.-H. (2000). Heat stroke in a subtropical country. *American Journal of Emergency Medicine, 18,* 474-477.

Intergovernmental Panel on Climate Change. (2013). Summary for policymakers. In T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex & P.M. Midgley (Eds.), Climate change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, (pp. 3-29). Cambridge, and New York, NY: Cambridge University Press.

Johnson, H., Kovats, R.S., McGregor, G., Stedman, J., Gibbs, M., Walton, H., Cook, L., & Black, E. (2005). The impact of the 2003 heat wave on mortality and hospital admissions in England. *Health Statistics Quarterly, 25,* 6-11.

Josseran, L., Caillère, N., Brun-Ney, D., Rottner, J., Filleul, L., Brucker, G., & Astagneau, P. (2009). Syndromic surveillance and heat wave morbidity: a pilot study based on emergency departments in France. *BMC Medical Informatics and Decision Making, 9,* 14.

Klenk, J., Becker, C., & Rapp, K. (2010). Heat-related mortality in residents of nursing homes. *Age and Ageing, 39*, 245-252.

Leiper, J.B., Primrose, C.S., Primrose, W.R., Phillimore, J., & Maughan, R.J. (2005). A comparison of water turnover in older people in community and institutional settings. *The Journal of Nutrition, Health & Aging, 9,* 189-193.

Lowe, D., Ebi, K.L., & Forsberg, B. (2011). Heatwave early warning systems and adaptation advice to reduce human health consequence of heatwaves. *International Journal of Environmental Research and Public Health, 8,* 4623-4648.

Maxwell, T.A. (2003). The public need to know: emergencies, government organizations, and public information policies. *Government Information Quarterly, 20,* 233-258.

Michelozzi, P., de' Donato, F.K., Bargagli, A.M., D'Ippoliti, D., De Sario, M., Marino, C., Schifano, P., Cappai, G., Leone, M., Kirchmayer, U., Ventura, M., di Gennaro, M., Leonardi, M., Oleari, F., De Martino, A., & Perucci, C.A. (2010). Surveillance of summer mortality and preparedness to reduce the health impact of heat waves in Italy. *International Journal of Environmental Research and Public Health, 7,* 2256-2273.

Morabito, M., Profili, F., Crisci, A., Francesconi, P., Gensini, G.F., & Orlandini, S. (2012). Heat-related mortality in the Florentine area (Italy) before and after the exceptional 2003 heat wave in Europe: an improved public health response? *International Journal of Biometeorology, 56,* 801–810.

National Institute of Water and Atmospheric Research. (2010). New Zealand national climate summary 2009. Retrieved from http://www.niwa.co.nz/climate/summaries/annual/2009

New Zealand Ministry of Health. (2000). *The New Zealand health strategy*. Wellington: Author.

New Zealand Ministry of Health. (2002). *Health of older people strategy*. Wellington: Author.

New Zealand Ministry of Health. (2015a). *Protecting your health in an emergency*. Wellington: Author.

New Zealand Ministry of Health. (2015b). *National health emergency plan: a framework for the health and disability sector*. Wellington: Author.

Oven, K.J., Curtis, S.E., Reaney, S., Riva, M., Stewart, M.G., Ohlemüller, R., Dunn, C.E., Nodwell, S., Dominelli, L., & Holden, R. (2012). Climate change and health and social care: Defining future hazard, vulnerability and risk for infrastructure systems supporting older people's health care in England. *Applied Geography, 33*, 16-24.

Palecki, M.A., Changnon, S.A., & Kunkel, K.E. (2001). The nature and impacts of the July 1999 heat wave in the Midwestern United States: learning from the lessons of 1995. *Bulletin of the American Meteorological Society, 82*, 1353-1367.

Public Health Dayton & Montgomery County. (2011). *Heat advisory plan*. Dayton & Montgomery County, Ohio: Author.

Queensland Government. (2004). *Queensland heatwave response plan*. Queensland Health Department.

Rural City of Wangaratta. (2009). *Heatwave response plan.* Wangaratta, Victoria: Author.

Sheridan, S.C. (2007). A survey of public perception and response to heat warnings across four North American cities: an evaluation of municipal effectiveness. *International Journal of Biometeorology, 52,* 3-15.

Simón, F., Lopez-Abente, G., Ballester, E., & Martínez, F. (2005). Mortality in Spain during the heat waves of summer 2003. *Eurosurveillance, 10(7),* 156-160.

Smoyer-Tomic, K.E., & Rainham, D.G.C. (2001). Beating the heat: development and evaluation of a Canadian hot weather health-response plan. *Environmental Health Perspectives, 109,* 1241-1248.

Stafoggia, M., Forastiere, F., Agostini, D., Biggeri, A., Bisanti, L., Cadum, E., Caranci, N., de'Donato, F., De Lisio, S., De Maria, M., Michelozzi, P., Miglio, R., Pandolfi, P., Picciotto, S., Rognoni, M., Russo, A., Scarnato, C., & Perucci, C.A. (2006). Vulnerability to heat-related mortality: a multicity, population-based, case-crossover analysis. *Epidemiology, 17,* 315-323.

State Government of Victoria. (2016). Local councils. Retrieved from http://www.vic.gov.au/government-economy/local-councils.html

State of Victoria, Department of Health. (2011). *Heatwave plan for Victoria. Protecting health and reducing harm from heatwaves.* Melbourne, Victoria: Author.

The World Bank Group. (2016). *High-income OECD members.* Retrieved from http://data.worldbank.org/about/country-classifications/country-and-lending-groups

UK Department of Health. (2010). *Supporting vulnerable people before and during a heatwave: Advice for care home managers and staff.* London: Author.

UK Department of Health. (2012). *Heatwave plan for England 2012: Protecting health and reducing harm from severe heat and heatwaves.* London: Author.

US Centers for Disease Control and Prevention (CDC). (2016). *Extreme heat: about CDC's program.* Retrieved from http://www.bt.cdc.gov/disasters/extremeheat/program.asp

Vaneckova, P., Beggs, P.J., de Dear, R.J., & McCracken, K.W.J. (2008). Effect of temperature on mortality during the six warmer months in Sydney, Australia, between 1993 and 2004. *Environmental Research, 108,* 361-369.

Vaneckova, P., Beggs, P.J., & Jacobson, C.R. (2010). Spatial analysis of heat-related mortality among the elderly between 1993 and 2004 in Sydney, Australia. *Social Science & Medicine, 70,* 293-304.

Victorian Government Department of Health. (2010). *Residential aged care services heatwave ready resource.* Melbourne, Victoria: Author (Aged Care Branch).

Victorian Government Department of Human Services. (2009). *Heatwave planning guide: Development of heatwave plans in local councils in Victoria.* Melbourne, Victoria: Author.

Warrnambool City Council. (2012). *Heatwave plan.* Warrnambool, Victoria: Author.

Weisskopf, M.G., Anderson, H.A., Foldy, S., Hanrahan, L.P., Blair, K., Török, T.J., & Rumm, P.D. (2002). Heat wave morbidity and mortality, Milwaukee, Wis, 1999 vs 1995: An improved response? *American Journal of Public Health, 92,* 830–833.

Welsh Government. (2012). *Heatwave plan for Wales: A framework for preparedness and response.* Cardiff: Author.

Wilmoth, J.M., & Longino, C.F. Jr. (2006). Demographic trends that will shape U.S. policy in the twenty-first century. *Research on Aging, 28,* 269-288.

World Health Organization. (2009). *Improving public health responses to extreme weather/heat-waves-EuroHEAT.* Technical summary. Copenhagen: WHO Regional Office for Europe.

Yardley, J., Sigal, R.J., & Kenny, G.P. (2011). Heat health planning: The importance of social and community factors. *Global Environmental Change, 21,* 670-679.

Yarriambiack Shire Council. (2011-2012). *Heatwave plan.* Yarriambiack Shire, Victoria: Author.

Table 1. Presence of 13 heat stress prevention strategies in 23 heatwave response plans. Strategies are ordered from the least frequent to the most frequent. Plans are ordered alphabetically by country, state, municipality and then city, with the latter three levels indented sequentially.

	Heat stress prevention strategies													
Plan	Indoor temperature at 26°C	Eat fruit/vegetables	Avoid fans in high humidity	Air-condition/Community Centers	Take cold shower, bath or body wash	Contact with families/others	Rest breaks/protective clothing	Wearing loose light-colour clothing	Supply of power, water/cooling areas	Know signs and symptoms of heat	Stay out of the sun	Minimise physical activities	Drink enough fluid to hydrate	**Total**
Australia														
Australia				●	●	●		●	●	●	●	●	●	9
Queensland						●				●	●	●	●	5
South Australia					●	●	●	●	●	●		●	●	8
Victoria (Plan)		●		●	●	●		●			●	●	●	8

Victoria (Resource)			●				●	●	●	●	●	●	●	8
Baw Baw	●	●	●		●	●	●	●	●	●	●	●	●	12
Central Goldfields							●	●	●	●	●	●	●	7
Darebin			●	●	●		●	●		●	●	●	●	9
East Gippsland		●	●	●	●	●		●	●	●	●	●	●	11
Gannawarra		●	●	●	●		●	●		●	●	●	●	10
Shepparton				●		●			●	●	●		●	6
Wangaratta			●		●	●	●	●	●	●	●	●	●	10
Warrnambool						●	●	●	●	●	●	●	●	8
Yarriambiack						●	●	●	●		●	●	●	7
Perth (WA)	●								●					2
Canada														
Canada	●	●	●	●	●	●	●	●	●	●	●	●	●	13
Vancouver (BC)				●		●			●	●		●	●	6
Toronto (Ontario)				●					●	●	●		●	5

United Kingdom														
England (Advice)	●				●			●		●	●	●	●	7
England (Plan)	●	●	●		●	●	●	●	●	●	●	●	●	12
Wales	●	●			●	●	●	●	●	●	●	●	●	11
United States														
Arizona				●	●		●	●	●	●	●	●	●	9
Dayton & Montgomery (Ohio)							●	●	●			●	●	5
Total	6	7	8	10	13	14	14	18	18	19	19	20	22	

Table 2. Presence of 12 communication strategies in 23 heatwave response plans. Strategies are ordered from the least frequent to the most frequent. Plans are ordered alphabetically by country, state, municipality and then city, with the latter three levels indented sequentially.

Plan	Communication strategies												Total
	Twitter/Facebook	Care home managers/staff	Community health forums	Poster	Flyers/Brochures	Radio/television broadcast	Mental health agencies	Hospitals	Councils/municipalities	Bureau of meteorology	Heatwave media warnings	Departments of health	
Australia													
Australia	●					●			●	●	●	●	6
Queensland					●			●		●	●	●	5
South Australia			●	●		●	●	●	●	●	●	●	9
Victoria (Plan)			●	●	●	●	●	●	●	●	●	●	10
Victoria (Resource)		●		●	●		●	●	●	●	●	●	9

Baw Baw						●		●	●	●	●	●	6
Central Goldfields						●			●	●	●	●	5
Darebin				●			●		●	●		●	5
East Gippsland				●			●		●	●	●	●	6
Gannawarra			●		●	●		●	●	●	●	●	8
Shepparton				●	●	●			●	●	●	●	7
Wangaratta						●		●	●	●	●	●	6
Warrnambool				●	●		●	●	●	●	●	●	8
Yarriambiack					●		●	●	●	●	●	●	7
Perth (WA)							●	●	●	●	●	●	6
Canada													
Canada		●			●		●	●	●	●	●	●	8
Vancouver (BC)	●		●	●	●	●	●	●	●		●	●	10
Toronto			●								●	●	3

(Ontario)													
United Kingdom													
England (Advice)		●								●		●	3
England (Plan)						●	●	●	●	●	●	●	7
Wales						●		●	●	●	●	●	6
United States													
Arizona			●		●				●	●	●	●	6
Dayton & Montgomery (Ohio)							●	●		●	●	●	5
Total	2	3	6	8	10	11	12	15	19	21	21	23	

Online Supplementary Table. Target audience of selected heatwave response plans.

Location	Document name (Publication year)	Target audience
Australia.	Protecting Human Health and Safety During Severe and Extreme Heat Events. A National Framework. (2011).	[1]Emergency services; essential services; government; health services; social services; and other.
Victoria, Australia.	Heatwave Plan for Victoria. Protecting Health and Reducing Harm From Heatwaves. (2011).	Community Health Services; Ambulance & Emergency Services; Victorian Police; General Practitioners; Fire Services Commissioner.
Victoria, Australia.	Residential Aged Care Services Heatwave ready resource. (2010).	Residential aged care service providers; staff, volunteers, residents and their families of residential aged care services.
Warrnambool City, Victoria, Australia.	Heatwave Plan. (2012).	[2]Home and Community Care Managers; District Nurses; Chronic Disease Management; Office of Housing; Accident & Emergency Manager; Rural Access; Aged Care Facilities; Senior Citizens; Day Centre; Planned Activity Groups; Mental Health Agencies; Disability Agencies; Respite Agencies; Community Houses; Chief Executive Officer of Health Services; Managers of Community Health Services; Maternal and Child

		Health Nurses; Ambulance; Southwest Primary Care Partnership.
Yarriambiack Shire, Victoria, Australia.	Heatwave Plan. (2011-2012).	Local Health Services; Red Cross; Motel Owners; Department of Veteran Affairs.
Gannawarra Shire, Victoria, Australia.	Heatwave Plan. (2012).	Police Municipal Emergency Response Coordinator; Council's Chief Executive Officer; Media; External Agencies.
Rural City of Wangaratta, Victoria, Australia.	Heatwave Response Plan. (2009).	Local Government; Community and Community Health Organisations; Private/Sporting Sector; Emergency and Professional Health Services.
Baw Baw Shire, Victoria, Australia.	Heatwave Response & Action Plan. (2009-2010).	Local Council's and Departmental Staff; Media.
Darebin City, Victoria, Australia.	Darebin Heatwave Plan. (2009).	Departmental and Local Council Staff.
East Gippsland Shire, Victoria, Australia.	Heatwave Plan. (2010).	Tourists; International Visitors; Aged Care Network; Gippsland Mental Health Alliance; Gippsland and East Gippsland Aboriginal Co-operative.
Greater Shepparton City, Victoria, Australia.	Greater Shepparton Heatwave Plan 2009.	Ambulance Victoria; Red Cross; Range of Stakeholders; Department of Health Regional Offices; Municipal Council.

Central Goldfields Shire, Victoria, Australia.	Heat Wave Response Plan. (2010).	Municipal Emergency Management Committee; Senior Environmental Health Officer; Municipal Emergency Resource Officer; Municipal Emergency Management Plan Committee Sub Committee; Municipal Recovery Manager; Home Care Services; Human Resources; Children's Services.
Queensland, Australia.	Queensland Heatwave Response Plan. (2004).	Queensland Health; Department of Emergency Services (lead agency – Queensland Ambulance Service); Queensland Police Service; Bureau of Meteorology; Workplace Health and Safety; Education Queensland; Disability Services; Queensland Transport; Department of Energy; Carers of aged people; State Medical Controller; Chief Health Officer.
Perth metropolitan area, Western Australia, Australia.	Operational Directive: Heatwave Policy. (2010).	WA Department of Health agencies; State Health Coordinator; On-call Duty Officer.
South Australia, Australia.	Extreme Heat Operational Plan. (2013).	SA State Emergency Service; State Government Departments/Agencies.
Canada.	Extreme Heat Events Guidelines: Technical Guide for Health Care	Health care workers (Health Workforce) including Medical Officers of Health; public health practitioners; medical physicians; medical helpline

	Workers. (2011).	workers; Nurse practitioners; Nurses; naturopathy practitioners; 911 dispatchers; Chiropractors; paramedics; Midwives; dieticians; home care workers; pharmacists; respiratory therapists; occupational therapists; physiotherapists; athletic therapists; personal trainers; personal support workers; community support workers; traditional and indigenous healers; workplace health and safety personnel; staff and managers of public health organizations and various health facilities including hospitals, retirement homes and long-term care facilities.
City of Toronto, Ontario, Canada.	Hot Weather Response Plan. (2012).	Medical Officer of Health; Toronto City Council and Public Health staff: Healthy Environments; Emergency Planning and Preparedness; Healthy Living; Healthy Families; Communications and Public Relations; Communicable Disease Control; City Partners: Toronto Shelter Support and Housing Administration; Toronto Emergency Medical Services; Toronto Public Library; Toronto Parks Forestry and Recreation; Toronto Police Services; Toronto Community Housing Corporation; Toronto Office of Emergency Management; Toronto Homes for the Aged; Toronto Animal Services; 311 Toronto; Community Partners: Canadian Red Cross,

		Toronto Region; Office of the Chief Coroner, Toronto Region; Street Health; Community Care Access Centres; Ontario Community Support Association; Community Health Centres; Environment Canada; Kent State University; Change Toronto.
City of Vancouver, British Columbia, Canada.	2010 Extreme Hot Weather Preparedness & Response Plan.	Community organisations; City of Vancouver & Vancouver City Health Authority Chief Medical Officers; health providers in community clinics; home support workers; health and housing outreach workers.
England.	Supporting Vulnerable People Before and During a Heatwave: Advice for Care Home Managers and Staff. (2010).	Care Home Managers and Staff.
England.	Heatwave Plan for England 2012: Protecting Health and Reducing Harm From Severe Heat and Heatwaves.	[3]Registered Nursing Homes Association and Carers UK; Community and District Nurses Association; Directors of Housing and Planning Authority; National Health Service Trust Medical Director; Domiciliary care organisations; and others.
Wales.	Heatwave Plan for Wales: A Framework for Preparedness and	Local health boards; National Health Service Direct Wales; General Practitioners; Social Care Facilities Managers, Nurses and Staff; and others.

	Response. (2012).	
Arizona, United States of America.	Heat Emergency Response Plan. (2011).	Incident Commander; Tribal and Regional Behavioural Health Authority. Arizona Department of Health Services Divisions, counties, cities, tribes and other agencies that provide services to the homeless, seniors and medically-at-risk persons.
Dayton & Montgomery County, Ohio, United States of America.	Dayton & Montgomery County Heat Advisory Plan. (2011).	Media; Fire Chiefs; Law Enforcement; Local municipal and township governments; Greater Dayton Area Hospital Association; Montgomery County Office of Emergency Management; Ombudsman; Coroner; Red Cross; Help-Link.

1 Listed as “stakeholders” in the report.

2 Participants/Organisations that provided input into the Plans.

3 Circulation List for the Plan.

CHAPTER 5

PAPER 2.

ADAPTATION TO CLIMATE CHANGE IMPACTS IN AGED CARE FACILITIES: AN INTERNATIONAL PERSPECTIVE

Names of all authors:

Benjamin Okwuofu-Thomas, MAgeHlth

Department of Environmental Sciences, Faculty of Science and Engineering, Macquarie University, Sydney, New South Wales 2109, Australia

Paul J. Beggs, PhD

Department of Environmental Sciences, Faculty of Science and Engineering, Macquarie University, Sydney, New South Wales 2109, Australia

Ross J. MacKenzie, PhD

Department of Psychology, Faculty of Human Sciences, Macquarie University, Sydney, New South Wales 2109, Australia

P2.1 *Individual contributions*

Consultations with my principal supervisor (Associate Professor Paul J. Beggs) led to the general concept and design for this manuscript: to review the literature and theory on adaptation policy frameworks for climate change in the context of heatwave impacts in aged care facilities. The development of paper 2 was undertaken by the candidate, with frequent input from both the principal and associate supervisors (Associate Professor Paul J. Beggs, Dr Ross MacKenzie).

ADAPTATION TO CLIMATE CHANGE IMPACTS IN AGED CARE FACILITIES: AN INTERNATIONAL PERSPECTIVE

Abstract

Heatwaves have the capacity to impact on the health of aged care facility residents, especially those with pre-existing disease. Heatwaves have been projected to increase in the coming decades as a result of climate change, and many countries are experiencing an increase in the number and proportion of elderly people in their population. This will consequently affect public health systems globally. Preparing for and adapting to climate change will minimise health risks of aged care facility residents. This paper explores this topic, with a focus on potential adaptive categories of primary, secondary and tertiary preventions: divided into short-term and long-term adaptation measures. These short- and long-term measures include adaptations such as aged care in heatwave response plans; hydration; heat-alarm sensor detector; national heatwave legislations and policy frameworks; clients' care plan review schedule; increased staffing; families and carers' involvement; active and passive air-conditioning; backup power supplies; education and research. Given the projected morbidity and mortality associated with climate change in the coming decades, it is important that national governments, states/provinces, and municipal governments across continents that are yet to establish climate change adaptation act now for the protection of residents in aged care facilities against future changing climates.

Keywords: Climate change; public health; adaptation; heatwave response plans; aged care facilities; elderly health.

1. Introduction

Aged care facilities (also known as long-term care facilities or nursing homes) are residential care institutions (Crotty et al. 2004; Harrington et al. 1992). These institutions are where the elderly incapable of taking care of themselves or needing 24 hour extended medical and social assistance reside. Human pathophysiology is generally determined by the dynamic state of human health and adaptation capacity to the environment. Individuals and the general public can adapt themselves from excessive heatwaves by behavioural adaptation and simply spending more time in climate controlled environments; by using appropriate heat stress preventive measures such as drinking fluids to hydrate, staying out of the sun during hot days, refraining from strenuous exercise during heat periods, knowing the signs and symptoms of heat (Alberini et al. 2011; Public Health England 2015; UK Department of Health 2010; UK Department of Health 2012).

However, currently, there is little research on adaptation strategies to the impacts of climate change specifically in aged care facilities. The focus of this paper therefore is on adaptation strategies to climate change impacts on elderly 65 years and over aged care facility residents' health. The officials responsible for aged care facilities and public health care planning need such information to develop appropriate adaptation policies to handle the consequences projected warmer climate will have for population health (Rocklöv and Forsberg 2008).

In response to the call for adaptation to climate change through the development and evaluation of response options: subsequent sections of this paper will describe climate change as observed in the past and as projected into the future, followed by public health implications of heatwaves, heatwave impacts in aged care facilities, and potential adaptation strategies to ameliorate impacts of heatwave in aged care facilities.

Through review of the literature and theory, major focus of the paper therefore is comprehensive consideration of adaptation measures which included: aged care in heatwave response plans; hydration; heat-alarm sensor detector; legislative intervention; client's care plan review schedule; increased staffing; families and carer's intervention; active and passive air-conditioning; backup power supplies; community and professional education and evaluation research.

2. Climate Change

The Intergovernmental Panel on Climate Change (IPCC 2013a) defines climate change as "a change in the state of the climate that can be identified, for example, by using statistical tests, by changes in the mean and/or the variability of its properties which persists for an extended period, typically decades or longer".

Carbon dioxide (CO_2), one of the anthropogenic greenhouse gases, has increased its concentration since the pre-industrial era by 40%, primarily from fossil fuel emissions (IPCC 2013b). Based on the current understanding of climate-carbon cycle feedback, global carbon dioxide concentration in 1959 was recorded as 315.97 parts per million (The US Department of Commerce, National Oceanic and Atmospheric Administration's (NOAA 2015). In 2014, CO_2 concentration records showed 398.61 parts per million (US Department of Commerce, NOAA 2015).

The average air surface temperature increase may cause increase in the uncharacteristic weather patterns (IPCC 2013b; Lemmen et al. 2008). Continued increase in greenhouse gases concentrations such as carbon dioxide emissions will increase greenhouse warming potential (IPCC 2013b). Heatwave events increase is evident with the frequency, intensity and duration. This increase in heatwaves is projected to become hotter and drier in near future climate (Commonwealth of Australia, Bureau of Meteorology 2016).

3. Public Health Impacts of Heatwave

Heatwaves caused by climate change are generally important public health threat, hence, the need for designing and implementation of adaptation interventions. Climate change adaptation is described as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2014).

Studies around the globe about heatwaves in South Africa, The Americas, Australia, Asia, Europe and the Nordic have indicated dangerous levels of thermal stress on their populations; hence the necessity for the development and implementation of public health measures on their populations to reduce the huge health burden associated with extreme high temperatures (Bi et al. 2011; Campetella and Rusticucci 1998; Carter et al. 2016; Collins et al. 2009; Conti et al. 2005; Départment Santé Environnement 2003; Lyon 2009; Nogueira 2005; Tan et al. 2007). The effects of climate change on health are likely to be predominantly negative and impact most heavily on low-income countries where capacity to adapt is weakest, but also on the most vulnerable groups in developed countries (Carter et al. 2016; Haines et al. 2006).

In examining the impacts of high temperature on heat-related mortality, the timing of heatwave episodes across the summer months must be considered (Basu and Samet 2002). Heatwaves occurring early in the summer or spring often result in more deaths than heatwaves occurring later in the summer (Wolfe et al. 2001).

High temperature exposure has been found to have negative effects on diseases such as diabetes, hypertension, myocardial infarct and chronic heart disease (Barnett 2007; Davido et al. 2006; Qian et al. 2008; Reid et al. 2009a; US CDC 2002; Vandentorren et al. 2004; Vaneckova et al. 2008a; Vaneckova et al. 2008b; WHO 2003; WHO 2004). Similarly, Oberlin et al.'s (2010) study of 726 patients aged over 65 years in French emergency departments during the 2003 heatwave found that those who died had higher heart rate, higher body temperature, dyspnoea, higher plasma creatinine levels and central nervous system dysfunction than survivors.

Research is still ongoing as to which gender is most affected by summer heatwaves. Presently, there is no consensus on whether elderly males or females were the most affected by heatwaves. However, Vaneckova et al.'s (2008b) Sydney, Australia synoptic analysis study showed elderly women to be more vulnerable to extreme hot weather than males; whereas in the United States of America, elderly males of black race and those from low socioeconomic status were at greater risks of high temperature exposure (Greenberg et al. 1983; Reid et al. 2009a).

The World Health Organization (2008) report on improving public health responses to extreme weather events, suggested that more than 70,000 additional deaths occurred in Europe during the summer 2003 heatwaves. In Australia, in January 2009, approximately 370 excess deaths were recorded due to heatwave, mostly in the elderly (Commonwealth Government of Australia 2011). As climate change has been projected to continue into the 21st century, there is the need to assess vulnerabilities in aged care facilities and identify cost-effective interventions and adaptation options in the health sector and in other sectors that have direct links to human health.

4. Impacts in Aged Care Facilities

The impacts of heatwave events on the health of elderly 65 years and over aged care facility residents are well established. Research in Europe, for example, shows that heatwave has been associated with increased mortality in the elderly in aged care facilities (Foroni et al. 2007; Garssen et al. 2005; Klenk et al. 2010; Mackenbach et al. 1997; Stafoggia et al. 2006). Extreme high temperature also has much greater effects on residents living with one or more medical conditions such as dementia, and for those residents needing assistance with activities of daily living (Foroni et al. 2007; Garssen et al. 2005; Klenk et al. 2010; Oberlin et al. 2010; Stafoggia et al. 2006).

Klenk et al. (2010) conducted a population-based study of men and women aged ≥65 years living in nursing homes in Baden-Württemberg, Germany, between 2001 and 2005. In the study, residents were categorised into different levels of care. The study found 444 excess deaths in the first month of the 2003 heatwave, and 356 in the following two months. The study also found that residents with lowest care need were less susceptible to heat than those with higher care.

In The Netherlands, Mackenbach et al.'s (1997) study of heat-related mortality among nursing home residents found that mortality rates among nursing home residents increased or decreased with temperature variability. For instance, lower mortality rates were observed in weeks with average outside temperatures between 15°C and 19°C while in the hottest weeks of 25°C – 29.9°C the mortality rate was 50% higher than the minimum rate. The study also showed that mortality increases during hot periods were larger for women than for men and that age did not appear to be consistently related to excess mortality at high outside temperatures within this group of nursing home residents. In addition, like other studies before this one, the authors found patients with cardiovascular and respiratory conditions to be at risk of dying during hot summer spells.

In another Netherlands study, by Garssen et al. (2005), of the effects of the August 2003 heatwave on mortality, it was observed that the impact manifest in the elderly in nursing homes more than in the non-institutionalised elderly population. The result of this study demonstrated a strong increase in heat-related mortality with age. In addition, as stated by the authors of the study, the institutionalised elderly population had a much higher share of frail and demented persons than the non-institutionalised population (Garssen et al. 2005).

Foroni et al.'s (2007) study of risk factors for heat-related death in Modena, Italy, during the heatwave month of August 2003, found that those who died had a greater degree of comorbidity and dependence; and living in nursing homes.

In an Italian study of vulnerability to heat-related mortality in summertime high temperature among city residents by Stafoggia et al. (2006), temperature-related mortality was higher among people residing in nursing homes. Overall odds ratios increased with age and were higher among widows and widowers. In addition, among the pre-existing medical conditions investigated, effects modification was detected for previous psychiatric disorders, depression, heart conduction disorders, and circulatory disorders of the brain.

5. Adaptations

Globally, there exist several international and national framework guidelines for climate change impacts and adaptation assessment, such as the United Nations Adaptation Policy Frameworks for Climate Change: developing strategies, policies and measures 2004; and Australia's National Climate Change Adaptation Research Plan 2009. Burton et al. (2005) structure adaptation policies into four major principles. The principles are the hazard-based principle; vulnerability-based principle; adaptive-capacity principle and the policy-based principle. These principles provide the bases in which actions to climate change adaptation can be developed.

The Intergovernmental Panel on Climate Change (2014) define adaptive capacity "as the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences". Examples of human heatwave adaptation behaviour include drinking enough fluids to hydrate and to stay out of the sun. Table 1 illustrates the integrated adaptive categories and human system adaptation interventions.

Table 1. Integrated adaptive categories and human system adaptation interventions.

Adaptive category	Adaptation interventions
Primary prevention	Primary prevention attempts to reduce climate change-related exposure. For example, primary prevention of adverse health impacts of heatwaves will be to reduce or eliminate the exposure of elderly residents to thermal stress by the introduction of adaptation response plans in aged care facilities.
Secondary prevention	Secondary prevention measures such as heatwave surveillance systems would prevent the onset of thermal stress and slow the progression of climate change-related health impacts. For example, secondary prevention will be to identify those vulnerable elderly residents with underlying cardiovascular disease risk such as hypertension, myocardial infarction, chronic heart diseases and diabetes, and psychiatric illnesses, so as to be able to provide appropriate advice on adaptation, approaches and treatment.
Tertiary prevention	Tertiary prevention treats and manages the health impacts that cannot be prevented. For example, through provision of infrastructure such as green-intent built environment that will assist to cope with cardiovascular and respiratory illnesses, treat mental health and manage heat-related morbidity.

The examples of adjustments in resources and technology within public adaptation programs include adequate supply of power and water in cooling areas. The human system adaptive interventions can be framed in relation to the 3 traditional pillars of public health which include primary, secondary and tertiary preventions prescribed by (McMichael et al. 2009).

Human health has been observed to be associated with a range of climate change impacts such as extreme heatwave events for which short-term and long-term adaptation interventions are likely to be needed. Figure 1 displays both short-term and long-term adaptation interventions for heatwaves in aged care facilities that could lead to reduced aged heat-health impacts.

Short-term adaptation interventions

5.1 Aged care in heatwave response plans

Heatwave response plans set out what should happen before and during periods of severe heat (Public Health England 2015). They spell out what preparations both individuals and organisations can make to reduce health risks and include specific measures to protect at-risk groups (Public Health England 2015). Therefore, any measure such as a formalised 'written aged care heatwave response plan' to improve the general care of elderly aged care residents in heatwave seasons is a welcome strategy in reducing future climate change heatwave impacts.

The study by Palecki et al. (2001) found heatwave response plans in both Chicago and St. Louis to be quite effective at reducing heatwave mortality rates. For example, 114 deaths were recorded in the July 1999 heatwave events in Chicago compared to 700 deaths recorded in 1995. Reduced heatwave mortality in St. Louis was not due solely to meteorological differences but due to St. Louis' implementation of detailed heatwave response plans.

Improved heatwave response plans targeting vulnerable populations have been known to reduce heat-related deaths (Weisskopf et al. 2002). Those countries that have already introduced heatwave response plans for their communities, did so to prepare and increase their response for and prevent the direct and indirect impacts on community infrastructures and human health (Australian Government 2010; Lemmen et al. 2008; United Kingdom Department of Health 2012). As noted in the previous chapter, the English national heatwave plan (UK Department of Health, 2015) and the Residential Aged Care Services Heatwave Ready Resource for Victoria (Victorian Government Department of Health, 2010) are particularly substantial and noteworthy government plans that do include, and indeed focus on, heatwave response in aged are facilities.

Studies have found that effective public health preventive strategies for reaching vulnerable people and preventing deaths in future heatwaves are by central principles of heatwave response plans and efficacy of adaptation through direct communication strategies in terms of providing awareness; and evoking response from their citizens by public health officials, social care staffs, friends, volunteers and the media (Semenza et al. 1996; Sheridan 2007).

Khalaj et al.’s (2010) study identified several main diagnoses and underlying conditions that are particularly susceptible to extreme heat events, leading to emergency hospital admission. The study suggests the development of policies and programme initiatives such as heatwave plans designed to reduce the burden of disease resulting from the impacts of climate change.

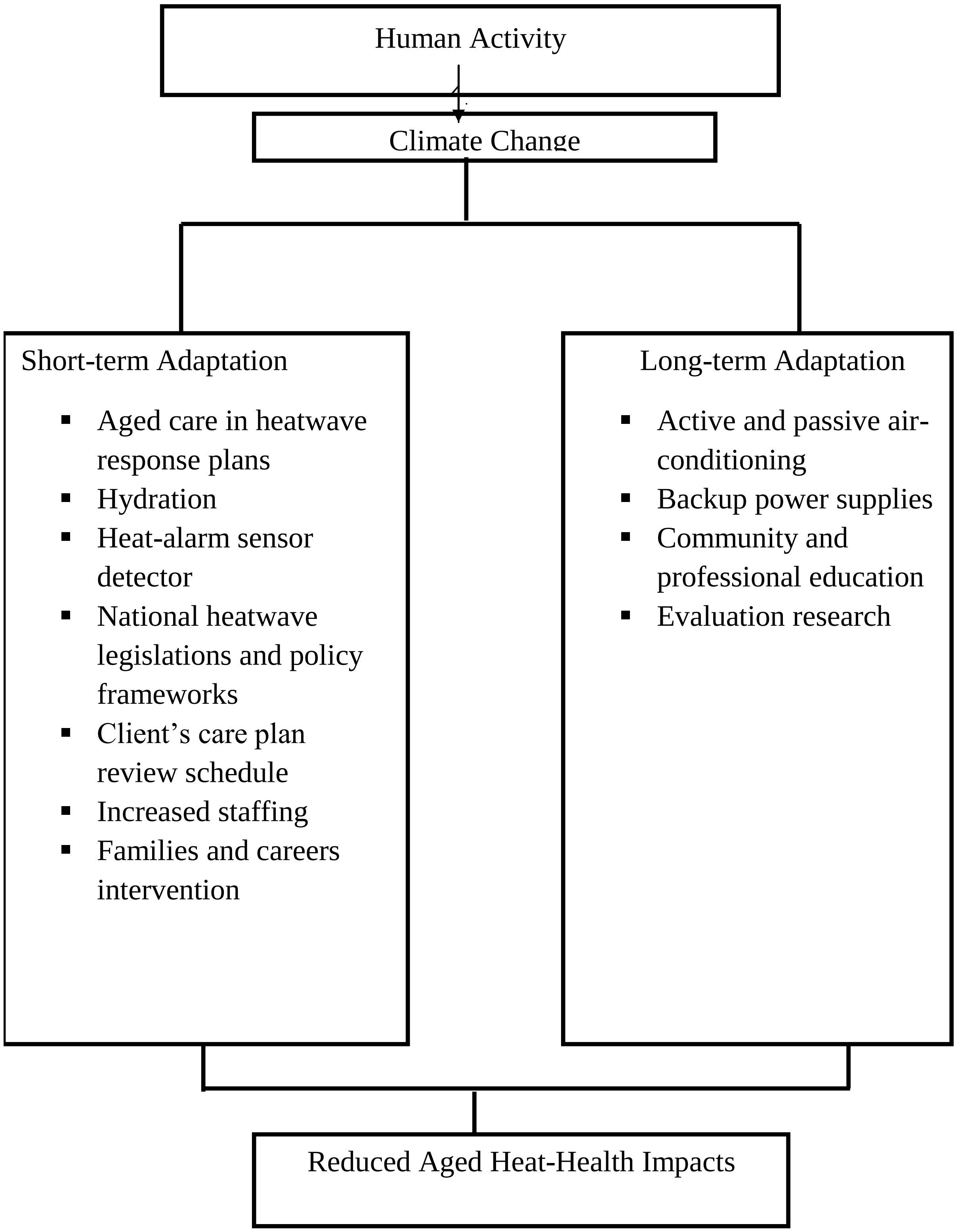

Figure 1. Short-term and long-term adaptation interventions.

Chiotti and Lavender (2008) noted in their treatise about subregional perspectives of climate sensitivities, impacts and vulnerability, by citing Toronto's hot weather response plan as a case study, that when a heat alert is issued, public health officials are made to notify the media and community stakeholders such as long-term care facilities likely to be affected by the extreme temperatures.

Lowe et al.'s (2011) research found that majority of heatwave early warning systems reviewed focused on adaptation interventions that improve measures to cool residents and their environments. To take advantage of adaptation to climate change on human health in aged care facilities therefore, governments' officials, aged care professionals, aged care providers, policy makers, staff, carers and families should begin to work together for the establishment of heatwave response plans. Hence adaptation to climate change impacts in aged care facilities is advocated. To ensure its establishment, aged care facilities heatwave response plans should be made known and available to health departments when the need arise.

5.2 Hydration

Maintenance of body hydration is particularly important, ideally before, as well as during and after a heatwave. Eating of vegetables and fruits, particularly salad, coupled with drinking of cool fluids and restraining from alcoholic and caffeine beverages, are sources of hydration and dietary fibre during hot weather conditions (Arizona Department of Human Services 2011; Elleuch et al. 2011; Kleiner 1999). It has also been observed that to prevent dehydration during periods of high temperature, average sedentary adult men and women must consume at least 2,900 ml and 2,200 ml of fluids, particularly water, per day respectively (Kleiner 1999).

Accordingly, in aged care facilities, one could suggest that more salads be served to clients during lunch time of heatwave events. Similarly, one could also suggest that provision of drinking water with meals be automatic during heatwaves. The consumption of these nourishing nutrients usually assists to replenish lost body fluid in extreme heatwave events.

Furthermore, there is the need for staff in aged care facilities to communicate to residents the importance of hydration during heatwaves.

5.3 Heat-alarm sensor detector

Assistive technology can make an important contribution to the care of elderly people in institutions and at home (Miskelly 2001). Health monitor systems such as heat-alarm sensor detectors which continuously monitor pulse, skin temperature and movements, and that can be the size and shape of a wrist watch to be worn on the wrist, can improve elderly people's health and safety during heatwave events (Mimura et al. 2014; Miskelly 2001).

In heatwave event periods when temperature thresholds are crossed, assistive technology such as heat-alarm sensor detectors can serve as a prompter to staff at aged care facilities via their pager of the impending illness which will in turn set them up for effective and timely treatment and intervention. Therefore, heat alarm-sensor detectors that can be worn as a necklace or on the wrist by residents of aged care facilities or alternatively be installed in residents rooms can be a valuable instrument for use to monitor indoor temperature, high body temperature and increased pulsation during heatwave events.

5.4 National heatwave legislations and policy frameworks

One barrier to effective heatwave adaptation is inadequate regional, national and international legislative policies. Legislative policies such as the Emergency Management Act 2013 of Victoria (2015), Public Health and Wellbeing Act of Victoria 2008, Disaster Management Act of the Republic of South Africa 2002, and Disaster Risk Reduction and Management Act of the Republic of the Philippines 2010, should mobilise adaptation resources required when things go wrong (Klein et al. 2014; Noble et al. 2014). Explicit inclusion of heatwaves and aged care facilities in such Acts would provide a particularly strong foundation for management of these disasters.

Lessons identified from legislative acts provided access to power for facilitating policies and implementation (Noble et al. 2014). In Canada, for example, most provinces/territories have legislative policies that require employers to install engineering and implement administrative controls to ease the heat stress risks of their working environment should it exceed the levels permissible by Health Canada (Jay and Kenny 2010). Multi-layered governance as a key determinant of health has been supported to underpin public health, climate change adaptation and adaptive capacity (Bowen et al. 2012).

5.5 Client's care plan review schedule

Clients' care plans can be described as nursing and medical health progress documents stating the care needs of clients such as 'activities of daily living', from the first day they became resident in aged care facilities or institutions. Developing clients' care plans is usually in conference with the representation of the aged care facility and client's family such as next of kin. The care plans involve nursing/medical assessments, care planning and evaluation.

A change in the environmental system as a result of increased air temperature and high body temperature caused by heatwave will impact on the human health system. While the concept of adaptation is simple, the process of adaptation within the human systems is complex. In many cases, adaptation involves careful planning, guided by both scientific research and detailed understanding of the systems involves (Lemmen et al. 2008).

Furthermore, the nursing and medical clients' care plans normally state what clients' diagnoses are; what their social lives are like before admission into care institutions; the state of their mental health and their physical capabilities. All these are subject to change as climatic hazards such as heatwave is influenced by the environmental system; hence increase in clients' morbidity and mortality. Additionally, by regularly updating residents' health status in aged care facilities during extreme heatwave events enables care plans to serve as one of a number of adaptation measures.

Besides, a change in any of the client's nursing/medical health care or clinical status for example, either through concentrated colour of urine; odour or behaviour/mood swing requires immediate update. Consistent ward review of clients' urine analysis to determine (1) hydration status and (2) the urine specific gravity is one of the easier and cost effective ways of detecting if a client is suffering from body fluid depletion. A second daily review of clients' weights and weight charts during heatwave periods may assist nurses and managers in residential aged care facilities identify underweight, dehydrated and vulnerable residents. These actions not only create a good working relationship between families and aged care facilities but also ensures nursing care of client's are at the highest level.

5.6 Increased staffing

Inadequate staffing and scarcity of health professional personnel tend to impede on care delivery systems for the elderly and good adaptation procedures (Hospers et al. 2007). Nogueira (2005) noted that passive systems such as using the media to spread messages of interest during heat stress periods are not reliable in a very long heatwave. Therefore, more active ways such as the involvement of staff, for example, in adaptation procedures in aged care facilities will be a clinical practical choice than the passive ways of the usage of media, for example, to convey heatwave information warnings to the elderly residents at risk (Hospers et al. 2007; Nogueira 2005). Adequate staffing means readily available staff on the ground to act in the event of any heatwave. This will in turn lead to improvement in elderly residents' nursing care and health, and decrease in heat-related morbidity and mortality.

5.7 Families and Carers involvement

Evidence has shown that latter life phenomenon of second language attrition and first language reversion is possible in healthy ageing. Goral's (2004) treatise of language attrition in bilingualism noted that internally induced change in language representation or language use may be due to lack of use of the first language; or due to externally induced language change of bilingualism. Having a family member of such second language attrition residents assist during heatwaves will improve if not remove one of the adaptation barriers (language barrier) during heatwave events.

In aged care facilities, 'nursing care' is derived from both subjective and objective assessments. Family caregivers are best positioned to give the subjective assessment (Gordon et al. 2004). Hence the need for more involvement of family caregivers and carers in the nursing care of the aged care facilities residents during heatwaves.

Long-term adaptation interventions

5.8. Active and passive air-conditioning

Architectural designs of 'Green buildings', also referred to as green-intent buildings, by definition aim to reduce their environmental impact by using less energy in both their construction and operation (Deuble and de Dear 2012a). One of the most foreseen long-term adaptation measures globally is the adaptation towards green building technology. Climate risks are now considered in new building engineering, technology and design (Noble et al. 2014). New aged care facilities around the globe should aim towards built environments that have green-intent to allow active and passive air-conditioning and provision of green spaces (Deuble and de Dear 2012b; Reid et al. 2009a; Tan et al. 2007; Younger et al. 2008).

In the United Kingdom, for example, there is a statutory requirement by the Climate Change Act 2008 that all statutory sectors including the health sector report to an 'Adaptation Sub-

Committee' of the Committee on Climate Change regularly on national progress in areas such as design and renovation of residential buildings (United Kingdom Climate Change Act 2008; United Kingdom Committee on Climate Change 2011). Green building technological measures that keep building interiors cool whenever outdoor temperatures exceed between 25°C and 26°C will assist to improve the general care of older people in reducing future heatwave impacts (Deuble and de Dear 2012a; Hajat and Kosatsky 2010; United Kingdom Department of Health 2010).

5.9 Backup power supplies

Renewable energy including solar photovoltaic (PV) accounted for almost 21% of world primary energy supply in 2012, and its deployment has increased substantially since the IPCC Fourth Assessment Report (AR4) (Bruckner et al. 2014). Renewable-energy systems can contribute to the security of energy supply in aged care facilities around the globe. In Australia, for example, the aged care sector currently consumes around 7.8 million gigajoules (GJ) of energy each year (State of New South Wales 2014). Approximately a third of this consumption cost is in New South Wales (NSW), Australia, a state with more than 930 aged care facilities (State of New South Wales 2014).

Beyond acting as a potential backup power supply during heatwaves, solar energy systems in aged care facilities would reduce energy cost and be environmentally friendly through reduction in greenhouse gas emissions and pollution reduction. A NSW residential aged care facilities energy audit review found that by implementing energy efficiency projects, site savings of more than 15% for electricity, and 18% for gas could be achieved (State of New South Wales 2014).

During extreme heatwave events, the likelihood of electricity power failure both in the community and in aged care facilities is increased. Aged care facility services such as air-conditioning, refrigeration, communications systems, medical equipment such as ventilators, oxygen concentrators, percutaneous endoscopic gastrostomy (peg) feed infusion pumps, electrical beds and computer use for patient records require considerable electricity consumption. According to Nates (2004), in his paper which aimed to increase awareness of specific risks to health care systems during a natural disaster, it is imperative that healthcare facilities take the necessary measures to preserve electrical power at all times. In particular it was suggested that battery-operated internal and external communication systems should be readily available in the event of a widespread disaster and communication outage.

Not all aged care facilities currently supplement their energy supply with solar power supply or have a back-up generator to provide electricity in the event of electricity power failure. During the day, solar energy can be connected for use and simultaneously be stored for use later at night. Hence the increased need for solar power supply and a backup generator as an adaptation to maintain power during a heatwave.

5.10. Community and professional education

The essence of adaptation education is to inform the general public, for example, individuals, families and communities what heatwave events are, what impacts they can have and what people can do to adapt to these impacts for themselves and for groups most at risk in the community (Commonwealth Government of Australia 2011). If adaptation in aged care facilities is to be successful, staff education and training should be paramount.

A well trained and adequately paid workforce is required for a good health system to deliver quality service to all people when and where they need it (WHO 2016). McInnes and Ibrahim's (2010) qualitative study of the role of community-based health profession and carer organisations in Victoria in minimising harm to older people from heatwaves observed that representatives of the four health professional groups and carer organisations interviewed saw the need for extra resources and training if responses to heatwaves were required more frequently.

Adaptation education programs targeted specifically to influence psychological barriers to behaviour change that limit climate change adaptation will certainly result in adaptation benefits (Gifford 2011). The anticipated measures include public education such as public fora and town hall meetings. The public forum and research network became a necessity as these are the medium to share adaptation experiences (Government of South Australia 2010; Government of Western Australia Department of Health 2010; Lemmen et al. 2008; State Government of Victoria 2013).

5.11. Evaluation research

Climate change adaptation should involve planning that is guided by scientific research and the understanding of all systems involves (Lemmen et al. 2008; Mimura et al. 2014). The importance of adaptation research to identify critical gaps in the information needed to manage climate change impacts and risks in such area as human health has led for example, in 2008, to the establishment of the Australian National Climate Change Adaptation Research Facility (Australian Government 2010).

More research that continuously and systematically collates, analyses and interprets heat health-related data needed for the planning, implementation and evaluation of adaptation procedures to the impacts of climate change caused by heatwaves in aged care facilities should be vigorously pursued as health is a dynamic state of equilibrium. Future experimental research that examines the efficacy of the adaptation options outlined here in extreme heatwave periods in aged care facilities is therefore recommended.

6. Conclusions

Given the limited climate change adaptation knowledge in aged care facilities, the impacts of climate change on residents' health is an important public health concern which requires development and implementation of appropriate adaptation strategies.

Now is the time to act to reduce the mortality impacts associated with heatwave events now and into the future. This chapter highlights the need for necessary internal systems and protocols for adaptation policies in aged care facilities. Aged care providers, managers and policy makers at various institutions need to consider adaptation to climate change measures suggested by this chapter as they will play significant roles during projected heatwave events.

References

Alberini A, Gans W, Alhassan M. Individual and public-program adaptation: coping with heat waves in five cities in Canada. *Int J Environ Res Public Health* 2011; 8: 4679-4701.

Arizona Department of Health Services. Heat emergency response plan. Arizona: United States of America, 2011.

Australian Government. Adapting to climate change in Australia. An Australian Government Position Paper. Department of Climate Change, Australia, 2010.

Barnett AG. Temperature and cardiovascular deaths in the US elderly: changes over time. *Epidemiology* 2007; 18: 369-372.

Basu R, Samet JM. Relation between elevated ambient temperature and mortality: a review of the epidemiologic evidence. *Epidemiol Rev* 2002; 24: 190-202.

Beggs PJ. Adaptation to impacts of climate change on aeroallergens and allergic respiratory diseases. *Int J Environ Res Public Health* 2010; 7: 3006-3021.

Bernard SM, McGeehin MA. Municipal heatwave response plans. *Am J Public Health* 2004; 94: 1520-1522.

Bi P, William S, Loughnan M, Lloyd G, Hansen A, Kjellstrom T, Dear K, Saniotis A. The effects of extreme heat on human mortality and morbidity in Australia: implications for public health. *Asia-Pac J Public Health* 2011; supplement 23 (2) 27S-36S.

Bowen KJ, Friel S, Ebi K, Butler CD, Miller F, McMichael AJ. Governing for a healthy population: towards an understanding of how decision-making will determine our global health in a changing climate. *Int J Environ Res Public Health* 2012; 9: 55-72.

Boyd DR, Genuis SJ. The environmental burden of disease in Canada: respiratory disease, cardiovascular disease, cancer and congenital affliction. *Environ Res* 2008; 106: 240-249.

Bruckner T, Bashmakov IA, Mulugetta Y, Chum H, de la Vega Navarro A, Edmonds J, Faaij A, Fungtammasan B, Garg A, Hertwich E, Honnery D, Infield D, Kainuma M, Khennas S, Kim S, Nimir HB, Riahi K, Strachan N, Wiser R, Zhang X, 2014: Energy Systems. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer O, Pichs-Madruga R, Sokona Y, Farahani E, Kadner S, Seyboth K, Adler A, Baum I, Brunner S, Eickemeier P, Kriemann B, Savolainen J, Schlömer S, von Stechow C, Zwickel T, Minx JC. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Burton I, Malone E, Huq S. Adaptation policy frameworks for climate change: developing strategies, policies and measures. Lim B, Spanger-Siegfried E (eds). Cambridge, Cambridge University Press, 2005.

Campetella C, Rusticucci M. Synoptic analysis of an extreme heat wave over Argentina in March 1980. *Meteorol Appl* 1998; 5: 217-226.

Carter TR, Fronzek S, Inkinen A, Lahtinen I, Lahtinen M, Mela H, O’Brien KL, Rosentrater LD, Ruuhela R, Simonsson L, Terama E. Characterising vulnerability of the elderly to climate change in the Nordic region. *Reg Environ Change* 2016; 16: 43–58.

Chiotti Q, Lavender B. Climate sensitivities, impacts and vulnerability: subregional perspectives: In From Impacts to Adaptation: Canada in a changing climate 2008. (Eds) Lemmen DS, Warren FJ, Lacroix J, Bush E. Government of Canada, Ottawa, ON, p. 227-274.

Collins JM, Chaves RR, Marques VD. Temperature variability over South America. *J Clim* 2009; 22: 5854-5869.

Commonwealth of Australia, Bureau of Meteorology. Glossary: heat wave. (2016). http://www.bom.gov.au/lam/glossary/hpagegl.shtml (Viewed 02 June 2016).

Commonwealth Government of Australia. Protecting human health and safety during severe and extreme heat events: a national framework. *PricewaterhouseCoopers,* Australia, November 2011.

Conti S, Meli P, Minelli G, Solimini R, Toccaceli V, Vichi M, Beltrano C, Perini L. Epidemiologic study of mortality during the summer 2003 heat wave in Italy. *Environ Res* 2005; 98: 390-399.

Crotty M, Halbert J, Rowett D, Giles L, Birks R, Williams H, Whitehead C. An outreach geriatric medication advisory service in residential aged care: a randomised controlled trial of case conferencing. *Age and Ageing* 2004; 33: 612-617.

Davido A, Patzak A, Dart T, Sadier MP, Méraud P, Masmoudi R, Sembach N, Cao TH. Risk factors for heat related death during the August 2003 heat wave in Paris, France, in patients evaluated at the emergency department of the Hôpital Europėen Georges Pompidou. *Emergency Medicine Journal* 2006; 23: 515-518.

Département Santé Environnement. Impact sanitaire de la vague de chaleurd'août 2003 en France. Institut de Veille Sanitaire. Paris, 2003.

Deuble MP, de Dear RJ. Green occupants for green buildings: the missing link? *Build Environ* 2012a; 56: 21-27.

Deuble MP, de Dear RJ. Mixed-mode buildings: a double standard in occupants' comfort expectations. *Build Environ* 2012b; 54: 53-60.

Elleuch M, Bedigian D, Roiseux O, Besbes S, Blecker C, Attia H. Dietary fibre and fibre-rich by-products of food processing: characterisation, technological functionality and commercial applications: a review. *Food Chem* 2011; 124: 411-421.

Emergency Management Act 2013. Authorised Version No. 010. The Parliament of Victoria. Office of the Emergency Services Commissioner. Victoria, Australia, 2014.

Foroni M, Salvioli G, Rielli R, Goldoni CA, Orlandi G, Sajani SZ, Guerzoni A, Maccaferri C, Daya G, Mussi C. A retrospective study on heat-related mortality in an elderly population during the 2003 heat wave in Modena, Italy: The Argento Project. *Journal of Gerontology: Medical Sciences* 2007; 62A: 647-651.

Garssen J, Harmsen C, de Beer J. The effect of the summer 2003 heat wave on mortality in the Netherlands. *Eurosurveillance* 2005; 10: 165-167.

Gifford R. The dragons of inaction: psychological barriers that limit climate change mitigation and adaptation. *American Psychologist* 2011; 66: 290-302.

Gilbert NL, Gauvin D, Guay M, Héroux M, Dupuis G, Legris M, Chan CC, Dietz RN, Lévesque B. Housing characteristics and indoor concentration of nitrogen dioxide and formaldehyde in Quebec City, Canada. *Environ Res* 2006; 102: 1-8.

Goral M. First-language decline in health aging: implications for attrition in bilingualism. *J Neurolinguistics* 2004; 17: 31-52.

Gordon SM, Jackson JC, Ely EW, Burger C, Hopkins RO. Clinical identification of cognitive impairment in ICU survivors: insights for intensivists. *Intensive Care Med* 2004; 30: 1997-2008.

Government of South Australia. Prospering in a changing climate. A draft climate change adaptation framework for South Australia, 2010.

Government of Western Australia, Department of Health. *Heatwave policy*. Perth: Australia, 2010.

Greenberg JH, Bromberg J, Reed CM, Gustafson TL, Beauchamp RA. The epidemiology of heat-related deaths, Texas-1950, 1970-79, and 1980. *Am J Public Health* 1983; 73: 805-807.

Haines A, Kovats RS, Campbell-Lendrum D, Corvalan C. Climate change and human health: impacts, vulnerability and public health. *The Royal Institute of Public Health* 2006; 120: 586-596.

Hajat S, Kosatky T. Heat-related mortality: a review and exploration of heterogeneity. *J Epidemiol Community Health* 2010; 64: 753-760.

Harrington C, Tompkins C, Curtis M, Grant L. Psychotropic drug use in long-term care facilities: a review of the literature. *The Gerontologist* 1992; 32: 822-833.

Hospers APN, Chahine LM, Chemali Z. Health care delivery systems for older adults: how do the Netherlands and Lebanon compare? *Soc Sci Med* 2007; 65: 1979-1985.

Intergovernmental Panel on Climate Change. Annex III: Glossary [Planton, S. (ed.)]. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker TF, Qin D, Plattner G-K, Tignor M, Allen SK, Boschung J, Nauels A, Xia Y, Bex V, Midgley PM. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2013a.

Intergovernmental Panel on Climate Change. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker TF, Qin D, Plattner G-K, Tignor M, Allen SK, Boschung J, Nauels A, Xia Y, Bex V, Midgley PM. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2013b.

Intergovernmental Panel on Climate Change. Glossary. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2014.

Jay O, Kenny GP. Heat exposure in the Canadian workplace. *Am J Ind Med* 2010; 53: 842-853.

Khalaj B, Lloyd G, Sheppeard V, Dear K. The health impacts of heat waves in five regions of New South Wales, Australia: a case-only analysis. *Int Arch Occup Environ Health* 2010; 83: 833-842.

Klein RJT, Midgley GF, Preston BL, Alam M, Berkhout FGH, Dow K, Shaw MR. Adaptation opportunities, constraints, and limits. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Kleiner SM. Water: An essential but overlooked nutrient. *J Am Diet Assoc* 1999; 99: 200-206.

Klenk J, Becker C, Rapp K. Heat-related mortality in residents of nursing homes. *Age and Ageing* 2010; 39: 245-252.

Lavis JN, Oxman AD, Moynihan R, Paulsen EJ. Evidence-informed health policy I – Synthesis of findings from a multi-method study of organizations that support the use of research evidence. *Implementation Science* 2008; 3: 53.

Lemmen DS, Warren FJ, Lacroix J. Synthesis: In: From Impacts to Adaptation: Canada in a Changing Climate 2007. Lemmen DS, Warren FJ, Lacroix J, Bush E (eds). Government of Canada, Ottawa, Ontario, 2008. pp. 1-20.

Loughnan ME, Nicholls N, Tapper NJ. The effects of summer temperature, age and socioeconomic circumstance on acute myocardial infarction admissions in Melbourne, Australia. *Int J Health Geogr* 2010; 9: 41-51.

Lowe D, Ebi KL, Forsberg B. Heatwave early warning systems and adaptation advice to reduce human health consequence of heatwaves. *Int J Environ Res Public Health* 2011; 8: 4623-4648.

Lyon B. Southern Africa summer drought and heat waves: observations and coupled model behaviour. *J Clim* 2009; 22: 6033-6046.

Mackenbach JP, Borst V, Schols JMGA. Heat-related mortality among nursing-home patients. *Lancet* 1997; 349: 1297-1298.

McInnes JA, Ibrahim JE. Minimising harm to older Victorians from heatwaves: a qualitative study of the role of community-based health profession and carer organisations. *Australas Ageing* 2010; 29: 104-110.

McMichael A, Weaver HJ, Berry H, Beggs PJ, Currie B, Higgins J, Kelly B, McDonald J, Tong S. National Climate Change Adaptation Research Plan for Human Health. 2009. National Climate Change Adaptation Research Facility, Gold Coast, Australia. 64pp.

Mimura N, Pulwarty RS, Duc DM, Elshinnawy I, Redsteer MH, Huang HQ, Nkem JN, Sanchez Rodriguez RA. Adaptation planning and implementation. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee

M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Miskelly FG. Assistive technology in elderly care. *Age and Ageing* 2001; 30: 455-458.

Nates JL. Combined external and internal hospital disaster: impact and response in a Houston trauma center intensive care unit. *Crit Care Med* 2004; 32: 686-690.

National Climate Change Adaptation Research Facility. National Climate Change Adaptation Research Plan. NCCARF Publication. Gold Coast, Australia, 2009.

Noble IR, Huq S, Anokhin YA, Carmin J, Goudou D, Lansigan FP, Osman-Elasha B, Villamizar A. Adaptation needs and options. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Nogueira PJ. Examples of heat health warning systems: Lisbon's íCARO's surveillance system, summer of 2003. *Springer-Verlag Berlin Heidelberg* 2005; 141-159.

Oberlin M, Tubery M, Cances-Lauwers V, Ecoiffier M, Laugue D. Heat-related illnesses during the 2003 heatwave in an emergency service. *Emerg Med J* 2010; 27: 297-299.

Palecki MA, Changnon SA, Kunkel KE. The nature and impacts of the July 1999 heat wave in the Midwestern United States: learning from the lessons of 1995. *Bull Am Meteorol Soc* 2001; 82: 1353-1367.

Public Health England. Supporting vulnerable people before and during a heatwave: advice for care home managers and staff. London: Author, 2015.

Public Health and Wellbeing Act 2008. The Parliament of Victoria. http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/PubStatbook.nsf/f932b66241ecf1b7ca256e92000e23be/8B1B293B576FE6B1CA2574B8001FDEB7/$FILE/08-46a.pdf (Viewed 02 June 2016).

Qian Z, He Q, Lin H, Kong L, Bentley CM, Liu W, Zhou D. High temperatures enhanced acute mortality effects of ambient particle pollution in the “Oven” City of Wuhan, China. *Environ Health Perspect* 2008; 116: 1172-1178.

Reid CE, Gamble JL. Aeroallergens, allergic disease, and climate change: Impacts and adaptation. *EcoHealth* 2009a; 6: 458-470.

Reid CE, O’Neill MS, Gronlund CJ, Brines SJ, Brown DG, Diez-Roux AV, Schwartz J. Mapping community determinants of heat vulnerability. *Environ Health Perspect* 2009b; 117:1730-1736.

Republic of South Africa. Disaster Management Act, 2002.

Republic of the Philippines. Philippine disaster risk reduction and management Act of 2010. Congress of the Philippines. Metro Manila.

Rocklöv J, Forsberg B. The effect of temperature on mortality in Stockholm 1998-2003: a study of lag structures and heatwave effects. *Scand J Public Health* 2008; 36: 516-523

Semenza JC, Rubin CH, Falter KH, Selanikio JD, Flanders WD, Howe HL, Wilhelm JL. Heat-related deaths during the July 1995 heat wave in Chicago. *N Engl J Med* 1996; 335: 84-90.

Shea KM, Truckner RT, Weber RW, Peden DB. Climate change and allergic disease. *J Allergy Clin Immun* 2008; 122: 443-453.

Sheridan SC. A survey of public perception and response to heat warnings across four North American cities: an evaluation of municipal effectiveness. *Int J Biometeorol* 2007; 52: 3-15.

Stafoggia M, Forastiere F, Agostini D, Biggeri A, Bisanti L, Cadum E, Caranci N, De'Donato F, De Lisio S, De Maria M, Michelozzi P, Miglio R, Pandolfi P, Picciotto S, Rognoni M, Russo A, Scarnato C, Perucci CA. Vulnerability to heat-related mortality: a multicity, population-based, case-crossover analysis. *Epidemiology* 2006; 17: 315-323.

State Government of Victoria. Victorian climate change adaptation plan 2013. http://www.depi.vic.gov.au/__data/assets/pdf_file/0004/284044/4493_DSE_Climate_Change_Adaptation_Plan_WEB.pdf (Viewed 02 June 2016).

State of New South Wales. Energy saver. Aged-care toolkit. Office of Environment and Heritage. Sydney, Australia 2014. http://www.environment.nsw.gov.au/resources/business/140393-aged-care-toolkit.pdf (Viewed 02 June 2016).

Tan J, Zheng Y, Song G, Kalkstein LS, Kalkstein AJ, Tang X. Heat wave impacts on mortality in Shanghai, 1998 and 2003. *Int J Biometeorol* 2007; 51: 193-200.

United Kingdom Climate Change Act 2008. Impact of and Adaptation to Climate Change http://www.legislation.gov.uk/ukpga/2008/27/pdfs/ukpga_20080027_en.pdf (Viewed 02 June 2016).

United Kingdom Committee on Climate Change. Measuring progress. Adaptation Sub-Committee progress report 2011. www.theccc.org.uk (Viewed 02 June 2016).

United Kingdom Department of Health. Heatwave plan for England: Supporting vulnerable people before and during a heatwave - advice for care home managers and staff. Public Health England, United Kingdom, 2015.

United Kingdom Department of Health. Heatwave plan for England: protecting health and reducing harm from extreme heat and heatwave. England: United Kingdom, 2012.

United Nations Development Program. Adaptation policy frameworks for climate change: developing strategies, policies and measures. Lim, B., Spanger-Siegfried, E (Ed). Cambridge University Press, Cambridge, United Kingdom, 2004.

US Centers for Disease Control and Prevention. Heat wave related mortality. Media relations-telebriefing transcripts 2002. www.cdc.gov/media/transcripts/t020703.htm (Viewed 02 June 2016).

United States Department of Commerce, National Oceanic and Atmospheric Administration. Trends in atmospheric carbon dioxide. Earth system research laboratory: global monitoring division. United States of America, 2015.
http://www.esrl.noaa.gov/gmd/ccgg/trends/#mlo_full (Viewed 02 June 2016).

Vandentorren S, Suzan F, Medina S, Pascal M, Mautpoix A, Cohen J, Ledrans M. Mortality in 13 French cities during the August 2003 heat wave. *Am J Public Health* 2004; 94: 1518-1520.

Vaneckova P, Beggs PJ, de Dear RJ, McCracken KWJ. Effect of temperature on mortality during the six warmer months in Sydney, Australia, between 1993 and 2004. *Environ Res* 2008a; 108: 361-369.

Vaneckova P, Hart M, Beggs PJ, de Dear RJ. Synoptic analysis of heat-related mortality in Sydney, Australia, 1993-2001. *Int J Biometeorol* 2008b; 52: 439-451.

Vaneckova P, Beggs PJ, Jacobson CR. Spatial analysis of heat-related mortality among the elderly between 1993 and 2004 in Sydney, Australia. *Soc Sci Med* 2010; 70: 293-304.

Weisskopf MG, Anderson HA, Foldy S, Hanrahan LP, Blair K, TörökTJ, Rumm PD. Heat wave morbidity and mortality, Milwaukee, Wis, 1999 vs 1995: an improved response? *Am J Public Health* 2002; 92: 830-833.

Wolfe MI, Kaiser R, Naughton MP, Mirabelli MC, Yoon SS, Hanzlick R, Henderson AK. Heat-related mortality in selected United States Cities, summer 1999. *Am J Forensic Med Pathol* 2001; 22: 352-357.

World Health Organization. Ageing and Health: a health promotion approach for developing countries 2003. http://www.wpro.who.int/publications/pub_9290610662/en/ (Viewed 02 June 2016).

World Health Organization. Extreme Weather and Climate events and public health responses. Report on a WHO meeting Bratislava, Slovakia 09-10 February 2004. http://www.eird.org/isdrbiblio/PDF/Extreme%20weather%20and%20climate%20events.pdf (Viewed 28 April 2016).

World Health Organization. Improving public health responses to extreme weather/heat-waves-EuroHeat 2008. file:///F:/WHO%20Documents/WHO%202008_Improving%20public%20health%20responses%20to%20heatwaves.pdf (Viewed 02 June 2016).

World Health Organization. Health systems 2016. http://www.searo.who.int/india/topics/healthsystems/en/ (Viewed 02 June 2016).

Younger M, Morrow-Almeida HR, Vindigni SM, Dannenberg AL. The built environment, climate change, and health: opportunities for co-benefits. *Am J Prev Med* 2008; 35: 517-526.

Zhang L, Steinmaus C, Eastmond D, Xin XK, Smith MT. Formaldehyde exposure and Leukaemia: a new meta-analysis and potential mechanisms. *Mutation Research/Reviews in Mutation Research* 2008; 681: 150-168.

CHAPTER 6

PAPER 3.

HEATWAVE PREPAREDNESS AND PLANNING IN AGED CARE FACILITIES IN VICTORIA, AUSTRALIA

Names of all authors:

Benjamin Okwuofu-Thomas, MAgeHlth

Department of Environmental Sciences, Faculty of Science and Engineering, Macquarie University, Sydney, New South Wales 2109, Australia

Paul J. Beggs, PhD

Department of Environmental Sciences, Faculty of Science and Engineering, Macquarie University, Sydney, New South Wales 2109, Australia

Ross J. MacKenzie, PhD

Department of Psychology, Faculty of Human Sciences, Macquarie University, Sydney, New South Wales 2109, Australia

P3.1 *Individual contributions*

Discussions with my principal supervisor (Associate Professor Paul J. Beggs) led to the concept and design (survey questionnaire) of research on heatwave preparedness and planning in Victorian aged care facilities. The acquisition, analysis, and interpretation of data for paper 3 were undertaken by the candidate, with frequent input from both the principal and associate supervisors (Associate Professor Paul J. Beggs, Dr Ross MacKenzie).

HEATWAVE PREPAREDNESS AND PLANNING IN AGED CARE FACILITIES IN VICTORIA, AUSTRALIA

Abstract: Residents of aged care facilities are one of the vulnerable subgroups found to be impacted by heatwave events. Due to the increase in heat-related hospital admissions and the 374 additional heat-related elderly deaths in the January 2009 Victorian heatwave event, the Victorian state government developed heatwave planning guides and directed that the resources be used to support vulnerable populations, particularly residents of aged care facilities, to adapt to heatwaves. Despite the state government's requirement, the extent of individual care facility planning is unknown. In the coming decades heatwave is globally projected to become more severe, more frequent and long lasting. This research therefore, describes heatwave preparedness and planning in a sample of Victorian aged care facilities. Aged care facilities were invited by email to complete an online survey containing 50 questions on heatwave preparedness and planning. Thirty-nine surveys were completed. Eighty-seven percent had a heatwave policy in place, and 92% had a heatwave response plan. Chi squared (χ^2) test statistics found a strong statistically significant relationship between facilities having heatwave response plans and their healthcare assessment process including consideration of the risks and prevention of dehydration. Our study found 92% of sampled aged care facilities use air-conditioning to cool residents during heatwaves. Seventy-nine percent of care facility buildings had pitched roofs compared to 18% with flat roofs, with this result being significant because flat roofs are known to retain higher indoor temperatures. These results suggest living in sampled Victorian aged care facilities is not a risk factor for direct heat-related illnesses during heatwaves. However, ongoing staff heatwave education, training, and communication must continue to reduce heat-related illnesses associated with residents of aged care facilities.

Keywords: Heatwaves, aged care facilities, heatwave response plans, heatwave adaptation.

Introduction

Residents of aged care facilities are one of the vulnerable subgroups found to be impacted by heatwave events. Due to the increase in heat-related hospital admissions and the 374 additional heat-related elderly deaths in the January 2009 Victorian heatwave event, the Victorian state government developed heatwave planning guides and directed that these resources be used to support vulnerable populations, particularly residents of aged care facilities, to adapt to heatwaves. Despite the state government's requirement, the extent of individual care facility planning is unknown. This chapter therefore, describes heatwave preparedness and planning in a sample of Victorian aged care facilities.

Heatwave can generally be defined as a period of abnormally hot weather lasting several days within a local climate (Commonwealth of Australian, Bureau of Meteorology 2016; IPCC 2013a). Heatwaves have a wide range of impacts including on human health (WHO 2009). There are a number of particularly vulnerable groups, with one of them being the elderly (de' Donato et al. 2015; WHO 2009).

The elderly with existing cardiovascular, cerebrovascular, respiratory, and psychiatric illnesses are particularly vulnerable to impacts of heatwaves on their health (de' Donato et al. 2015; Stafoggia et al. 2008; Vescovi et al. 2005). Elderly residents of aged care facilities, and those on certain medications such as diuretics, psychotropics and cardiac regulating anti-hypertensives are some of the subgroups affected by heatwaves (Brown and Walker 2008; Hajat et al. 2007; Klenk et al. 2010; WHO 2009). In Germany, for example, during and after the 2003 European heatwaves, 444 excess deaths were recorded amongst residents of aged care facilities in 1 month, and 356 in the following 2 months (Klenk et al. 2010).

According to the World Health Organization (2016), the proportion of the global population aged 60 years and over is increasing. By the year 2020, the number of people aged 60 years and older for the first time in history will outnumber children younger than 5 years, and in 2050, the world's population aged 60 years and older is expected to total 2 billion, up from 900 million in 2015 (WHO 2016). This population ageing trend had also been projected in Victoria (Australian Bureau of Statistics 2013). For example, the 65 years and over population is projected to increase from 809,796 in 2012 to 2.3 million in 2061.

In the coming decades heatwave is globally projected to become more severe, more frequent and long lasting (IPCC 2013b). Similarly in Australia, the projection for increasing heatwave is consistent with the projected global trends (Climate Council of Australia Limited 2014). In many of Australia's capital cities, including Melbourne, increasing extreme heat can already be observed as measured by the annual number of hot days (over 35°C). In Melbourne, for example, the increase in hot weather that was observed in the 2000–2009 decade had already reached the level previously projected for 2030 (Climate Council of Australia Limited 2014). This is expected to continue through this century (Climate Council of Australia Limited 2014).

Heatwave management and response efforts include the development and implementation of heat-health action plans at the international, national and regional levels (Smith et al. 2014; WHO 2009). A World Health Organization (2009) assessment of actions to improve the resilience of vulnerable populations to heatwaves recommended public health staff planning over the summer period, cooling of health care facilities, monitoring of at risk population groups and training of staff to recognise the threat of heat strain.

Research on heatwave adaptation strategies suggests early heatwave warnings and response plans, and increasing communication on heatwave warnings and responses (de' Donato et al. 2015; McInnes and Ibrahim 2010; Price et al. 2013; White-Newsome et al. 2014). Heatwave education of health professionals and carers, and access to air-conditioning are some of the heatwave adaptation strategies found commonly used by those that experience heatwave extremes (Loughnan et al. 2015; McInnes and Ibrahim 2013). The incorporation of green infrastructures (e.g., cool roof, permeable pavement) on the inside and on the outside of built environments, and public health leadership of local governments are other important components of heatwave adaptation (Bowler et al. 2010; O'Neill et al. 2010).

Due to the 2009 Victorian heatwave human health impacts, the state government developed heatwave planning guides and directed the resources be use particularly in residential aged care facilities (State of Victoria Department of Human Services 2009; Victorian Government Department of Health 2010). The government's directive was based on the understanding that adaptation of health and social services to changing climate is often made at local community levels (Björnberg and Hansson 2011; Costello et al. 2009; Kravchenko et al. 2013; O'Neill et al. 2009a; State of Victoria Department of Human Services 2009).

It would be expected that a considerable number of Victorian aged care facilities have heatwave response plans because it was a requirement of the Victorian Government (State of Victoria Department of Human Services 2009; Victorian Government Department of Health 2010). However, the extent of individual facility planning is unknown.

In the state of Victoria, studies on heatwave harm minimisation strategies focused on the elderly living in the community (Ibrahim et al. 2012; McInnes and Ibrahim 2010), whereas McInnes and Ibrahim (2013) used semi-structured interviews with 14 Victorian Health Service campus senior staff to describe preparation for extreme hot weather at 23 public sector residential aged care services during the 2010-11 summer. A study on strategies to keep elderly aged care facility residents well during periods of extreme heat focused on three Australian states: New South Wales (NSW), Queensland and South Australia (SA) (Black et al. 2013). Hence, the needs for similar aged care facilities heatwave planning study in other

Australian states and territories. Therefore, the aim of this study is to explore and describe heatwave preparedness and planning in Victorian aged care facilities.

Methods

Survey setting

This is a cross-sectional survey questionnaire of heatwave preparedness and planning in Victorian aged care facilities. In Victoria, there are over 800 aged care facilities (Ibrahim et al. 2012). The Australian Government Department of Social Services' (2016) aged care service list for Victoria was used to obtain aged care facility information including name, physical address, organisation type, and Australian Bureau of Statistics (ABS) remoteness area class. The ABS Remoteness Structure is one of the seven structures that compose the Australian Standard Geographic Classification (ASGC), and its purpose is to "provide a classification for the release of statistics that inform policy development by classifying Australia into large regions that share common characteristics of remoteness" (ABS, 2014). A web-based search was then conducted for the e-mail address of the aged care facilities. Altogether, e-mail addresses were obtained for 525 aged care facilities. A letter of introduction to the research and a link to the survey were emailed to the directors and managers of these aged care facilities.

Survey design

The survey questions were a revised version of the study questionnaire by Black et al. (2013). Black et al.'s (2013) questionnaire contained approximately 74 questions on staff knowledge about heatwave policies and planning, and heatwave prevention strategies in aged care facilities. Our revised survey contained 50 questions on similar heatwave preparedness and planning (Appendix 2). There were additional response options to the survey questions beyond just the 'Yes' and 'No' options used by Black et al. (2013). Added response options were 'Currently under development', 'Not applicable', 'Not sure', and 'Other', as appropriate.

The included response options allowed participants to respond more accurately to the questions. Because our survey questionnaire was on aged care facilities in Victoria, Black et al.'s (2013) question on the NSW Health Department's 'Beat the Heat' was changed to question 50 in our survey about the Victorian Government Department of Health 'Residential Aged Care Services Heatwave Ready Resource' (Victorian Government Department of Health 2010). The meaning of a number of the questions in the Black et al. (2013) survey was not perfectly clear and such questions were modified slightly to clarify meaning and/or to use consistent terminology (e.g., consistently using the word "facility" rather than alternating between "facility' and "service").

Sampled Victorian aged care facilities were asked about heatwave response plans; annual in-service heatwave training; and process for communicating heatwave procedures to staff, residents and families. Other healthcare assessments and processes asked about included the risks and prevention of dehydration.

The survey was conducted using the online Qualtrics system for 4 weeks, between 28 July 2015 and 21 August 2015. Due to initial low response rates, two subsequent reminder emails were sent, one after the first 2 weeks and one in the last week of the survey. Ethical aspects of the study were approved by the Macquarie University Human Research Ethics Committee (Ethics Approval Number: 5201401035) (Appendix 1).

All data generated by this study was analysed using Chi squared test statistics. "The Chi-square statistic is the primary statistic used for testing the statistical significance of the cross-tabulation table. Chi-square tests whether or not the two variables are independent" (Qualtrics 2011). If the variables are independent (have no relationship), then the results of the statistical test will be non-significant and the null hypothesis is not able to be rejected, meaning that there is no relationship between the variables (Qualtrics 2011). A p value less than 0.05 was considered statistically significant.

Results

Sampled aged care facility characteristics

A total of 39 surveys were completed. The 39 sampled aged care facilities were spread across Inner (e.g., Hume) and Outer (e.g., Loddon-Mallee) Regional Victoria, and Major Cities (e.g., Southern Metro) of Victoria as classified by the ABS ASGC Remoteness Structure (Figure 1). The aged care facilities included a range of organisational types, including private incorporated body, religious, charitable, community based, or local or state governments (Australian Government Department of Social Services 2016). The number of beds in sampled aged care facilities ranged between 16 and 198 (Figure 2), with a median number of 61 beds. The sampled Victorian aged care facility bed numbers represented a total of 2,787 Australian elderly residents. Most facilities (82% (n=32/39)) identified as high care level facilities and only 18% (n=7/39) identified as low care level facilities.

Figure 1. Sampled Victorian aged care facility locations.

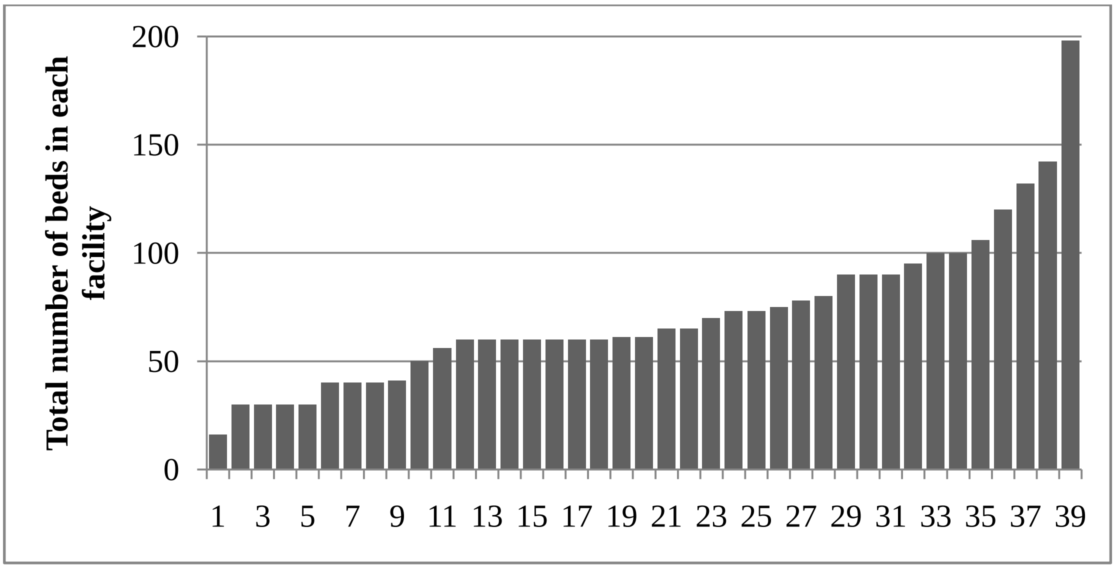

Figure 2. Sampled Victorian aged care facility bed number distribution.

Heatwave response policy

Participants in our study were asked if their facility had a heatwave policy in place. Approximately 87% (34/39) of facilities responded as having a heatwave policy in place. An even higher percentage (92%) of aged care facilities stated they had a plan to implement during a heatwave. One aged care facility's heatwave plan was incorporated in its emergency management plan. Although many (79%) of the aged care facilities had monitoring processes in place during a heatwave to confirm heatwave procedures are being implemented, several did not have such monitoring processes or were unsure. About 31% of sampled aged care facilities had not completed a self assessment to check key organisational processes relating to extreme heat management. Of the aged care facilities with heatwave response plans, the majority (88% (30/34)) included consideration of the risks and prevention of dehydration in their healthcare assessment process (χ^2=50.05; df = 16; p = 0.00). All (100%) facilities were found to have sighted the Victorian Government Department of Health's Residential Aged Care Services Heatwave Ready Resource published in 2010.

Heat-health risks factors

Sampled Victorian aged care facilities were asked if they know why the elderly are higher risk in periods of extreme temperatures. Most (89% (35/39)) facilities indicated that the elderly are at higher risk in periods of extreme temperatures because dehydration occurs quickly in the elderly; the elderly are more sensitive to heat because of their impaired ability to regulate body temperature; the inability to self implement cooling actions due to disability and mobility problems; cognitive impairment; and they are on diuretic medications that deplete body fluids volume. Other reasons indicated by a majority of sampled aged care facilities as to why the elderly were at higher risk in periods of extreme temperatures were inappropriate summer dress, and as the lack of use of air-conditioning. Two-thirds of the surveyed aged care facilities assessed individual patients for risk of heat related illness, but 15% did not.

Staff heatwave education and training

Almost half (44%) of the sampled aged care facilities did not have annual in-service heatwave response training. There was no significant relationship between aged care facilities having heatwave response plans and them conducting annual in-service heatwave training ($\chi^2=13.70$; df = 16; p = 0.62). Our study found aged care facilities reported that their heatwave education measures include annual in-service heatwave training, displaying of heatwave placards and red flags for staff during heatwave events, printed heatwave newsletters, staff ad-hoc heatwave discussions, and staff heatwave meetings.

Almost all (87% (34/39)) care facilities indicated all their staff were orientated to the facility's policies regarding relocation and emergency evacuation preparedness. In the event of equipment failure the actions the surveyed aged care facilities would take included: some care facilities have evacuation agreement plan with each other, improved hydration by providing drinking water and icy poles (a water-based coloured iced block), cold water sponge and cool towels with water bottles, fans and air coolers, dressing residents with light clothing, and regular checks of rooms' air temperatures.

Heatwave communication

Most aged care facilities reported a range of heatwave communicating processes (Figure 3). Eighty seven percent (n=34/39) of sampled aged care facilities had a plan for communicating the details of an extreme hot weather forecast to all staff. Seventy-four percent of surveyed aged care facilities had a plan for communicating the details of an extreme hot weather forecast to residents and their families, and 15% did not.

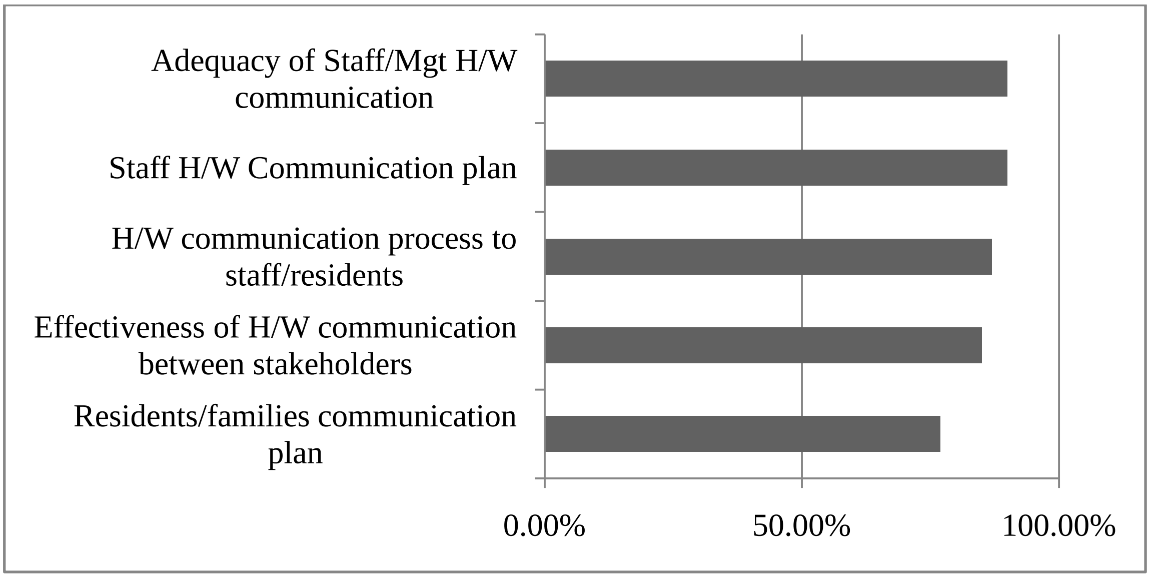

Figure 3. Percentage of aged care facilities with various heatwave communication processes.

The communication processes are usually by sending general heatwave management activities with relatives' newsletters, letters, memos and emails. Our study found a strong statistically significant association between care facilities having heatwave response plans and having a process for communicating heatwave policies and procedures to all staff, residents and families (χ^2=78.13; df = 16; p = 0.00). Most of the facilities (82%, 32/39) had processes in place to ensure preparations and requirements for planning and responding to periods of extreme heat are effectively communicated between the management, nursing and care staff, residents and their families.

Building features, roof designs and types, and air-conditioners

Sixty four percent (n=25/39) of surveyed aged care facility buildings had a steel/aluminium roof, while 28% (n=11/39) had a clay or other tile roof (Table 1). Steel/aluminium roofs were relatively more common amongst the inner and outer regional aged care facilities (12/18 and 3/4 respectively) compared to those in the major cities (10/17). Pitched roof designs were common amongst sampled Victorian aged care facilities (Table 1), with our study finding 77% (n=30/39) of facilities having such roofs (including all but one of the inner regional aged care facilities), while most of the others had flat roof design. Only 23% (n=9/39) of the sampled Victorian aged care facilities had solar panels.

Overall, 92% (n=36/39) of the sampled Victorian aged care facilities had air-conditioning, 5% had partial air-conditioning in communal lounges, corridors, staff area, kitchen and laundry, and 3% did not have air-conditioning. Fans were identified by a very few (n=3/39) care facilities as an alternative cooling process employed in the absence of air-conditioning. Sampled aged care facilities were asked if a cool part of the facility had been identified that could be used as a cool shelter in the event of power failure and/or loss of air-conditioning, and 62% (n=24/39) stated that this had been done.

Another survey question was about emergency provisions and back-up systems in case of air-conditioning equipment failure during heatwave. Just over three-quarters of the sampled Victorian aged care facilities (77% (30/39)) stated that they had such emergency provisions and back-up systems; 5% were not sure, 3% indicated the question was not applicable (no air-conditioning); and another 8% had limited back-up by obtaining external coolers.

Building features/designs	Classification	Responses (n/39)	%
Air-conditioning	Air-conditioning provision	36	92.3
	Partial air-conditioning	2	5.1
	No air-conditioning	1	2.5
Window shading	On the inside	38	97.4
	On the outside	11	28.2
Window type	All windows can be opened	34	87.1
Roof design	Flat roof	7	17.9
	Pitched roof	30	76.9
	Other	1	2.5
Roof type	Clay or other tile	11	28.2
	Steel/aluminium	25	64.1
	Green roof	1	2.5
	White coloured (reflective) roof	1	2.5
	Other (heat reflective paint)	1	2.5

Table 1. Sampled Victorian aged care facility building features.

Discussion

In order to be able to avoid the dangers associated with heatwaves and save elderly lives, having a heatwave response plan is recommended (Chau et al. 2009; Price et al. 2013). Aged care facilities heatwave response plans are suggested to facilitate heatwave preparedness processes (McInnes and Ibrahim 2013). This study found 87% of the surveyed aged care facilities had heatwave response plans, compared to 2009 when there was none (McInnes and Ibrahim 2010; State of Victoria Department of Human Services 2009). This high percentage is higher than Black et al. (2013) found in NSW, Queensland, and South Australia where 60%, 41%, and 77% of facilities had heatwave policies in place, respectively.

In major cities of the world, the population is vulnerable to urban heat island (UHI) effects (Memon et al. 2008), where air temperature in cities is higher than that in the surrounding suburban and rural environments (Memon et al. 2008; O'Neill and Ebi 2009b; Wanka et al. 2014). In addition, through the process of ageing, elderly bodies become more susceptible to environmental stressors (Wanka et al. 2014). Environmental stressor of note is extreme high temperature. Extreme high temperatures affects people particularly the elderly in urban environments (Wanka et al. 2014). In our study, approximately 44% (n=17/39) of sampled care facilities were located in the major cities, and 46% (n=18/39) in the inner regions. Cities and areas of residence have been found to determine population heat-health vulnerability (Alberini et al. 2011). This may be suggested another reason for having heatwave response plans by majority of the sampled aged care facilities, secondary to the directive of the Victoria state government.

Dehydration in the elderly is commonly believed by geriatricians to be a precipitating factor in hospital admissions, and heat stress may increase symptoms in susceptible individuals (Maughan 2012). Moreover, in the elderly, dehydration and changes in blood viscosity and volume distribution associated with heat exposure, and the thermoregulatory response can influence drug actions, their kinetics and excretion, and their pharmacological activities (Matthies and Menne 2009). It is therefore suggested that heat risk individuals maintain good hydration status when heatwave events are forecast, seek cool indoor shelter where possible, as well as minimise exposure to outdoor environments (Maughan 2012).

Heat-related disease prevention provisions found in sampled Victorian facilities heatwave management policies support vulnerable residents adapt to heatwaves by monitoring vulnerable residents in hot weather seasons. The provisions also requested registered nurses monitor and consult with pharmacists and general practitioners regarding residents' medication use in hot weather season; and the identification of cool shelters.

In NSW, approximately 60% of care facilities roof types were made of tiles, whereas steel/aluminium roof types were more common in Queensland (60%) and South Australia (58%) (Black et al. 2013). Like these latter states, our study found steel/aluminium roof types to be more common in Victorian aged care facilities. It is significant that almost a fifth of the surveyed aged care facilities had flat roof given higher indoor temperatures are associated with flat roof buildings (Loughnan et al. 2015). The rationale for the choice of roof types and design may be due to differences in climatic weather conditions in respective states; however, this was not investigated in our study.

A study of the July 1995 Chicago heatwave suggested that having working air-conditioners was associated with an 80% reduction in the risk of death due to heat (Semenza et al. 1996). In South Australia and Queensland at least 98% of aged care facilities were fully air-conditioned, whereas in NSW only 65% of care facilities were fully air-conditioned (Black et al. 2013). While our study in Victoria found a similarly high prevalence of air-conditioning to that found in South Australia and Queensland, the lack of air-conditioning in 3% of sampled aged care facilities in Victoria is a risk for such facilities in this state.

In the event of electricity outage, care facilities with emergency back-up generators or solar panels can switch to these for the period of the outage. Solar energy supply in care facilities can also supplement their energy supply, and reduce energy costs. In Victoria, 23% of sampled care facilities use solar panels. This was higher than previously found by Black et al. (2013), in South Australia (14%), and Queensland (13%).

Given there will be longer lasting heatwaves in coming decades, and that this could lead to more elderly heat-related illnesses and deaths, it is essential that aged care facilities promote heatwave training and education for staff members to support the elderly (Black et al. 2013; Chau et al. 2009; O'Neill et al. 2009a). Staff heatwave education and training in many

Victorian aged care facilities are necessary given the results of our study that 44% of sampled facilities have not run annual in-service heatwaves training. While the Victorian situation is better than in NSW where only 34% of staff have had in-service heatwave training, it falls short of the 50% of aged care facilities in South Australia and 57% in Queensland that have annual in-service heatwave training (Black et al. 2013). A recent study that describes preparations for heatwaves at Victorian residential aged care services suggested staff heatwave education as a strategy to minimise the harmful impact of heatwave in aged care facilities (McInnes and Ibrahim 2010).

Successes of any heatwave prevention provision depend on the effectiveness of the communication strategy. In Victoria, staff education, newsletters and family meetings are some of the communication processes undertaken at aged care facilities to prepare for heatwave events (McInnes and Ibrahim 2013). A previous US study that examined county-level local heat preparedness and response, found heatwave communication (73% (132/180)) the most common adaptation strategy to the 2011 extreme heat (White-Newsome et al. 2014). Other frequent methods of communicating heat risks include websites, social media, flyers and posters, email messages, telephone hotlines, and door-to-door and public service announcements (White-Newsome et al. 2014). Similarly in Hong Kong, Chau et al.'s (2009) study that compares the impacts of hot weather on ischemic heart disease (IHD) and stroke, found health education and media announcements are good interventions to communicate heat risks (Chau et al. 2009).

Effective heatwave communication measures should be defined before heatwave events, and be maintained during activation of the heatwave response period (Luber and McGeehin 2008). This study found relatives' newsletters, heatwave letters, heatwave memos and heatwave emails as processes for communicating heatwave in sampled Victorian aged care facilities. Some of these heatwave communication processes are consistent with findings from previous studies on heatwave preparedness and response; and communication about heat risks (McInnes and Ibrahim 2010; Price et al. 2013; White-Newsome et al. 2014).

Notwithstanding the heatwave readiness of the sampled Victorian aged care facilities, a number of important limitations of this study should be noted. The number of participants in the survey was small compared to the 525 aged care facilities emailed and invited to participate. In light of this low response rate the results of this study cannot be taken as representative of all aged care facilities in Victoria.

Another limitation is reflected by way of reply to the question, do you have air-conditioning? A very small fraction (3%) of sampled care facilities stated they have no air-conditioning. However, when asked if there are emergency provisions and back-up systems in case of air-conditioning equipment failure; 8% of care facilities answered not applicable (no air-conditioning); while another 3% stated that they have no air-conditioning. These minor inconsistencies in the replies to these questions may demonstrate participants not thinking within the full context of the questions. In our study the response rate is low (7%) compared to Black et al.'s (2013) 18% response rate. The low response rate is a major source of bias in our study. Since there are state government requirements on the heatwave response plans for aged care facilitates, those facilities that did not respond to our online survey had a higher chance that they did not have such a plan. The percentages as shown in the results may likely be an overestimation.

Finally, there may be an inherent bias in the responses to some of the survey questions where respondents consciously or unconsciously select responses that would reflect favourably on them and their aged care facility. However, our survey method (anonymous and online survey) should have minimised this.

In conclusion, staff heatwave education, training and communication must continue because of the potential to influence and improve heatwave planning opportunities, and consequently reduce heat-related illnesses and deaths in residents of aged care facilities. With the results of this study, it may be suggested that living in sampled Victorian aged care facilities is likely a protective factor against heat-related illnesses and death.

References

Alberini, A., Gans, W., Alhassan, M., 2011. Individual and public-program adaptation: coping with heat waves in five cities in Canada. International Journal of Environmental Research and Public Health, 8, 4679-4701.

Australian Bureau of Statistics, 2013. 3222.0 - Population Projections, Australia, 2012 (base) to 2101 http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/3222.0Main%20Features82012%20(base)%20to%202101?opendocument&tabname=Summary&prodno=3222.0&issue=2012%20(base)%20to%202101&num=&view= (Viewed 01 January 2016).

Australian Bureau of Statistics, 2014. Remoteness Structure. http://www.abs.gov.au/websitedbs/D3310114.nsf/home/remoteness+structure (Viewed 31 May 2016).

Australian Government Department of Social Services, 2016. *Aged care service lists-Victoria as at June 2015*. https://www.dss.gov.au/sites/default/files/documents/10_2015/service_list_-_vic.pdf (Viewed 26 May 2016).

Björnberg, K.E., Hansson, S.O., 2011. Five areas of value judgement in local adaptation to climate change. Local Government Studies, 37, 671–687.

Black, D., Veitch, C., Wilson, L., Hansen, A., 2013. Heat-ready: *Heatwave awareness, preparedness and adaptive capacity in aged care facilities in three Australian states: New*

South Wales, Queensland and South Australia. University of Sydney and National Climate Change Adaptation Research Facility.

Bowler, D.E., Buyung-Ali, L., Knight, T.M., Pullin, A.S., 2010. Urban greening to cool towns and cities: a systematic review of the empirical evidence. Landscape and Urban Planning, 97, 147–155.

Brown, S., Walker, G., 2008. Understanding heat wave vulnerability in nursing and residential homes. Building Research and Information, 36, 363-372.

Chau, P.H., Chan, K.C., Woo, J., 2009. Hot weather warning might help to reduce elderly mortality in Hong Kong. International Journal of Biometeorology, 53, 461–468.

Climate Council of Australia Limited, 2014. Heatwaves: Hotter. Longer, more often. Climate Council of Australia Limited.

Commonwealth of Australia, Bureau of Meteorology, 2016. Glossary: Heat Wave. http://www.bom.gov.au/lam/glossary/hpagegl.shtml (Viewed 04 January 2016).

Costello, A., Abbas, M., Allen, A., Ball, S., Bell, S., Bellamy, R., Friel, S., Groce, N., Johnson, A., Kett, M., Lee, M., Levy, C., Maslin, M., McCoy, D., McGuire, B., Montgomery, H., Napier, D., Pagel, C., Patel, J., Antonio, J., de Oliveira, P., Redclift, N., Rees, H., Rogger, D., Scott, J., Stephenson, J., Twigg, J., Wolff, J., Patterson, C., 2009. Managing the health effects of climate change. Lancet, 373, 1693-1733.

de' Donato, F.K., Leone, M., Scortichini, M., De Sario, M., Katsouyanni, K., Lanki, T., Basagaña, X., Ballester, F., Åström, C., Paldy, A., Pascal, M., Gasparrini, A., Menne, B., Michelozzi, P., 2015. Changes in the effect of heat on mortality in the last 20 years in nine European cities. Results from the PHASE Project. International Journal of Environmental Research and Public Health, 12, 15567–15583.

Hajat, S., Kovats, R.S., Lachowycz, K., 2007. Heat-related and cold-related deaths in England and Wales: who is at risk? Occupational and Environmental Medicine, 64, 93-100.

Ibrahim, J.E., McInnes, J.A., Andrianopoulos, N., Evans, S., 2012. Minimising harm from heatwaves: a survey of awareness, knowledge, and practices of health professionals and care providers in Victoria, Australia. International Journal of Public Health, 57, 297–304.

Intergovernmental Panel on Climate Change, 2013a: Annex III: Glossary [Planton, S. (ed.)]. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex,V., Midgley, P.M (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Intergovernmental Panel on Climate Change, 2013b: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Klenk, J., Becker, C., Rapp, K., 2010. Heat-related mortality in residents of nursing homes. Age and Ageing, 39, 245-252.

Kravchenko, J., Abernethy, A.P., Fawzy, M., Lyerly, A.K., 2013. Minimization of heatwave morbidity and mortality. American Journal of Preventive Medicine, 44, 274-282.

Loughnan, M., Carroll, M., Tapper, N.J., 2015. The relationship between housing and heat wave resilience in older people. International Journal of Biometeorology, 59, 1291–1298.

Luber, G., McGeehin, M., 2008. Climate change and extreme heat events. American Journal on Preventive Medicine, 35, 429-435.

Matthies, F., Menne, B., 2009. Prevention and management of health hazards related to heatwaves. International Journal of Circumpolar Health, 68, 8–22.

Maughan, R.J., 2012. Hydration, morbidity, and mortality in vulnerable populations. Nutrition Reviews, 70, (Suppl. 2):S152–S155.

McInnes, J.A., Ibrahim, J.E., 2010. Minimising harm to older Victorians from heatwaves: a qualitative study of the role of community-based health profession and carer organisations. Australasian Journal on Ageing, 29, 104–110.

McInnes, J.A., Ibrahim, J.E., 2013. Preparation of residential aged care services for extreme hot weather in Victoria, Australia. Australian Health Review, 37, 442–448.

Memon, R.A., Leung, D.Y.C., Chunho, L., 2008. A review on the generation, determination and mitigation of urban heat island. Journal of Environmental Sciences, 20, 120–128.

O'Neill, M.S., Cater, R., Kish, J.K., Gronlund, C.J., White-Newsome, J.L., Manarolla, X., Zanobetti, A., Schwartz, J.D., 2009a. Preventing heat-related morbidity and mortality: new approaches in a changing climate. Maturitas, 64, 98-103.

O'Neill, M.S., Ebi, K.L., 2009b. Temperature extremes and health: impacts of climate variability and change in the United States. Journal of Occupational and Environmental Medicine, 51, 13-25.

O'Neill, M.S., Jackman, D.K., Wyman, M., Manarolla, X., Gronlund, C.J., Brown, D.G., Brines, S.J., Schwartz, J., Diez-Roux, A.V., 2010. US local action on heat and health: are we prepared for climate change? International Journal of Public Health, 55, 105–112.

Price, K., Perron, S., King, N., 2013. Implementation of the Montreal heat response plan during the 2010 heat wave. Canadian Journal of Public Health-Revue Canadienne De Santé Publique, 104, e96-e100.

Semenza, J.C., Rubin, C.H., Falter, K.H., Selanikio, J.D., Flanders, W.D., Howe, H.L., Wilhelm, J.L., 1996. Heat-related deaths during the July 1995 heatwave in Chicago. The New England Journal of Medicine, 335, 84-90.

Smith, K.R., Woodward, A., Campbell-Lendrum, D., Chadee, D.D., Honda, Y., Liu, Q., Olwoch, J.M., Revich, B., Sauerborn, R., 2014: Human health: impacts, adaptation, and co-benefits. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Stafoggia, M., Forastiere, F., Agostini, D., Caranci, N., de'Donato, F., Demaria, M., Michelozzi, P., Miglio, R., Rognoni, M., Russo, A., Perucci, C.A., 2008. Factors affecting in-hospital heat-related mortality: a multi-city case-crossover analysis. Journal of Epidemiology and Community Health, 62, 209–215.

State of Victoria Department of Human Services, 2009. *Heatwave planning guide: Development of heatwave plans in local councils in Victoria.* State of Victoria Department of Human Services. Melbourne, Victoria Australia.

Vescovi, L., Rebetez, M., Rong, F., 2005. Assessing public health risk due to extremely high temperature events: climate and social parameters. Climate Research, 30, 71–78.

Victorian Government Department of Health, 2010. *Residential Aged Care Services Heatwave Ready Resource.* Aged care branch of Victorian Government Department of Health: Melbourne, Victoria, Australia.

Wanka, A., Arnberger, A., Allex, B., Eder, R., Hutter, H.-P., Wallner, P., 2014. The challenges posed by climate change to successful ageing. Zeitschrift für Gerontologie und Geriatrie, 47, 468–474.

White-Newsome, J.L., Ekwurzel, B., Baer-Schultz, M., Ebi, K.L., O'Neill, M.S., Brooke Anderson, G., 2014. Survey of county-level heat preparedness and response to the 2011 summer heat in 30 U.S. States. Environmental Health Perspectives, 122, 573-579.

World Health Organization, 2009. Improving public health responses to extreme weather/heat-waves –EuroHEAT. Technical summary. WHO Regional Office for Europe, Copenhagen, Denmark.

World Health Organization, 2016. Ageing and Health. http://www.who.int/mediacentre/factsheets/fs404/en/ (Viewed 03 March 2016).

CHAPTER 7

DISCUSSION AND CONCLUSIONS

Chapters 4, 5, and 6 of this thesis present the results of the thesis, as well as discussion and conclusions of each study in turn. This chapter reviews the most important findings of the thesis as an integrated body of work. Three related pieces of research were conducted to explore different aspects of the topic, these being a comparison of heatwave response plans from an aged care facility perspective, strategies for adaptation to climate change impacts in aged care facilities, and heatwave preparedness and planning in aged care facilities in Victoria, Australia. This final chapter also focuses on the aims of this thesis and the way they were achieved. It also makes recommendations for future research.

The thesis is set in the context of climate change and ageing population. Heatwaves are projected to become more frequent, more severe and long lasting in the coming decades as a result of climate change. Across many countries of the world, elderly populations are also projected to increase in the coming decades.

7.1 Heatwave response plans and adaptation to cope with heatwaves in aged care facilities

Chapter 4 addressess the first two aims of the thesis:

1. To compare selected heatwave response plans sourced from Australia, Canada, NZ, UK and USA.
2. To specially examine the inclusion of aged care facilities in heatwave response plans sourced from Australia, Canada, NZ, UK and USA.

The study found that only three of the 23 plans reviewed accounted for aged care facilities. These three plans were the Canadian technical guide for health care workers (Health Canada, 2011), the English national plan (UK Department of Health, 2010), and Residential Aged Care Services Heatwave Ready Resource for Victoria (Victorian Government Department of Health, 2010). The Victoria resource, for example, includes detailed sections on heatwave planning, and a heatwave checklist for residential aged care. A similar review of heatwave response plans focused on 12 European countries (Lowe et al. 2011). The European study similarly indicated that aged care facilities were largely omitted from such plans. Given that one of the most susceptible groups within the community are the elderly 65 years and over, and that the elderly can be concentrated in aged care facilities, the absence of explicit reference to such facilities in all but three of the documents reviewed represents a significant shortcoming that paper 1 in Chapter 4 has emphasised.

Thirteen different heat stress prevention actions were listed in the heatwave response plans analysed. The most frequent were related to avoiding sun exposure, to knowing the signs and symptoms of heat, minimising physical activities, and hydration. Lowe et al.'s (2011) study also reported hydration to be one of the most common adaptation actions listed in the European plans it analysed.

Chapter 5 addressess the following aim:

4. To develop aged care facility heatwave adaptation strategies.

In Chapter 5 different theoretical climate change adaptation frameworks were analysed for the development of adaptation strategies for aged care facilities. Heatwave adaptation strategies found in Chapter 5 that may assist at-risk residents of aged care facilities cope with heatwaves are divided into short- and long-term measures. Eleven climate change adaptation measures against heatwaves were developed for aged care facilities. Heatwave response plans are one aspect of short-term adaptation for aged care facilities. Heatwave response plans set out what should happen before and during periods of severe heat (Public Health England 2015). They spell out what preparations both individuals and organisations can make to reduce health risks and include specific measures to protect at-risk groups (Public Health England 2015).

Other short-term measures include hydration, clients' care plan review schedule, increased staffing, families and carers involvement, heat-alarm sensor detector, and national heatwave legislations and policy frameworks. While some of these may appear simple and straight-forward, challenges will likely exist even for such strategies. For example, Courtney et al.'s (2009) previous study identified dehydration as the most noteworthy clinical care indicator resulting in poorer quality of life for residents in aged care facilities, even under normal (non-heatwave) conditions. Eating of vegetables and fruits, particularly salad, coupled with drinking of cool fluids and restraining from alcoholic and caffeine beverages, are sources of hydration and dietary fibre during hot weather conditions. The consumption of these nourishing nutrients usually will assists to replenish lost body fluid in extreme heatwave events. Long-term heatwave adaptation strategies are active and passive air-conditioning, backup power supplies, evaluation research, and community and professional education.

Chapter 6 addressed the following aim:

3 To explore heatwaves awareness, preparedness and planning in aged care facilities in Victoria, Australia.

Although previous studies have explored preparations for heatwaves at residential aged care services in Victoria, many aspects remained unanswered. Given the recent extreme high temperature trends and the future extreme high temperature projections for this region, more knowledge was needed about adaptation for heatwaves in aged care facilities to prevent possible future impacts and to tailor more specific adaptation measures. This thesis in Chapter

6, found aged care facility heatwave response plans are common in Victorian aged care facilities. The survey also examined building features such as building roofs, design and type, and air-conditioners that are important to cope with heatwave threats. Indeed, in a previous study, not having access to air-conditioning was the greatest infrastructural risk for heat-related deaths (Semenza et al. 1996). The study in Chapter 6 found an extremely high percentage of air-conditioner use in the Victorian aged care facilities surveyed.

The study in Chapter 6 further evaluates health professionals' role in response to heatwaves. It was found that the role of health professionals in heatwave management is many and varied. The roles may include monitoring heat-health risk residents during heatwaves, monitoring critical health infrastructures such as air-conditioning functions and back-up systems in case of air-conditioning equipment failure.

A number of limitations of this thesis have already been cited throughout the thesis, particularly in Chapters 4 and 6. Of particular note was the low response rate of the Victorian aged care facility survey, despite the adoption of several strategies to increase the response rate (such as redesigning the Black et al. (2013) survey to be shorter and sending reminder emails during the survey period).

7.2 Conclusions

Having an aged care facility heatwave response plan is significant with better heatwave planning, management, and good healthcare assessment processes. In the coming decades heatwaves are projected to become more dangerous to elderly health. Important aspects of aged care facility heatwave response plans are communication of the dangers of heatwave, identification of vulnerable residents, heatwave communication strategies, heat stress prevention strategies, and the need for ongoing heatwave education and training. There is also the need for national and sub-national governments to address heatwave response for such facilities. These are the recommendations in the three pieces of research (Chapters 4-6) conducted in this thesis.

7.3 Recommendations for future research work

There is much further research that could be conducted on the topic of this thesis. As noted in Chapter 4, differences between heatwave response plans at each level of government, connectivity and interrelatedness of heatwave response plans from each country, and the extent to which they may be hierarchical are analyses that could be insightful and lead to further improvement in the integration of plans at different levels.

In this thesis 18% of sampled Victorian aged care facilities were found to have flat roofs. Given that higher indoor temperatures are associated with flat roof buildings which is suggested can impact on residents health in aged care facilities, future research that will examine differences in residents of flat roof and pitched roof buildings in terms of heat-related hospital emergency visits/hospital admissions may assist to inform future aged care facility building features and designs (dwelling adaptation) in Australia and beyond.

Finally, a range of adaptation measures were discussed in Chapter 5, and a number of these could be trialled to evaluate their effectiveness. For example, a trial of personal heat-alarm sensor detectors to monitor the health of elderly residents of an aged care facility before, during and after a heatwave would be of value.

REFERENCES

Akompab, D.A., Bi, P., Williams, S., Saniotis, A., Walker, I.A., Augoustinos, M., 2013. Engaging stakeholders in an adaptation process: governance and institutional arrangements in heat-health policy development in Adelaide, Australia. Mitigation and Adaptation Strategies for Global Change, 18, 1001–1018.

Alberini, A., Gans, W., Alhassan, M., 2011. Individual and public-program adaptation: coping with heat waves in five cities in Canada. International Journal of Environmental Research and Public Health, 8, 4679-4701.

American Meteorological Society, 2012. Heat Wave. http://glossary.ametsoc.org/wiki/Heat_wave (Viewed 18 February 2016).

Anderson, G.B., Bell, M.L., 2011. Heatwaves in the United States: mortality risks during heatwaves and effect modification by heatwave characteristics in 43 U.S. communities. Environmental Health Perspectives, 119, 210-218.

Arizona Department of Health Services, 2011. Heat emergency response plan. Arizona: Author.

Australian Bureau of Statistics, 2013. Population Projections, Australia, 2012 (base) to 2101 http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/3222.0Main%20Features82012%20(base)%20to%202101?opendocument&tabname=Summary&prodno=3222.0&issue=2012%20(base)%20to%202101&num=&view= (Viewed 16 February 2016).

Australian Bureau of Statistics, 2014a. Population by Age and Sex, Regions of Australia, 2013
http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3235.02013 (Viewed 16 May 2016).

Australian Bureau of Statistics, 2014b. Remoteness Structure.
http://www.abs.gov.au/websitedbs/D3310114.nsf/home/remoteness+structure (Viewed 31 May 2016).

Australian Bureau of Statistics, 2015. 3235.0 - Population by Age and Sex, Regions of Australia, 2014
http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/3235.0Main%20Features102014?opendocument&tabname=Summary&prodno=3235.0&issue=2014&num=&view=
(Viewed 16 February 2016).

Australian Commonwealth Government, 2011. Protecting human health and safety during severe and extreme heat events. A national framework. PricewaterhouseCoopers Australia.

Australian Commonwealth Scientific and Industrial Research Organisation, 2014. The Report- State of the Climate.
http://www.csiro.au/en/Research/OandA/Areas/Assessing-our-climate/State-of-the-Climate/2014-SoC-Report (Viewed 13 January 2016).

Australian Government Department of Social Services, 2016. Aged care service lists-Victoria as at June 2015.
https://www.dss.gov.au/sites/default/files/documents/10_2015/service_list_-_vic.pdf (Viewed 26 May 2016).

Australian Institute of Health and Welfare, 2007. Older Australia at a glance: 4th edition. Cat. no. AGE 52. Canberra: AIHW.4th (Ed). 2007.

Barnett, A.G., 2007. Temperature and cardiovascular deaths in the US elderly: changes over time. Epidemiology, 18, 369-372.

Bassil, K.L., Cole, D.C., 2010. Effectiveness of public health interventions in reducing morbidity and mortality during heat episodes: a structured review. International Journal of Environmental Research and Public Health, 7, 991-1001.

Basu, R., Samet, J.M., 2002. Relationship between elevated ambient temperature and mortality: a review of the epidemiologic evidence. Epidemiologic Reviews, 24, 190-202.

Baw Baw Shire Council, 2009-2012. Heatwave response & action plan 2009-2010. Baw Baw Shire, Victoria: Author.

Beggs, P.J., 2000. Impacts of climate and climate change on medications and human health. Australian and New Zealand Journal of Public Health, 24, 630-632.

Beggs, P.J., 2010. Adaptation to impacts of climate change on aeroallergens and allergic respiratory diseases. International Journal of Environmental Research and Public Health, 7, 3006-3021.

Beggs, P.J., Vaneckova, P., 2008. Admission to hospital for effects of heat and light: 1993-94 to 2003-04. NSW Public Health Bulletin, 19, 132-137.

Bernard, S.M., McGeehin, M.A., 2004. Municipal heat wave response plans. American Journal of Public Health, 94, 1520-1522.

Berry, H.L., Bowen, K., Kjellstrom, T., 2010. Climate change and mental health: a causal pathways framework. International Journal of Public Health, 55, 123-132.

Bi, P., William, S., Loughnan, M., Lloyd, G., Hansen, A., Kjellstrom, T., Dear, K., Saniotis, A., 2011. The effects of extreme heat on human mortality and morbidity in Australia: implications for public health. Asia-Pacific Journal of Public Health, supplement 23, (2) 27S-36S.

Björnberg, K.E., Hansson, S.O., 2011. Five areas of value judgement in local adaptation to climate change. Local Government Studies, 37, 671–687.

Black, D., Veitch, C., Wilson, L., Hansen, A., 2013. Heat-ready: Heatwave awareness, preparedness and adaptive capacity in aged care facilities in three Australian states: New South Wales, Queensland and South Australia. University of Sydney and National Climate Change Adaptation Research Facility.

Blashki, G., Armstrong, G., Berry, H.L., Weaver, H.J., Hanna, E.G., Bi, P., Harley, D., Spickett, J.T., 2011. Preparing health services for climate change in Australia. Asia-Pacific Journal of Public Health, Supplement to 23 (2), 133S–143S.

Bowen, K.J., Friel, S., Ebi, K., Butler, C.D., Miller, F., McMichael, A.J., 2012. Governing for a healthy population: towards an understanding of how decision-making will determine our global health in a changing climate. International Journal of Environmental Research and Public Health, 9, 55-72.

Bowler, D.E., Buyung-Ali, L., Knight, T.M., Pullin, A.S., 2010. Urban greening to cool towns and cities: a systematic review of the empirical evidence. Landscape and Urban Planning, 97, 147–155.

Boyd, D.R., Genuis, S.J., 2008. The environmental burden of disease in Canada: respiratory disease, cardiovascular disease, cancer and congenital affliction. Environmental Research, 106, 240-249.

Bross, M.H., Nash, B.T. Jr., Carlton, F.B. Jr., 1994. Heat emergencies. American Family Physician, 50, 389-396.

Brown, S., Walker, G., 2008. Understanding heat wave vulnerability in nursing and residential homes. Building Research and Information, 36, 363-372.

Bruckner, T., Bashmakov, I.A., Mulugetta, Y., Chum, H., de la Vega Navarro, A., Edmonds, J., Faaij, A., Fungtammasan, B., Garg, A., Hertwich, E., Honnery, D., Infield, D., Kainuma, M., Khennas, S., Kim, S., Nimir, H.B., Riahi, K., Strachan, N., Wiser, R., Zhang, X., 2014: Energy Systems. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., Kriemann, B., Savolainen, J., Schlömer, S., von Stechow, C., Zwickel, T., Minx, J.C (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Burton, I., Malone, E., Huq, S., 2005. Adaptation policy frameworks for climate change: developing strategies, policies and measures. Lim B, Spanger-Siegfried E (eds). Cambridge, Cambridge University Press.

Campetella, C., Rusticucci, M., 1998. Synoptic analysis of an extreme heat wave over Argentina in March 1980. Meteorological Applications, 5, 217-226.

Carter, T.R., Fronzek, S., Inkinen, A., Lahtinen, I., Lahtinen, M., Mela, H., O'Brien, K.L., Rosentrater, L.D., Ruuhela, R., Simonsson, L., Terama, E., 2016. Characterising vulnerability of the elderly to climate change in the Nordic region. Regional Environmental Change, 16, 43–58.

Central Goldfields Shire Council 2010. Heat wave response plan. Central Goldfields Shire, Victoria: Author.

Cerutti, B., Tereanu, C., Domenighetti, G., Cantoni, E., Gaia, M., Bolgiani, I., Lazzaro, M., Cassis, I., 2006. Temperature related mortality and ambulance services interventions during the heat waves of 2003 in Ticino (Switzerland). Soz Praventiv Med, 51, 185-193.

Chau, P.H., Chan, K.C., Woo, J., 2009. Hot weather warning might help to reduce elderly mortality in Hong Kong. International Journal of Biometeorology, 53, 461–468.

Chiotti, Q., Lavender, B., 2008. Climate sensitivities, impacts and vulnerability: subregional perspectives: In From Impacts to Adaptation: Canada in a changing climate 2008. Lemmen, D.S., Warren, F.J., Lacroix, J., Bush, E (Eds). Government of Canada, Ottawa, ON.

Choudhary, E., Vaidyanathan, A., 2014. Heat Stress Illness Hospitalizations — Environmental Public HealthTracking Program, 20 States, 2001–2010. Surveillance Summaries, MMWR, Vol 63.

City of Toronto, 2012. Hot weather response plan. Toronto, Ontario: City of Toronto Public Health.

City of Vancouver, 2010. 2010 extreme hot weather preparedness & response plan. Vancouver, British Columbia: Author.

Claessens, Y.-E., Taupin, P., Kierzek, G., Pourriat, J.-L., Baud, M., Ginsburg, C., Jais, J.-P., Jougla, E., Riou, B., Dhainaut, J.-F., Landais, P., 2006. How emergency departments might alert for prehospital heat-related excess mortality? Critical Care, 10, R156.

Climate Council of Australia Limited, 2014. Heatwaves: hotter, longer, more often. Climate Council of Australia Limited.

Climate Council of Australia Limited, 2017. Cracking up the intensity: Climate change and extreme weather events. Climate Council of Australia Limited.

Collins, J.M., Chaves, R.R., Marques, V.D., 2009. Temperature variability over South America. Journal of Climate, 22, 5854-5869.

Commonwealth of Australia, 2003. Human health and Climate Change in Oceania: a risk assessment 2002. McMichael, A & Woodruff et al. (eds).
Retrieved from http://www.bvsde.paho.org/bvsacd/cd68/oceaniaclim.pdf

Commonwealth of Australia, 2009. Australian Climate Change Science: a National Framework. Australian Government, Department of Climate Change.

Commonwealth of Australia, Bureau of Meteorology 2016. Glossary: heat wave. http://www.bom.gov.au/lam/glossary/hpagegl.shtml (Viewed 04 January 2016).

Commonwealth Government of Australia, 2010. Adapting to climate change in Australia. An Australian Government Position Paper 2010. Department of Climate Change, Australia.

Commonwealth Government of Australia, 2011. Protecting human health and safety during severe and extreme heat events: a national framework. PricewaterhouseCoopers, Australia.

Conti, S., Meli, P., Minelli, G., Solimini, R., Toccaceli, V., Vichi, M., Beltrano, C., Perini, L., 2005. Epidemiologic study of mortality during the summer 2003 heat wave in Italy. Environmental Research, 98, 390–399.

Costello, A., Abbas, M., Allen, A., Ball, S., Bell, S., Bellamy, R., Friel, S., Groce, N., Johnson, A., Kett, M., Lee, M., Levy, C., Maslin, M., McCoy, D., McGuire, B., Montgomery, H., Napier, D., Pagel, C., Patel, J., Antonio, J., de Oliveira, P., Redclift, N., Rees, H., Rogger, D., Scott, J., Stephenson, J., Twigg, J., Wolff, J., Patterson, C., 2009. Managing the health effects of climate change. The Lancet, 373, 1693-1733.

Courtney, M., O'Reilly, M., Edwards, H., Hassall, S., 2009. The relationship between clinical outcomes and quality of life for residents of aged care facilities. Australian Journal of Advanced Nursing, 26(4), 49-57.

Crotty, M., Halbert, J., Rowett, D., Giles, L., Birks, R., Williams, H., Whitehead, C., 2004. An outreach geriatric medication advisory service in residential aged care: a randomised controlled trial of case conferencing. Age and Ageing, 33, 612-617.

Cusack, L., de Crespigny, C., Athanasos, P., 2011. Heatwaves and their impact on people with alcohol, drug and mental health conditions: a discussion paper on clinical practice considerations. Journal of Advance Nursing, 67, 915-922.

Darebin City Council, 2009. Darebin heatwave plan. Darebin City, Victoria: Author.

Davido, A., Patzak, A., Dart, T., Sadier, M.P., Méraud, P., Masmoudi, R., Sembach, N., Cao, T.H., 2006. Risk factors for heat related death during the August 2003 heat wave in Paris, France, in patients evaluated at the emergency department of the Hôpital Europėen Georges Pompidou. Emergency Medicine Journal, 23, 515-518.

de' Donato, F.K., Leone, M., Scortichini, M., De Sario, M., Katsouyanni, K., Lanki, T., Basagaña, X., Ballester, F., Åström, C., Paldy, A., Pascal, M., Gasparrini, A., Menne, B., Michelozzi, P., 2015. Changes in the effect of heat on mortality in the last 20 years in nine European cities. Results from the PHASE Project. International Journal of Environmental Research and Public Health, 12, 15567–15583.

Département Santé Environnement, 2003. Impact sanitaire de la vague de chaleurd'août 2003 en France. Institut de Veille Sanitaire. Paris.

Deuble, M.P., de Dear, R.J., 2012a. Green occupants for green buildings: the missing link. Building and Environment, 56, 21-27.

Deuble, M.P., de Dear, R.J., 2012b. Mixed-mode buildings: a double standard in occupants' comfort expectations. Building and Environment, 54, 53-60.

D'Ippoliti, D., Michelozzi, P., Marino, C., de'Donato, F., Menne, B., Katsouyanni, K., Kirchmayer, U., Analitis, A., Medina-Ramon, M., Paldy, A., Atkinson, R., Kovats, S., Bisanti, L., Schneider, A., Lefranc, A., Iñiguez, C., Perucci, CA., 2010. The impact of heat waves on mortality in 9 European cities: results from the EuroHEAT project. Environmental Health, 9, doi:10.1186/1476-069X-9-37.

Dolney, T., Sheridan, S., 2005. The relationship between extreme heat and ambulance response calls for the city of Toronto, Ontario, Canada. Environmental Research, 101, 94-103.

East Gippsland Shire Council, 2010. Heatwave plan. East Gippsland Shire, Victoria: Author.

Ebi, K.L., Kovats, R.S., Menne, B., 2006. An approach for assessing human health vulnerability and public health interventions to adapt to climate change. Environmental Health Perspectives, 114, 1930-1934.

Ebi, K.L., Teisberg, T.J., Kalkstein, L.S., Robinson, L., Weiher, R.F., 2004. Heat watch/warning systems save lives: estimated costs and benefits for Philadelphia 1995–98. Bulletin of the American Meteorological Society, 85, 1067-1073.

Elleuch, M., Bedigian, D., Roiseux, O., Besbes, S., Blecker, C., Attia, H., 2011. Dietary fibre and fibre-rich by-products of food processing: characterisation, technological functionality and commercial applications: a review. Food chemistry, 124, 411-421.

Emergency Management Act 2013. Authorised Version No. 010. The Parliament of Victoria. Office of the Emergency Services Commissioner. Victoria, Australia, 2014.

Flynn, A., McGreevy, C., Mulkerrin, E.C., 2005. Why do older patients die in a heatwave? Monthly Journal of the Association of Physicians, 98, 227-229.

Foroni, M., Salvioli, G., Rielli, R., Goldoni, C.A., Orlandi, G., Sajani, S.Z., Guerzoni, A., Maccaferri, C., Daya, G., Mussi, C., 2007. A retrospective study on heat-related mortality in an elderly population during the 2003 heat wave in Modena, Italy: the argento project. Journal of Gerontology: Medical Sciences, 62A, 647–651.

Fouillet, A., Rey, G., Wagner, V., Laaidi, K., Empereur-Bissonet, P., Le Tertre, A., Frayssinet, P., Bessemoulin, P., Laurent, F., De Crouy-Chanel, P., Jougla, E., Hémon, D., 2008. Has the impact of heat waves on mortality changed in France since the European heat wave of summer 2003? A study of the 2006 heat wave. International Journal of Epidemiology, 37, 309-317.

Fritze, J.G., Blashki, G.A., Burke, S., Wiseman, J., 2008. Hope, despair and transformation: climate change and the promotion of mental health and wellbeing. International Journal of Mental Health Systems, 2, 2-13.

Fuhrmann, C.M., Sugg, M.M., Konard II, C.E., Waller, A., 2016. Impact of extreme heat events on emergency department visis in North Carolina (2007-2011). Journal of community Health, 41, 146-156.

Gaillat, J., Dennetière, G., Raffin-Bru, E., Valette, M., Blanc, M.C., 2008. Summer influenza outbreak in a home for the elderly: application of preventive measures. Journal of Hospital Infection, 70, 272-277.

Gamble, J.L., Hurley, B.J., Schultz, P.A., Jaglom, W.S., Krishnan, N., Harris, M., 2013. Climate change and older Americans: state of the science. Environmental Health Perspectives, 121, 15–22.

Gannawarra Shire Council, 2012. Heatwave plan. Gannawarra Shire, Victoria: Author.

Garssen, J., Harmsen, C., de Beer, J., 2005. The effects of the summer 2003 heat wave on mortality in The Netherlands. Eurosurveillance, 10 (7), 165-167.

Gifford, R., 2011. The dragons of inaction: psychological barriers that limit climate change mitigation and adaptation. American Psychological Association, 66, 290-302.

Gilbert, N.L., Gauvin, D., Guay, M., Héroux, M., Dupuis, G., Legris, M., Chan, C.C., Dietz, R.N., Lévesque, B., 2006. Housing characteristics and indoor concentration of nitrogen dioxide and formaldehyde in Quebec City, Canada. Environmental Research, 102, 1-8.

Glazer, J.L., 2005. Management of heatstroke and heat exhaustion. American Family Physician, 71, 2133-2140.

Goral, M., 2004. First-language decline in health aging: implications for attrition in bilingualism. Journal of Neurolinguistics, 17, 31-52.

Gordon, S.M., Jackson, J.C., Ely, E.W., Burger, C., Hopkins, R.O., 2004. Clinical identification of cognitive impairment in ICU survivors: insights for intensivists. Intensive care Medicine, 30, 1997-2008.

Government of South Australia, 2010. Prospering in a changing climate. A draft climate change adaptation framework for South Australia.

Government of South Australia, SA Health 2013. Extreme heat operational plan. SA: Author.

Government of Western Australia Department of Health, 2010. Operational directive: heatwave policy. Perth, WA: Author.

Greater Shepparton City Council, 2009. Greater Shepparton heatwave plan 2009. Shepparton, Victoria: Author.

Greenberg, J.H., Bromberg, J., Reed, C.M., Gustafson, T.L., Beauchamp, R.A., 1983. The epidemiology of heat-related deaths, Texas-1950, 1970-79, and 1980. American Journal of Public Health, 73, 805-807.

Grize, L., Huss, A., Thommen, O., Schindler, C., Braun-Fahrländer, C., 2005. Heat wave 2003 and mortality in Switzerland. Swiss Medical Weekly, 135 (13), 200-205.

Haines, A., Kovats, R.S., Campbell-Lendrum, D., Corvalan, C., 2006. Climate change and human health: impacts, vulnerability and public health. Public Health, 120, 585-596.

Hajat, S., Kosatky, T., 2010. Heat-related mortality: a review and exploration of heterogeneity. Journal of Epidemiology and Community Health, 64, 753-760.

Hajat, S., Kovats, R.S., Lachowycz, K., 2007. Heat-related and cold-related deaths in England and Wales: who is at risk? Occupational and Environmental Medicine, 64, 93–100.

Hajat, S., O'Connor, M., Kosatsky, T., 2010a. Health effects of hot weather: from awareness of risk factors to effective health protection. Lancet, 375, 856-863.

Hajat, S., Sheridan, S.C., Allen, M.J., Pascal, M., Laaidi, K., Yagouti, A., Bickis, U., Tobias, A., Bourque, D., Armstrong, B.G., Kosatsky, T., 2010b. Heat-health warning systems: a comparison of the predictive capacity of different approaches to identifying dangerously hot days. American Journal of Public Health, 100, 1137-1144.

Hanna, E.G., Spickett, J.T., 2011. Climate change and human health: building Australia's adaptation capacity. Asia-Pacific Journal of Public Health, Supplement to 23(2) 7S–13S.

Hansen, A., Bi, P., Nitschke, M., Ryan, P., Pisaniello, D., Tucker, G., 2008. The effect of heat waves on mental health in a temperate Australian city. Environmental Health Perspectives, 116, 1369-1375.

Hartmann, D.L., Klein Tank, A.M.G., Rusticucci, M., Alexander, L.V., Brönnimann, S., Charabi, Y., Dentener, F.J., Dlugokencky, E.J., Easterling, D.R., Kaplan, A., Soden, B.J., Thorne, P.W., Wild, M., Zhai, P.M., 2013. Observations: Atmosphere and Surface. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Harrington, C., Tompkins, C., Curtis, M., Grant, L., 1992. Psychotropic drugs use in long-term care facilities: a review of the literature. The Gerontologist, 32, 822-833.

Havenith, G., 2005. Temperature regulation, heat balance and climatic stress. IN: Kirch, W., Menne, B. and Bertollini, R. (Eds.) Extreme Weather Events and Public Health Responses. Berlin: Springer-Verlag, pp 69-80.

Hayhoe, K., Sheridan, S., Kalkstein, L., Greene, S., 2010. Climate change, heat waves, and mortality projections for Chicago. Journal of Great Lakes Research, 36, 65-73.

Health Canada, 2011. Extreme heat events guidelines: technical guide for health care workers. Ottawa, Ontario: Author.

Hiete, M., Merz, M., Schultmann, F., 2011. Scenario-based impact analysis of a power outage on healthcare facilities in Germany. International Journal of Disaster Resilience in the Built Environment, 2, 222–244.

Holstein, J., Canouï-Poitrine, F., Neumann, A., Lepage, E., Spira, A., 2005. Were less disabled patients the most affected by 2003 heat wave in nursing homes in Paris, France? Journal of Public Health, 27, 359–365.

Hospers, A.P.N., Chahine, L.M., Chemali, Z., 2007. Health care delivery systems for older adults: how do the Netherlands and Lebanon compare? Social Science & Medicine, 65, 1979-1985.

How, C.-K., Chern, C.-H., Wang, L.-M., Lee, C.-H., 2000. Heat stroke in a subtropical country. American Journal of Emergency Medicine, 18, 474-477.

Huang, C., Barnett, A.G., Wang, X., Vaneckova, P., FitzGerald, G.,Tong, S., 2011. Projecting future heat-related mortality under climate change scenarios: a systematic review. Environmental Health Perspectives, 119, 1681–1690.

Ibrahim, J.E., McInnes, J.A., Andrianopoulos, N., Evans, S., 2012. Minimising harm from heatwaves: a survey of awareness, knowledge, and practices of health professionals and care providers in Victoria, Australia. International Journal of Public Health, 57, 297–304.

Intergovernmental Panel on Climate Change, 2013a: Annex III: Glossary [Planton, S. (ed.)]. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex,V., Midgley, P.M. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Intergovernmental Panel on Climate Change, 2013b: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Intergovernmental Panel on Climate Change, 2013c. Summary for policymakers. In: Climate Change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M. (Eds.)]. Cambridge University Press. United Kingdom and New York, NY, USA.

Intergovernmental Panel on Climate Change, 2014a. Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Intergovernmental Panel on Climate Change, 2014b. Glossary. In: Climate Change: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jay, O., Kenny, G.P., 2010. Heat exposure in the Canadian workplace. American Journal of Industrial Medicine, 53, 842-853.

Johnson, H., Kovats, R.S., McGregor, G., Stedman, J., Gibbs, M., Walton, H., Cook, L., Black, E., 2005. The impact of the 2003 heat wave on mortality and hospital admissions in England. Health Statistics Quarterly, 25, 6-11.

Josseran, L., Caillère, N., Brun-Ney, D., Rottner, J., Filleul, L., Brucker, G., Astagneau, P., 2009. Syndromic surveillance and heat wave morbidity: a pilot study based on emergency departments in France. BMC Medical Informatics and Decision Making, 9, 14.

Khalaj, B., Lloyd, G., Sheppeard, V., Dear, K., 2010. The health impacts of heat waves in five regions of New South Wales, Australia: a case-only analysis. International Archives of Occupational and Environmental Health, 83, 833-842.

Kim, D-W., Deo, R.C., Chung, J-H., Lee, J-S., 2016. Projection of heat wave mortality related to climate change in Korea. Natural Hazards, 80, 623–637.

Kim, K-H., Kabir, E., Jahan, S.A., 2014. A review of the consequences of global climate change on human health. Journal of Environmental Science and Health part C, 32, 299-318.

Kirtman, B., Power, S.B., Adedoyin, J.A., Boer, G.J., Bojariu, R., Camilloni, I., Doblas-Reyes, F.J., Fiore, A.M., Kimoto, M., Meehl, G.A., Prather, M., Sarr, A., Schär, C., Sutton, R., van Oldenborgh, G.J., Vecchi, G., Wang, H.J., 2013: Near-term Climate Change: Projections and Predictability. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Klein, R.J.T., Midgley, G.F., Preston, B.L., Alam, M., Berkhout, F.G.H., Dow, K., Shaw, M.R., 2014: Adaptation opportunities, constraints, and limits. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Kleiner SM., 1999. Water: An essential but overlooked nutrient. Journal of The American Dietetic Association, 2, 200-206.

Klenk, J., Becker, C., Rappi, K., 2010. Heat-related mortality in residents of nursing homes. Age and Ageing, 39, 245–252.

Knowlton, K., Kulkarni, S.P., Azhar, G.S., Mavalankar, D., Jaiswal, A., Connolly, M., Nori-Sarma, A., Rajiva, A., Dutta, P., Deol, B., Sanchez, L., Khosla, R., Webster, P.J., Toma, V.E., Sheffield, P., Hess, J.J and the Ahmedabad Heat and Climate Study Group., 2014. Development and implementation of South Asia’s first heat-health action plan in Ahmedabad (Gujarat, India). International Journal of Environmental Research and Public Health, 11, 3473-3492.

Katz PR. An international perspective on long term care: focus on nursing homes. Journal of the American Medical Directors Association 2011; 12 (7): 487-492.e1.
DOI: 10.1016/j.jamda.2011.01.017

Knowlton, K., Rotkin-Ellman, M., King, G., Margolis, H.G., Smith, D., Solomon, G., Trent, R., English, P., 2009. The 2006 California heat wave: impacts on hospitalizations and emergency department visits. Environmental Health Perspectives, 117, 61–67.

Kohn, M.A., Farley, T.A., Sundin, D., Tapia, R., McFarland, L.M., Arden, N.H., 1995. Three summertime outbreaks of influenza type A. Journal of Infectious Diseases, 172, 246-249.

Kovats, R.S., Ebi, K.L., 2006. Heatwaves and public health in Europe. European Journal of Public Health, 16, 592-599.

Kravchenko, J., Abernethy, A.P., Fawzy, M., Lyerly, A.K., 2013. Minimization of heatwave morbidity and mortality. American Journal of Preventive Medicine, 44, 274-282.

Lavis, J.N., Oxman, A.D., Moynihan, R., Paulsen, E.J., 2008. Evidence-informed health policy I – Synthesis of findings from a multi-method study of organizations that support the use of research evidence. BioMed Central, 3, 53.

Leiper, J.B., Primrose, C.S., Primrose, W.R., Phillimore, J., Maughan, R.J., 2005. A comparison of water turnover in older people in community and institutional settings. The Journal of Nutrition, Health & Aging, 9, 189-193.

Lemmen, D.S., Warren, F.J., Lacroix, J., Bush, E., 2008. Synthesis: In From Impacts to Adaptation: Canada in a Changing Climate 2007. Lemmen, D.S., Warren, F.J., Lacroix, J., Bush, E (eds). Government of Canada, Ottawa, Ontario.

Loughnan, M., Carroll, M., Tapper, N.J., 2015. The relationship between housing and heat wave resilience in older people. International Journal of Biometeorology, 59, 1291–1298.

Loughnan, M.E., Nicholls, N., Tapper, N.J., 2010. The effects of summer temperature, age and socioeconomic circumstance on acute myocardial infarction admissions in Melbourne, Australia. International Journal of Health Geographics, 9, 41-51.

Lowe, D., Ebi, K.L., Forsberg, B., 2011. Heatwave early warning systems and adaptation advice to reduce human health consequence of heatwaves. International Journal of Environmental Research and Public Health, 8, 4623-4648.

Luber, G., McGeehin, M., 2008. Climate change and extreme heat events. American Journal on Preventive Medicine, 35, 429-435.

Lyon, B., 2009. Southern Africa summer drought and heat waves: observations and coupled model behaviour. Journal of Climate, 22, 6033-6046.

Mackenbach, J.P., Borst, V., Schols, J.M.G.A., 1997. Heat-related mortality among nursing-home patients. The Lancet, 349, (9061), 1297-1298.

Marmor, M., 1978. Heat wave mortality in nursing homes. Environmental Research, 17, 102-115.

Matthies, F., Menne, B., 2009. Prevention and management of health hazards related to heatwaves. International Journal of Circumpolar Health, 68, 8–22.

Maughan, R.J., 2012. Hydration, morbidity, and mortality in vulnerable populations. Nutrition Reviews, 70, (Suppl. 2):S152–S155.

Maxwell, T.A., 2003. The public need to know: emergencies, government organizations, and public information policies. Government Information Quarterly, 20, 233-258.

McGreevy, C., Horan, J., Jones, D., Biswas, K., O'Meara, Y.M., Mulkerrin, E.C., 2008. A study of tubular potassium secretory capacity in older patients with hyperkalaemia. The Journal of Nutrition, Health & Aging, 12, 152-155.

McInnes, J.A., Ibrahim, J.E., 2010. Minimising harm to older Victorians from heatwaves: a qualitative study of the role of community-based health profession and carer organisations. Australasian Journal on Ageing, 29, 104–110.

McInnes, J.A., Ibrahim, J.E., 2013. Preparation of residential aged care services for extreme hot weather in Victoria, Australia. Australian Health Review, 37, 442–448.

McMichael, A., Weaver, H.J., Berry, H., Beggs, P., Currie, B., Higgins, J., Kelly, B., McDonald, J., Tong, S., 2009. National Climate Change Adaptation Research Plan for Human Health. National Climate Change Adaptation Research Facility, Gold Coast. Australia.

Memon, R.A., Leung, D.Y.C., Chunho, L., 2008. A review on the generation, determination and mitigation of urban heat island. Journal of Environmental Sciences, 20, 120–128.

Michelozzi, P., de' Donato, F.K., Bargagli, A.M., D'lppoliti, D., De Sario, M., Marino, C., Schifano, P., Cappai, G., Leone, M., Kirchmayer, U., Ventura, M., di Gennaro, M., Leonardi, M., Oleari, F., De Martino, A., Perucci, C.A., 2010. Surveillance of summer mortality and preparedness to reduce the health impact of heat waves in Italy. International Journal of Environmental Research and Public Health, 7, 2256-2273.

Mimura, N., Pulwarty, R.S., Duc, D.M., Elshinnawy, I., Redsteer, M.H., Huang, H.Q., Nkem, J.N., Sanchez Rodriguez, R.A., 2014: Adaptation planning and implementation. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Miskelly, F.G., 2001. Assistive technology in elderly care. Age and Ageing, 30, 455-458.

Molloy, S.L., Dreelin, E.A., Rose, J.B., 2008. Extreme weather events and human health. In: International Encyclopedia of Public Health, 536-544. Heggnhougen, K., Quah, S.R (eds). Amsterdam. Elsevier.

Morabito, M., Profili, F., Crisci, A., Francesconi, P., Gensini, G.F., Orlandini, S., 2012. Heat-related mortality in the Florentine area (Italy) before and after the exceptional 2003 heat wave in Europe: an improved public health response? International Journal of Biometeorology, 56, 801–810.

Mudarri, D., 2010. Public health consequences and cost of climate change impacts on indoor environments. Prepared for: The Indoor Environments Division Office of Radiation and Indoor Air. US Environmental Protection Agency, Washington, D. C.

National Institute of Water and Atmospheric Research, 2010. New Zealand national climate summary 2009.
Retrieved from http://www.niwa.co.nz/climate/summaries/annual/2009

Nates, J.L., 2004. Combined external and internal hospital disaster: impact and response in a Huston trauma center intensive care unit. Critical Care Medicine, 32, 686-690.

New Zealand Ministry of Health, 2000. The New Zealand health strategy. Wellington: Author.

New Zealand Ministry of Health, 2002. Health of older people strategy. Wellington: Author.

New Zealand Ministry of Health, 2015a. Protecting your health in an emergency. Wellington: Author.

New Zealand Ministry of Health, 2015b. National health emergency plan: a framework for the health and disability sector. Wellington: Author.

Nitschke, M., Tucker, G., Bi, P., 2007. Morbidity and mortality during heatwaves in metropolitan Adelaide. The Medical Journal of Australia, 187, 662-665.

Noble, I.R., Huq, S., Anokhin, Y.A., Carmin, J., Goudou, D., Lansigan, F.P., Osman-Elasha, B., Villamizar, A., 2014: Adaptation needs and options. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Nogueira, P.J., 2005. Examples of heat health warning systems: Lisbon's íCARO's surveillance system, summer of 2003. Springer-Verlag Berlin Heidelberg, 141-159.

Oberlin, M., Tubery, M., Cances-Lauwers, V., Ecoiffier, M., Laugue, D., 2010. Heat-related illnesses during the 2003 heatwave in an emergency service. Emergency Medicine Journal, 27, 297-299.

O'Neill, M.S., Cater, R., Kish, J.K., Gronlund, C.J., White-Newsome, J.L., Manarolla, X., Zanobetti, A., Schwartz, J.D., 2009a. Preventing heat-related morbidity and mortality: new approaches in a changing climate. Maturitas, 64, 98-103.

O'Neill, M.S., Ebi, K.L., 2009b. Temperature extremes and health: impacts of climate variability and change in the United States. Journal of Occupational and Environmental Medicine, 51, 13-25.

O'Neill, M.S., Jackman, D.K., Wyman, M., Manarolla, X., Gronlund, C.J., Brown, D.G., Brines, S.J., Schwartz, J., Diez-Roux, A.V., 2010. US local action on heat and health: are we prepared for climate change? International Journal of Public Health, 55, 105–112.

Oven, K.J., Curtis, S.E., Reaney, S., Riva, M., Stewart, M.G., Ohlemüller, R., Dunn, C.E., Nodwell, S., Dominelli, L., Holden, R., 2012. Climate change and health and social care: defining future hazard, vulnerability and risk for infrastructure systems supporting older people's health care in England. Applied Geography, 33, 16-24.

Palecki, M.A., Changnon, S.A., Kunkel, K.E., 2001. The nature and impacts of the July 1999 heat wave in the Midwestern United States: learning from the lessons of 1995. Bulletin of the American Meteorological Society, 82, 1353-1367.

Patz, J.A., McGeehin, M.A., Bernard, S.M., Ebi, K.L., Epstein, P.R., Grambsch, A., Gubler, D.J., Reiter, P., Romieu, I., Rose, J.B., Samet, J.M., Trtanj, J., 2000. The potential health impacts of climate variability and change for the United States: executive summary of the report of the health sector of the U.S. National Assessment. Environmental Health Perspectives, 108, 367-376.

Phung, D., Thai, P.K., Guo, Y., Morawska, L., Rutherford, S., Chu, C., 2016. Ambient temperature and risk of cardiovascular hospitalization: an updated systematic review and meta-analysis. Science of the Total Environment, 550, 1084-1102.

Price, K., Perron, S., King, N., 2013. Implementation of the Montreal heat response plan during the 2010 heat wave. Canadian Journal of Public Health-Revue Canadienne De Sante Publique, 104, e96-e100.

Public Health Dayton & Montgomery County, 2011. Heat advisory plan. Dayton & Montgomery County, Ohio: Author.

Public Health England, 2015. Supporting vulnerable people before and during a heatwave: Advice for care home managers and staff. London: Author.

Public Health and Wellbeing Act 2008 http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/PubStatbook.nsf/f932b66241ecf1b7ca256e92000e23be/8B1B293B576FE6B1CA2574B8001FDEB7/$FILE/08-46a.pdf (Viewed 29 April 2016).

Qian, Z., He, Q., Lin, H., Kong, L., Bentley, C.M., Liu, W., Zhou, D., 2008. High temperatures enhanced acute mortality effects of ambient particle pollution in the “Oven” City of Wuhan, China. Environmental Health Perspectives, 116, 1172-1178.

Qualtrics. Cross Tabulation Analysis. Version November 1, 2011. https://www.qualtrics.com/wp-content/uploads/2013/05/Cross-Tabulation-Theory.pdf (Accessed: 31 March 2017).

Queensland Government, 2004. Queensland heatwave response plan. Queensland Health Department.

Reid, C.E., Gamble, J.L., 2009a. Aeroallergens, allergic disease, and climate change: impacts and adaptation. EcoHealth, 6, 458-470.

Reid, C.E., O'Neill, M.S., Gronlund, C.J., Brines, S.J., Brown, D.G., Diez-Roux, A.V., Schwartz, J., 2009b. Mapping community determinants of heat vulnerability. Environmental Health Perspectives, 117, 1730-1736.

Reisinger, A., Kitching, R.L., Chiew, F., Hughes, L., Newton, P.C.D., Schuster, S.S., Tait, A., Whetton, P., 2014: Australasia. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., Field, C.B., Dokken, D.J., Mastrandrea, M.D., Mach, K.J., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY , USA.

Republic of South Africa. Disaster Management Act 2002.

Republic of the Philippines. Philippine disaster risk reduction and management Act of 2010. Congress of the Philippines. Metro Manila.

Rocklöv, J., Forsberg, B., 2008. The effect of temperature on mortality in Stockholm 1998-2003: a study of lag structures and heatwave effects. Scandinavian Journal of Public Health, 36, 516-523.

Roldán, E., Gómez, M., Pino, M.R., Pórtoles, J., Linares, C., Díaz, J., 2016. The effect of climate-change-related heat waves on mortality in Spain: uncertainties in health on a local scale. Stochastic Environmental Research and Risk Assessment, 30, 831–839.

Rural City of Wangaratta, 2009. Heatwave response plan. Wangaratta, Victoria: Author.

Sarofim, M.C., Saha, S., Hawkins, M.D., Mills, D.M., Hess, J., Horton, R., Kinney, P., Schwartz, J., Juliana, A.St., 2016. Temperature-related death and illness. The impacts of climate change on human health in the United States: a scientific assessment. U.S. Global change research program, Washington , DC. https://s3.amazonaws.com/climatehealth2016/low/ClimateHealth2016_02_Temperature_small.pdf (Viewed 16 April 2016).

Semenza, J.C., Rubin, C.H., Falter, K.H., Selanikio, J.D., Flanders, W.D., Howe, H.L., Wilhelm, J.L., 1996. Heat-related deaths during the July 1995 heatwave in Chicago. The new England Journal of Medicine, 335, 84-90.

Shea, K.M., Truckner, R.T., Weber, RW., Peden, D.B., 2008. Climate change and allergic disease. The Journal of Allergy and Clinical Immunology, 122, 443-453.

Sheffield, P.E., Durante, K.T., Rahona, E., Zarcadoolas, C., 2014. Emerging roles of health care providers to mitigate climate change impacts: a perspective from East Harlem, New York. Health and Human Rights Journal, 16, 113-121.

Sheridan, S.C., 2007. A survey of public perception and response to heat warnings across four North American cities: an evaluation of municipal effectiveness. International Journal of Biometeorology, 52, 3-15.

Simón, F., Lopez-Abente, G., Ballester, E., Martínez, F., 2005. Mortality in Spain during the heat waves of summer 2003. Eurosurveillance, 10 (7), 156-160.

Smith, K.R., Woodward, A., Campbell-Lendrum, D., Chadee, D.D., Honda, Y., Liu, Q., Olwoch, J.M., Revich, B., Sauerborn, R., 2014. Human health: impacts, adaptation, and co-benefits. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Smoyer-Tomic, K.E., Rainham, D.G.C., 2001. Beating the heat: development and evaluation of a Canadian hot weather health-response plan. Environmental Health Perspectives, 109, 1241–1248.

Stafoggia, M., Forastiere, F., Agostini, D., Biggeri, A., Bisanti, L., Cadum, E., Caranci, N., De'Donato, F., De Lisio, S., De Maria, M., Michelozzi, P., Miglio, R., Pandolfi, P., Picciotto, S., Rognoni, M., Russo, A., Scarnato, C., Perucci, C., 2006. Vulnerability to heat-related mortality: a multicity, population-based, case-crossover analysis. Epidemiology, 17, 315-323.

Stafoggia, M., Forastiere, F., Agostini, D., Caranci, N., de'Donato, F., Demaria, M., Michelozzi, P., Miglio, R., Rognoni, M., Russo, A., Perucci, C.A., 2008. Factors affecting in-hospital heat-related mortality: a multi-city case-crossover analysis. Journal of Epidemiology and Community Health, 62, 209–215.

State Government of Victoria, 2013. Victorian climate change adaptation plan.

http://www.depi.vic.gov.au/__data/assets/pdf_file/0004/284044/4493_DSE_Climate_Change_Adaptation_Plan_WEB.pdf (Viewed 02 June 2016).

State Government of Victoria, 2016. Local councils.
Retrieved from http://www.vic.gov.au/government-economy/local-councils.html

State of Victoria Department of Health, 2011. Heatwave plan for Victoria. Protecting health and reducing harm from heatwaves. Melbourne, Victoria: Author.

State of Victoria Department of Human Services, 2009. Heatwave planning guide: Development of heatwave plans in local councils in Victoria. Melbourne, Victoria: Author.

State of New South Wales, 2014. Energy saver. Aged-care toolkit. Office of Environment and Heritage. Sydney, Australia.
http://www.environment.nsw.gov.au/resources/business/140393-aged-care-toolkit.pdf
(Viewed 29 April 2016).

Stocker, T.F., Qin, D., Plattner, G.-K., Alexander, L.V., Allen, S.K., Bindoff, N.L., Bréon, F.-M., Church, J.A., Cubasch, U., Emori, S., Forster, P., Friedlingstein, P., Gillett, N., Gregory, J.M., Hartmann, D.L., Jansen, E., Kirtman, B., Knutti, R., Krishna Kumar, K., Lemke, P., Marotzke, J., Masson-Delmotte, V., Meehl, G.A., Mokhov, I.I., Piao, S., Ramaswamy, V., Randall, D., Rhein, M., Rojas, M., Sabine, C., Shindell, D., Talley, L.D., Vaughan, D.G., Xie, S.-P., 2013: Technical Summary. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Tan, J., Zheng, Y., Song, G., Kalkstein, L., Kalkstein, A., Tang, Xu., 2007. Heat wave impacts on mortality in Shanghai, 1998 and 2003. International Journal of Biometeorology, 51, 193-200.

The second Lancet Commission on Health and Climate Change, 2015. Editorial: Health professionals: be prepared for heatwaves. Lancet, 386, July 18.
http://www.thelancet.com/commissions/climate-change

The World Bank Group, 2016. High income OECD members.
Retrieved from http://data.worldbank.org/about/country-classifications/country-and-lending-groups

Thomas, P., Swaminathan, A., Lucas, R.M., 2012. Climate change and health with an emphasis on interactions with ultraviolet radiation: a review. Global Change Biology, 18, 2392–2405.

United Kingdom Climate Change Act 2008. Impact of and Adaptation to Climate Change http://www.legislation.gov.uk/ukpga/2008/27/pdfs/ukpga_20080027_en.pdf
(Viewed 29 April 2016).

United Kingdom Climate Change Committee. Measuring progress. Adaptation sub-committee progress report 2011. www.theccc.org.uk (Viewed 29 April 2016).

UK Department of Health, 2010. Supporting vulnerable people before and during a heatwave: Advice for care home managers and staff. London: Author.

UK Department of Health, 2012. Heatwave plan for England 2012: Protecting health and reducing harm from severe heat and heatwaves. London: Author.

United Nations Development Program, 2004. Adaptation policy frameworks for climate change: developing strategies, policies and measures. Lim, B., Spanger-Siegfried, E (Ed). Cambridge University Press, Cambridge, United Kingdom.

US Centers for Disease Control and Prevention, 2016. Extreme heat: about CDC's program. http://www.bt.cdc.gov/disasters/extremeheat/program.asp (Viewed 16 February 2016).

US Centers for Disease Control and Prevention 2002. Heat wave related mortality. Media relations-telebriefing transcripts. www.cdc.gov/media/transcripts/t020703.htm
(Viewed 28 April 2016).

United States Department of Commerce, National Oceanic and Atmospheric Administration, 2015. Trends in atmospheric carbon dioxide. Earth system research laboratory: global monitoring division. United States of America.
http://www.esrl.noaa.gov/gmd/ccgg/trends/#mlo_full (Viewed 30 November 2015).

Vandentorren, S., Suzan, F., Medina, S., Pascal, M., Mautpoix, A., Cohen, J., Ledrans, M., 2004. Mortality in 13 French cities during the August 2003 heat wave. American Journal of Public Health, 94, 1518-1520.

Vaneckova, P., Beggs, P.J., De Dear, R.J, McCracken, K.W.J., 2008a. Effect of temperature on mortality during the six warmer months in Sydney, Australia, between 1993 and 2004. Environmental Research, 108, 361-369.

Vaneckova, P., Hart, M.A., Beggs, P.J., 2008b. Synoptic analysis of heat-related mortality in Sydney, Australia, 1993-2001. International Journal of Biometeorology, 52, 439-451.

Vaneckova, P., Beggs, P.J., Jacbson, C.R., 2010. Spatial analysis of heat-related mortality among the elderly between 1993 and 2004. Social Science & Medicine, 70, 293-304.

van Loenhout, J.A.F., le Grand., Duijm, F., Greven, F., Vink, N.M., Hoek, G., Zuurbier, M., 2016. The effect of high indoor temperatures on self-perceived health of elderly persons. Environmental Research, 146, 27-34.

Vescovi, L., Rebetez, M., Rong, F., 2005. Assessing public health risk due to extremely high temperature events: climate and social parameters. Climate Research, 30, 71–78.

Victorian Government Department of Health, 2010. Residential aged care heatwave ready resource. Melbourne, Victoria: Author (Aged Care Branch).

Victorian Government Department of Human Services, 2009. Heatwave planning guide: Development of heatwave plans in local councils in Victoria. Melbourne, Victoria: Author.

Wang, L., Green, F.H.Y., Smiley-Jewell, S.M., Pinkerton, K.E., 2010. Susceptibility of the aging lung to environmental injury. Seminars in Respiratory and Critical Care Medicine, 31, 539-553.

Wanka, A., Arnberger, A., Allex, B., Eder, R., Hutter, H.-P., Wallner, P., 2014. The challenges posed by climate change to successful ageing. Zeitschrift für Gerontologie und Geriatrie, 47, 468–474.

Warrnambool City Council, 2012. Heatwave plan. Warrnambool, Victoria: Author.

Weisskopf, M.G., Anderson, H.A., Foldy, S., Hanrahan, L.P., Blair, K., Török, T.J., Rumm, P.D., 2002. Heat wave morbidity and mortality, Milwaukee, Wis, 1999 vs 1995: an improved response? American Journal of Public Health, 92, 830–833.

Welsh Government, 2012. Heatwave plan for Wales: A framework for preparedness and response. Cardiff: Author.

White-Newsome, J.L., Ekwurzel, B., Baer-Schultz, M., Ebi, K.L., O'Neill, M.S., Brooke Anderson, G., 2014. Survey of county-level heat preparedness and response to the 2011 summer heat in 30 U.S. states. Environmental Health Perspectives, 122, 573-579.

White-Newsome, J.L., Sánchez, B.N., Parker, E.A., Dvonch, J.T., Zhang, Z., O'Neill, M.S., 2011. Assessing heat-adaptive behaviors among older, urban-dwelling adults. Maturitas, 70, 85– 91.

Wilmoth, J.M., Longino, C.F. Jr., 2006. Demographic trends that will shape U.S. policy in the twenty-first century. Research on Aging, 28, 269-288.

Wolfe, M.I., Kaiser, R., Naughton, M.P., Mirabelli, M.C., Yoon, S.S., Hanzlick, R., Henderson, A.K., 2001. Heat-related mortality in selected United States Cities, summer 1999. American Journal of Forensic Medicine and Pathology, 22, 352-357.

World Health Organization, 2003. Ageing and Health: A health promotion approach for developing countries.
http://www.wpro.who.int/publications/pub_9290610662/en/ (Viewed 29 April 2016).

World Health Organization, 2004. Extreme Weather and Climate events and public health responses. Report on a WHO meeting Bratislava, Slovakia 09-10 February 2004. http://www.eird.org/isdrbiblio/PDF/Extreme%20weather%20and%20climate%20events.pdf (Viewed 28 April 2016).

World Health Organization, 2008a. A Global Response to Elder Abuse and Neglect: Building Primary Health Care Capacity to Deal with the Problem Worldwide: Main Report.

World Health Organization, 2008b. Improving public health responses to extreme weather/heat-waves-EuroHeat. file:///F:/WHO%20Documents/WHO%202008_Improving%20public%20health%20responses%20to%20heatwaves.pdf (Viewed 29 April 2016).

World Health Organization, 2009. Improving public health responses to extreme weather/heat-waves-EuroHeat. Technical summary. Copenhagen: WHO Regional Office for Europe.

World Health Organization, 2010. Climate change, extreme weather events and public health-Meeting report. Bonn, Germany. http://www.euro.who.int/__data/assets/pdf_file/0011/144389/e95103.pdf (Viewed 28 April 2016).

World Health Organization, 2016a. Ageing and Health. http://www.who.int/mediacentre/factsheets/fs404/en/ (Viewed 03March 2016).

World Health Organization, 2016b. Health systems. http://www.searo.who.int/india/topics/healthsystems/en/ (Viewed 29 April 2016).

World Health Organization, 2016c. WHO: Number of people over 60 years set to double by 2050; major societal changes required. http://www.who.int/mediacentre/news/releases/2015/older-persons-day/en (Viewed 19 February 2016).

Xu, Y., Dadvand, P., Barrera-Gómez, J., Sartini, C., Marí-Dell'Olmo, M., Borrell, C., Medina-Ramón, M., Sunyer, J., Basagaña, X., 2013. Differences on the effect of heat waves on mortality by sociodemographic and urban landscape characteristics. Journal of Epidemiology and Community Health, 67, 519–525.

Yardley, J., Sigal, R.J., Kenny, G.P., 2011. Heat health planning: the importance of social and community factors. Global Environmental Change, 21, 670-679.

Yarriambiack Shire Council, 2011-2012. Heatwave plan. Yarriambiack Shire, Victoria: Author.

Younger, M., Morrow-Almeida, H.R., Vindigni, S.M., Dannenberg, A.L., 2008. The built environment, climate change, and health opportunities for co-benefits. American Journal of Preventive Medicine, 35, 517-526.

Zacharias, S., Koppe, C., Mücke, H-G., 2015. Climate change effects on heat waves and future heat wave-associated IHD mortality in Germany. Climate, 3, 100-117.

Zhang, K., Chen, T-H., Begley, C.E., 2015. Impact of the 2011 heat wave on mortality and emergency department visits in Houston, Texas. Environmental Health, 14, 11-17.

Zhang, L., Steinmaus, C., Eastmond, D., Xin, X.K., Smith, M.T., 2008. Formaldehyde exposure and Leukaemia: a new meta-analysis and potential mechanisms. Mutation Research/Reviews in Mutation Research, 681, 150-168.

Zuo, J., Pullen, S., Palmer, J., Bennetts, H., Chileshe, N., Ma, T., 2015. Impacts of heat waves and corresponding measures: a review. Journal of Cleaner Production, 92, 1-12.

APPENDICES

Appendix 1. Macquarie University Faculty of Science Human Research Ethics Sub-Committee approval for study of heatwave preparedness and planning in Victoria Aged Care Facilities

Dear A/Prof Beggs

RE: Ethics project entitled: "A cross sectional analysis of heatwave adaptation options in Victoria, Australia”

Ref number: 5201401035

The Faculty of Science Human Research Ethics Sub-Committee has reviewed your application and granted final approval, effective 1/06/2015. You may now commence your research.

This research meets the requirements of the National Statement on Ethical Conduct in Human Research (2007). The National Statement is available at the following web site:

http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/e72.pdf.

The following personnel are authorised to conduct this research:

A/Prof Paul Beggs
Dr Ross MacKenzie
Mr Benjamin Okwuofu-Thomas

NB. STUDENTS: IT IS YOUR RESPONSIBILITY TO KEEP A COPY OF THIS APPROVAL EMAIL TO SUBMIT WITH YOUR THESIS.

Please note the following standard requirements of approval:

1. The approval of this project is conditional upon your continuing compliance with the National Statement on Ethical Conduct in Human Research (2007).

2. Approval will be for a period of five (5) years subject to the provision of annual reports.

Progress Report 1 Due: 1/06/2016
Progress Report 2 Due: 1/06/2017
Progress Report 3 Due1/06/2018
Progress Report 4 Due: 1/06/2019
Final Report Due: 1/06/2020

NB. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. If the project has been discontinued or not commenced for any reason, you are also required to submit a Final Report for the project.

Progress reports and Final Reports are available at the following website:

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/forms

3. If the project has run for more than five (5) years you cannot renew approval for the project. You will need to complete and submit a Final Report and submit a new application for the project. (The five year limit on renewal of approvals allows the Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).

4. All amendments to the project must be reviewed and approved by the Committee before implementation. Please complete and submit a Request for Amendment Form available at the following website:

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/forms

5. Please notify the Committee immediately in the event of any adverse effects on participants or of any unforeseen events that affect the continued ethical acceptability of the project.

6. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University. This information is available at the following websites:
http://www.mq.edu.au/policy/

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/policy

If you will be applying for or have applied for internal or external funding for the above project it is your responsibility to provide the Macquarie University's Research Grants Management Assistant with a copy of this email as soon as possible. Internal and External funding agencies will not be informed that you have final approval for your project and funds will not be released until the Research Grants Management Assistant has received a copy of this email.

If you need to provide a hard copy letter of Final Approval to an external organisation as evidence that you have Final Approval, please do not hesitate to contact the Ethics Secretariat at the address below.
Please retain a copy of this email as this is your official notification of final ethics approval.

Yours sincerely,
Peter Busch, Chair
Faculty of Science and Engineering
Human Research Ethics Sub-Committee
Macquarie University
NSW 2109

Appendix 2.

Victorian Aged Care Facilities Heatwave Response Policy Survey

Welcome to the Victorian Aged Care Facilities Heatwave Response Policy Survey

Please note: The following information is repeated from the email invitation you will have received. To commence the survey please proceed to the first question which follows this information. Thank you.

Dear Aged Care Facility Director/Manager,
You are invited to participate in a study of heatwave adaptation strategies in aged care facilities. The aim of the study is to identify and assess heatwave adaptation strategies in Victorian aged care facilities and evaluate their capacity to reduce heat-related morbidity and mortality.

The study is being conducted by Benjamin Okwuofu-Thomas as part of his research for a Doctor of Philosophy at Macquarie University, under the principal supervision of Associate Professor Paul Beggs of the Department of Environmental Sciences; his contact details are: 9850 8399 and paul.beggs@mq.edu.au. Dr Ross MacKenzie of the Department of Psychology is a co-investigator and co-supervisor; his contact details are: 9850 6393 and ross.mackenzie@mq.edu.au

If you decide to participate, you will be asked to complete a survey hosted by Qualtrics that will request your responses to questions on heatwave response at your institution such as capacity of air-conditioning system to maintain comfortable temperatures in communal rooms and bedrooms; and staff knowledge and training related to heatwave policy and procedure. The survey is a modified version of that used previously by Black et al. (https://www.nccarf.edu.au/publications/heat-ready-climate-aged-care).The survey will take approximately 15 minutes to complete and will be accessible from now until the end of Friday 21 August 2015.

Participation in this study is entirely voluntary: you are not obliged to participate and if you decide to participate, you are free to withdraw at any time without providing a reason and without consequence. Consent to participate is implied by you agreeing to complete the survey. Completed surveys will be de-identified to ensure that all responses are confidential. Access to the data will be restricted to the three researchers listed above, and all material will be securely stored including on a password-protected computer. An aggregated summary of the results will be made available via a project web page. Results will also be used in a peer-reviewed journal article and at research presentations. No individual or institution will be identified in any publication or presentation of the results.

The ethical aspects of this study have been approved by the Macquarie University Human Research Ethics Committee (Ethics Approval Number 5201401035). If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Committee through the Director, Research Ethics (telephone (02) 9850 7854; email ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

To take the survey please select the answer to each question below. Re-entry to the survey is not possible, so please complete the survey in one go.

......

Yours sincerely
Benjamin Okwuofu-Thomas
Higher Degree Research Candidate

Department of Environmental Sciences
Faculty of Science and Engineering
Macquarie University
NSW 2109 Australia

F: +61 2 9850 8420

Q1 What is the total number of beds in your facility?
Please type your answer in this box
____

Q2 What is the care level of your facility?
High care
Low care

Q3 Does your facility have a heatwave policy in place?
Yes
No
Currently under development
Not sure
Other ____________________

Q4 Does your aged care facility have a plan to implement during a heatwave?
Yes
No
Currently under development
Not sure
Other ____________________

Q5 Has your facility ever completed a self assessment to check key organisational processes related to managing extreme heat are in place?
Yes
No
Currently being completed
Not sure
Other ____________________

Q6 Do you have annual in-service training on heatwaves responses?
Yes
No
Currently under development
Not sure
Other ____________________

Q7 Are there processes in place for communicating heatwave policies and procedures to all staff, residents and their families?
Yes
No
Not applicable (no heatwave policies or procedures to communicate)
Not sure
Other ____________________

Q8 Does your facility have monitoring processes in place during a heatwave to confirm heatwave procedures are being implemented?
Yes
No
Not applicable (no heatwave policies or procedures to be monitored)
Not sure
Other ____________________

Q9 Does your facility have a plan for communicating the details of an extreme hot weather forecast to all staff?
Yes
No
Currently under development
Not sure
Other ____________________

Q10 Does your facility have a plan for communicating the details of an extreme hot weather forecast to residents and their families?
Yes
No
Currently under development
Not sure
Other ____________________

Q11 Does your facility have processes in place to ensure preparations and requirements for planning and responding to periods of extreme heat are effectively communicated between the management, nursing and care staff, residents and their families?
Yes
No
Currently under development
Not sure
Other ____________________

Q12 Are the communication processes between management and care staff adequate to explain what is needed when additional actions are needed for periods of extreme heat?
Yes
No
Not sure
Other ____________________

Q13 Do you assess individual patients for risk of heat related illnesses?
Yes
No
Not sure
Other ____________________

Q14 Does the healthcare assessment process include consideration of the risks and prevention of dehydration?
Yes
No
Not applicable (heat related health assessments are not done)
Not sure
Other ____________________

Q15 Does your facility have protocols to monitor and provide additional care and support for residents identified at most risk of heat related effects?
Yes
No
Not applicable (facility does not identify residents at most risk of heat related effects)
Not sure
Other ____________________

Q16 Do residents care plans include instructions on what to do if they become unwell if they have been identified at risk of heat effects?
Yes
No
Not applicable (facility does not identify residents at most risk of heat effects)
Not sure
Other ____________________

Q17 Does your facility have processes in place to consult with general practitioners and pharmacists regarding the use of resident's medication during periods of extreme hot weather?
Yes
No
Currently under development
Not sure
Other ____________________

Q18 Does your facility have processes in place for increased availability of cool drinks for residents and staff during periods of extreme heat?
Yes
No
Currently under development
Not sure
Other ____________________

Q19 Is the activities programme adjusted for hot weather events particularly outdoor events?
Yes
No
Not sure
Other ____________________

Q20 Does your facility undertake a training needs analysis and provide relevant training so that staff are well prepared to manage and respond during periods of extreme heat?
Yes
No
Not sure
Other ____________________

Q21 Does your facility training plan include cyclical seasonal needs?
Yes
No
Not sure
Other ____________________

Q22 Does your facility have plans in place to ensure sufficient staff are available during periods of extreme heat?
Yes
No
Currently under development
Not sure
Other ____________________

Q23 Have all staff attended training so they are skilled to perform their duties in extreme heat?
Yes
No
Not sure
Other ____________________

Q24 Are all staff in the facility orientated to facility policies regarding hydrating the residents?
Yes
No
Not sure
Other ____________________

Q25 Are all staff orientated to local policies and procedures regarding cooling?
Yes
No
Not sure
Other ____________________

Q26 Are all staff orientated to the facility policies regarding relocation and emergency evacuation preparedness?
Yes
No
Not sure
Other ____________________

Q27 Are all staff orientated to the facility policies regarding operation of equipment including air conditioners, fans, refrigerators and room thermometers?
Yes
No
Not sure
Other ____________________

Q28 Have you ever completed an environmental assessment of the facility that considers shade, air conditioning, power supply and generation, water-cooling and insulation?
Yes
No
Not sure
Other ____________________

Q29 Is the facility designed to provide a cool environment in the residents' rooms and communal rooms?
Yes
No

Not sure
Other ____________________

Q30 Can all windows be shaded on the inside of the building?
Yes
No
Not sure
Other ____________________

Q31 Can all windows be shaded on the outside of the building?
Yes
No
Not sure
Other ____________________

Q32 Can all windows be opened?
Yes
No
Not sure
Other ____________________

Q33 Do you have solar panels?
Yes
No
Not sure
Other ____________________

Q34 What type of roof do you have?
Clay or other Tile
Steel/Aluminium
Green roof
White coloured (reflective) roof
Other ____________________

Q35 Is it flat or pitched?
Flat
Pitched
Other ____________________

Q36 Has an assessment of the temperature profile of the facility been conducted, with particular attention paid to identifying the parts of the building that are cooler or warmer?
Yes
No
Not sure
Other ____________________

Q37 Has a cool part of the facility been identified that could be used as a cool shelter in the event of power failure and/or loss of air conditioning?
Yes
No
Not sure
Other ____________________

Q38 Do you have air conditioning?
Yes
No
Not sure
Other ____________________

Q39 If not, what cooling processes do you use?
Other ____________________

Q40 Is there sufficient air conditioning capacity to properly provide a cool environment in all parts of the facility, including common rooms and bedrooms?
Yes
No
Not sure
Not applicable (no air conditioning)
Other ____________________

Q41 Is there a maintenance programme in place to maintain the air conditioning equipment?
Yes
No
Not applicable (no air conditioning)
Not sure
Other ____________________

Q42 Is all air conditioning equipment currently operating effectively?
Yes
No
Not applicable (no air conditioning)
Not sure
Other ____________________

Q43 Are there emergency provisions and back-up systems in case of air conditioning equipment failure?
Yes
No
Not applicable (no air conditioning)
Not sure
Other ____________________

Q44 In the event of equipment failure what action would you take?
Please type your answer in this box
____

Q45 Is there a daily check record of temperatures in food and medication refrigerators?
Yes
No
Not sure
Other ____________________

Q46 If the refrigerators and freezers were required to operate at full capacity during very hot weather, would they be able to keep all the required items at an appropriate temperature including medications, drinks and food for residents and staff?
Yes

No
Not sure
Other ____________________

Q47 Are there emergency provisions and back-up systems in place in case of refrigeration failure?
Yes
No
Not sure
Other ____________________

Q48 Are reliable easy to read thermometers placed in locations within the facility to allow regular monitoring of the temperature of areas inhabited by residents and staff?
Yes
No
Not sure
Other ____________________

Q49 Do you know why the elderly are higher risk in periods of extreme temperatures?
Please type your answer in this box
____

Q50 The Victorian Government, Department of Health, in 2010 published Residential Aged Care Services Heatwave Ready Resource. Have you sighted this document?
Yes
No
Not sure
Other ____________________

Appendix 3.

Abstract accepted and presented on the comparison of heatwave response plans from Australia, Canada, the UK, and the USA, at the 2014 National Climate Change Adaptation Research Facility conference in Gold Coast, Australia.