Population Health and Climate Change: Public Perceptions, Attitudes and Adaptation to Heat waves in Adelaide, Australia

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Discipline of Public Health
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LIST OF ACRONYMS AND ABBREVIATIONS

Acronyms	**Abbreviations**
ADT	Average Daily Temperature
BoM	Bureau of Meteorology
CALD	Culturally and Linguistically Diverse
CI	Chief Investigator
CO_2	Carbon dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
^{o}C	Degrees Celsius
Dr	Doctor
ED	Emergency Department
EU	European Union
HBM	Health Belief Model
HWS	Heat Warning System
IPCC	Intergovernmental Panel on Climate Change
MSP	Multi-stakeholder processes
NWAHS	North West Adelaide Health Study
PhD	Doctor of Philosophy
Prof	Professor
SA	South Australia
SES	State Emergency Service
SMS	Short Message Service
SRES	Special Report on Emission Scenarios
TV	Television
UHI	Urban Heat Island
UK	United Kingdom
USA	United States of America

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DECLARATION

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Akompab, D., Bi, P., Williams, S., Grant, J., Walker, I. & Augoustinos, M. 2013, 'Awareness of and attitudes towards heat wavesin the context of climate change among a cohort of residents in Adelaide, Australia', *International Journal of Environmental Research and Public Health*, vol. 10, no. 1, pp. 1-17; doi:10.3390/ijerph10010001.

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Public perspectives, attitudes, risk perception and adaptation to heat waves in the context of climate change in Adelaide; Working Paper presented at the Ecosystem Sciences Division, Commonwealth Scientific and Industrial Research Organisation, Perth, Western Australia, 18 July 2013.

Socio-demographic predictors of heat-health adaptive behaviours in Adelaide, Australia: Oral presentation at the Second International Conference on Climate Change and Social Issues: Kuala Lumpur, Malaysia, 28-29 November 2012; organised jointly by the International Centre for Research and Development (ICRD), Sri Lanka & Glasgow Caledonian University, UK.

Emotional and psychological responses associated with heat waves in Adelaide, Australia: Oral presentation at the Fourth International Conference on Climate Change: Impacts and Responses, Seattle, Washington, WA, USA; 13-14 July 2012.

Adaptation to climate change: Does the public in Adelaide associate recent heat waves with global warming?: Oral presentation at the National Climate Adaptation Conference, Melbourne, Australia, 26-28 June 2012.

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THESIS ABSTRACT

Background and objectives: There is compelling scientific evidence that climate change will increase the frequency of heat waves which have an impact on population health. In Adelaide, unprecedented heat waves have been experienced in recent years which had significant impact on human health. The objectives of this research project were to: (1) explore public opinion (views and attitudes) about heat waves in relation to climate change, (2) explore public understanding of the consequences and the emotional and psychological responses associated with heat waves, (3) identify the predictors of risk perception using a heat wave scenario and adaptive behaviours during heat waves; and (4) explore the concept of multi-stakeholder processes during the development of an adaptation strategy for heat waves.

Methods: In the first study, interviews were conducted among fourteen residents to explore their views about heat waves, their understanding of its consequences and the emotional and psychological responses associated with heat waves. The second study was a cross-sectional study that examined the attitudes towards heat waves, risk perception and adaptive behaviours during heat waves among 267 participants with the health belief model used as the theoretical framework. The third study explored the concept of multi-stakeholder processes during the development of an adaptation strategy for heat waves. Data were gathered through a review of policy documents and interviews with eighteen stakeholders involved in the strategy development process. Qualitative data were analysed according to themes while descriptive and inferential statistical techniques were used to analyse quantitative data.

Results: In the first study, most participants didn't associate recent heat waves in Adelaide with climate change, although they acknowledged a considerable change in weather patterns over recent years. Although there were differences in the level of understanding among the participants, they modified their behaviours during a heat wave. Fear, worry, anxiety and concern were the main emotional responses associated with heat waves. Participants were concerned about low agricultural productivity, the costs of running an air-conditioner, sleeping well, and the threat of bush fires during a heat wave. In the second study, there was a significant association between gender, annual household income and concern for the societal effects of heat waves. About 43.2% of the participants believed that heat waves will extremely or very likely increase in Adelaide according to climate projections; 49.3% believed that the effects of heat waves were already being felt. The significant predictors of risk perception included age, marital status, annual household income, fan ownership and living arrangements. Participants' perceived benefit, cues to action, educational level, and annual household income were associated with adaptive behaviours during a heat wave. In the third study, there was high level governance, leadership, collaboration, coordination and good institutional arrangements during the adaptation strategy development process in South Australia. The process benefited from the Emergency Management Act 2004, which facilitated an enabling environment. Although the process was not entirely inclusive and the fact that it experienced a few challenges, the strategy development process was overall successful.

Conclusions: These findings suggest that there are variations in public opinion about heat waves in the context of climate change. Heat waves affect the emotional and psychological wellbeing of certain individuals. Using the health belief model as the theoretical framework, perceived benefit and cues to action predicted good adaptive behaviours. There were some demographic factors that were associated with risk perception in relation to heat waves. These factors would inform risk communication and behaviour change strategies for heat waves. An adaptation policy process for heat waves indicates that the process can be successful through a participatory process characterised by good leadership, excellent coordination, governance and institutional framework.

Key words: Climate change, human health, heat waves, mental models, health belief model, risk perception, adaptive behaviours, stakeholder engagements, Australia

CHAPTER 1

INTRODUCTION

1.1 Background

Climate change poses a challenge to the world and its impacts affects all sectors in society including human health (Hitz & Smith 2004). In particular, human health is determined by a complex interaction between social and economic factors, the physical environment, individual traits and behaviour. These factors which are known as the "determinants of health" when combined, influence the health status of individuals and the population. Many determinants of health can be affected by climate variability or other environmental changes induced by climate change (Health Canada 2008). It has been reported that climate change affects health through a complex and interrelated set of pathways (McMichael, Woodruff & Hales 2006). The pathways through which climate change affects health are either direct or indirect. However, other environmental, social and health system factors (Confalonieri et al., 2007) modify the relationship between health and climate change as illustrated in Figure 1.1.

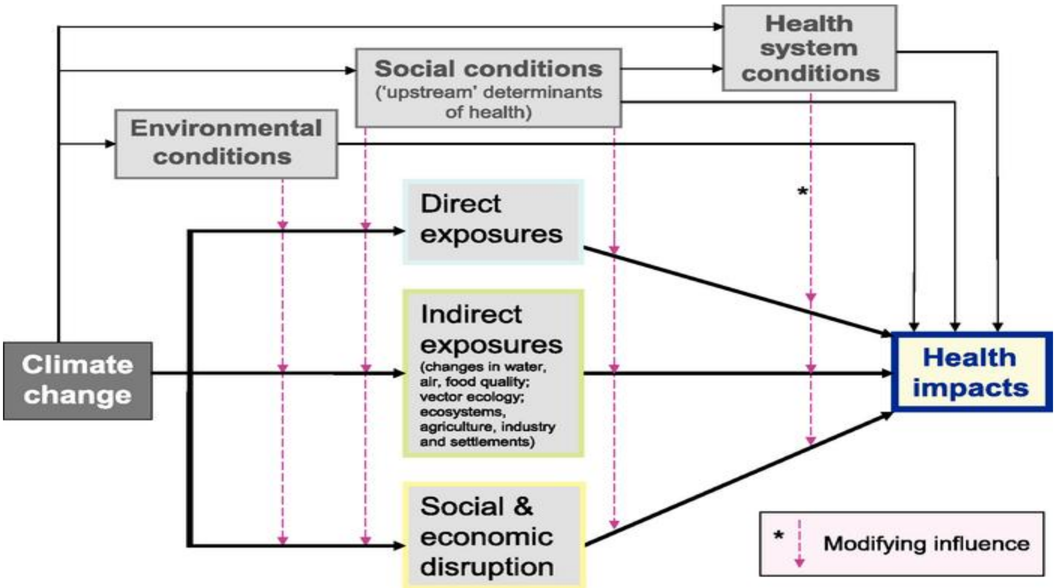

Figure 1.1: Pathways by which climate change impacts human health

Source: (Confalonieri et al., 2007)

Humans are exposed to climate change through direct effects such as the health impacts of extreme temperatures or other extreme weather events like cyclones, storms and hurricanes (Costello et al., 2009). Other impacts are characterised by indirect pathways which include health conditions related to air quality and aeroallergens, water and food-borne diseases, vector and rodent borne diseases and other infectious diseases (Epstein 2005; Haines & Patz 2004; Kinney 2008; Patz et al., 2000). Climate change would also affect food production systems, the availability and quality of freshwater that would further increase the risk of infectious diseases (McMichael et al., 2001). Further evidence shows that increase in climate-related extremes will result in more deaths, injuries and population displacements.

One direct effect of climate change on human health is the threat posed by an increase in heat waves (Haines & Patz 2004). The current and potential changes associated with climate change, including increases in the frequency of heat waves and their intensity is recognised as a public health concern since they are associated with heat-related illnesses, deaths and injuries (Argaud et al., 2007; Dhainaut et al., 2004; Hajat, O'Connor & Kosatsky 2010; Kovats & Ebi 2006). In addition, heat waves are also associated with other widespread social, environmental and economic consequences which have implications for human health (Dole et al., 2011; Parliament of Victoria 2010; UNEP 2004).

In Australia, heat waves are reported to have claimed more lives than any other natural hazard (Coates 1996). Some estimates have shown that approximately 1,115 heat-related deaths occur in the country every year (Whetton et al., 2005). Other projections indicate that the number of heat-related deaths may increase to between 2,300 to 2,500 per year by 2020, and 4,300 to 6,300 per year by 2050, for all Special Report on Emissions Scenarios (SRES), including demographic change (McMichael et al., 2003). Moreover, Australia’s annual average temperatures are projected to increase by between 0.4–2.0°C above 1990 levels by the year 2030, and from 1– 6°C by 2070 (Preston & Jones 2006). Such a rise in temperatures will concomitantly warm the Australian continent and likely lead to more heat waves.

Over the past decade, there has been much public discourse about climate change and its impacts, with individuals having different views, opinions and values about climate change. No doubt, public opinion about climate change and its effects are important because any success in addressing the societal challenges of climate variability may depend on public views and willingness to adapt (Lorenzoni, Pidgeon & O'Connor 2005). Previous studies have reported that public perceptions differ from that of scientific experts (Bord, Fisher & O'Connor 1998; Lazo, Kennel & Fisher 2000). In addition, public views and beliefs about climate change may be influenced by a number of factors: their pre-existing knowledge, world views, information they receive through the media, and interaction with friends, their families and communities (Carvalho 2007; Leiserowitz 2005). Another dimension of perception relates to how individuals conceptualise risks, *i.e.,* the perceived likelihood of negative consequences from climate change impacts (O'Connor, Bord & Fisher 1999).

As discussed, heat waves have been projected to increase due to climate change (Meehl & Tebaldi 2004). In order to reduce human vulnerability to heat waves in a changing climate, adaptation is necessary. Adaptation refers to measures, actions, strategies or plans undertaken to reduce vulnerability to the impacts of climate-related risks (Ebi & Schmier 2005). While adaptation can take place at the individual level through mechanisms such as behavioural modification, other measures are initiated by governments to assist the society cope with the risks posed by climate change (Adger et al., 2003). In the context of climate change, an example of an adaptation strategy for heat waves is a heat wave early warning system and response plan (Ebi & Schmier 2005; Poumadere et al., 2005; Weaver et al., 2010).

Experience has shown that the effectiveness of adaptation efforts depends on the extent to which relevant stakeholders take part in decision-making processes (Ebi & Semenza 2008; Lorenzoni, Pidgeon & O'Connor 2005). Therefore, adaptation planning should be participatory with a broad-based consultation and involvement of relevant players in the development and implementation of adaptation strategies or policies (Lorenzoni, Pidgeon & O'Connor 2005). Furthermore, successful adaptation efforts must take into account information needs, available human capacity, financial resources and technology (Burton, Diringer & Smith 2006). Additionally, adaptation policy design and implementation should consider the needs of the local population since they are the ones who are disproportionately affected by climate-related risks (Burton, Diringer & Smith 2006).

1.2 Aim, research questions and objectives

The overarching purpose of this research project was to investigate public perceptions, attitudes and adaptation to heat waves; and explore a multi-stakeholder process during the development of an adaptation strategy for heat waves. The research was conducted within the context of climate change and population health. Based on the overarching purpose of this work, the two main research questions were: 1) What are public's views, understanding, attitudes, and adaptive behaviours in relation to heat waves? 2) How was the concept of multi-stakeholder partnership conceptualised during the development of an adaptation strategy for heat waves in Adelaide? The specific research questions were:

- What are the public's views about heat waves in relation to global climate change?
- What are the public's understandings of the consequences of heat waves; and the emotional and psychological responses associated with heat waves?
- What are the public's attitudes towards heat waves in relation to climate change?
- What are the predictors of risk perception to heat waves and adaptive behaviours during a heat wave under a changing climate?
- What were the institutional arrangements and governance mechanisms that were in place during the development of the heat wave early warning system and response plan in Adelaide?
- How inclusive was the process that led to the development of the heat wave early warning system and response plan and what were main challenges that stakeholders faced during the participatory process?

The overarching research objectives were: 1) To explore public views, understanding, attitudes and adaptive behaviours during heat waves, 2) To examine a heat wave policy development process taking into consideration the concept of multi-stakeholder partnership. The specific objectives of the research were to:

- Investigate public opinion (views and attitudes) on heat waves in relation to global climate change.
- Explore community understandings of the risks/consequences of heat waves and identify their emotional and psychological reactions during a heat wave.
- Investigate how individuals conceptualise heat wave risks and identify the predictors of risk perception and adaptive behaviours related to heat waves.

- Explore the policy environment, the governance and institutional arrangements during the development of a heat wave warning system and response plan in Adelaide.

1.3 Thesis structure and outline

This thesis has been structured into three parts. The first part includes the introduction and the literature review (Chapters 1 and 2). The second part consists of six chapters (Chapter 3 to Chapter 8) organised in the form of published papers and/or manuscripts derived from studies conducted, using both qualitative and quantitative research methods. Each article and/or manuscript addresses one of the six research questions. The third part consists of the conclusion (Chapter 9) which highlights the conceptual model of the research project, the key findings, implications, recommendations and areas for future research. The schematic diagram of the thesis structure is shown in Figure 1.2.

The thesis has been presented in the form of ***"thesis by publication".*** Three studies were conducted for this research project; two published papers and/or manuscripts were derived from each study taking into account word limitations of some potential journals. Because two published papers and/or manuscripts were derived from each study, there are some similar materials that appear across them to give potential readers some background and perspectives about the setting where the study was conducted. For example, the setting and timing when the data were collected could be found in each of the chapters. This was considered important because when published, readers would be reading them as separate articles. It is essential to highlight the context and timing when the data were collected for each study. It is noteworthy that the research project was conducted in Adelaide, South Australia, a city that experiences dry, warm to hot summers in conjunction with heat waves.

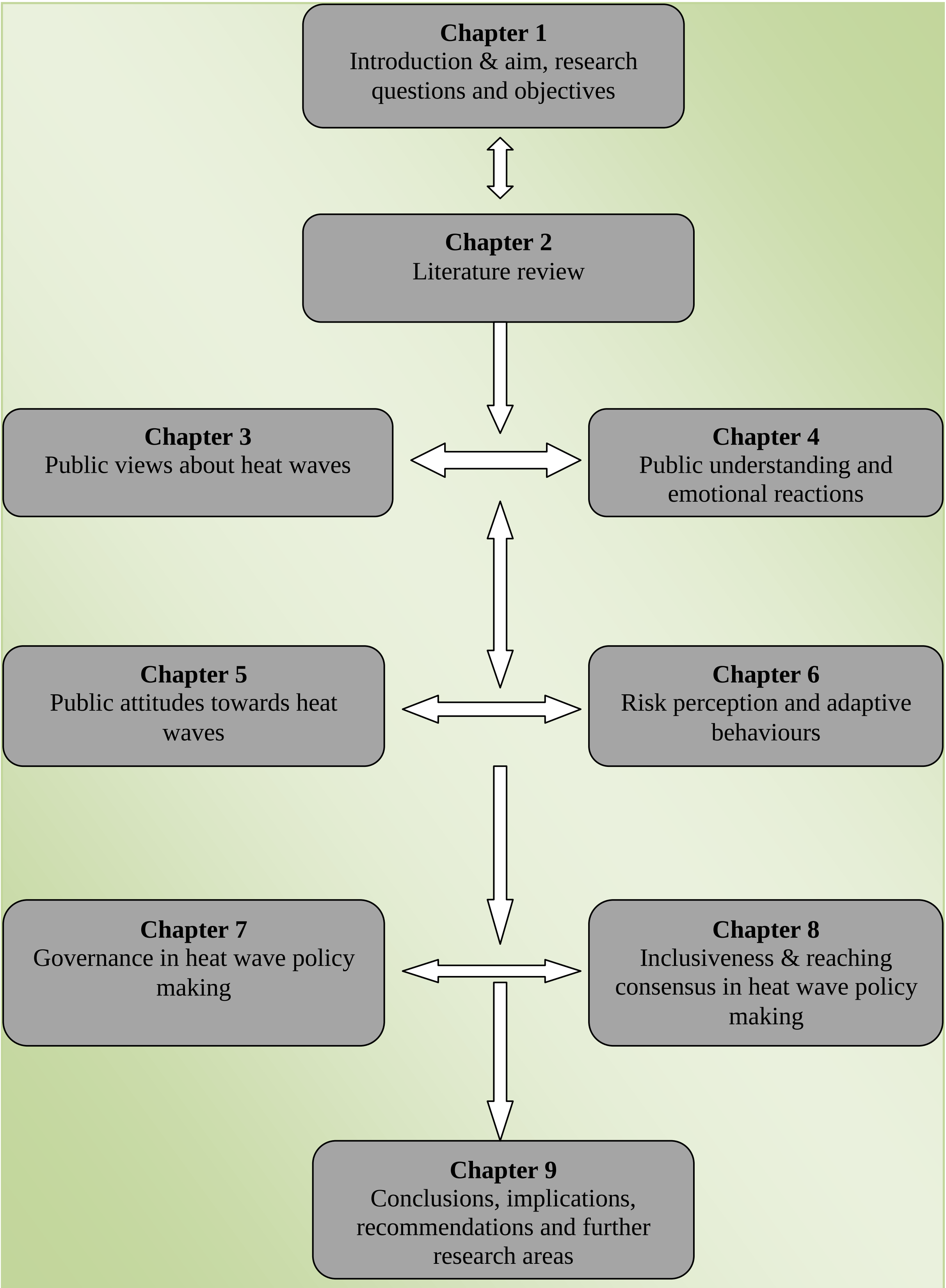

Figure 1.2: Schematic diagram of thesis structure

Below is a brief description of the contents of each chapter:

Chapter 1 presents an overview of the research project by describing the research background and defining the research problem. The overarching aim, research questions and objectives are also outlined. The schematic diagram of the thesis structure is then presented to show how the chapters are linked and the position of each chapter in framing the overall structure of the thesis.

Chapter 2 reviews the literature on heat waves in relation to climate change. The aim of this chapter is to provide a depth of knowledge and understanding about heat waves. The review examines episodes of heat waves, heat-related illnesses and mortality, the factors that may increase human vulnerability to heat waves, public perception of climate change and heat waves, risk perception and adaptation. It also outlines the role stakeholders play in developing strategies to respond to climate-related risks.

Chapter 3 outlines a study conducted to explore the public's views about heat waves in relation to climate change. It also identified what actions the public undertakes to stay safe during a heat wave. The chapter addressed the research question *"What are the public's views about heat waves in relation to global climate change".* The study was a qualitative study with semi-structured interviews conducted among a group of residents in Adelaide.

Chapter 4 is an extension of the previous chapter and describes the community's understanding of the consequences associated with heat waves. The paper also identified the emotional and psychological responses associated with heat waves. The mental model approach was used to explore participants' knowledge and understanding about heat waves. The mental model assists a researcher to identify gaps in knowledge and existing beliefs about a particular phenomenon so as to inform the development of education and communication strategies to fill the knowledge gaps. Lastly, the paper explored the issues which are of concern to residents during a heat wave in Adelaide. The chapter addressed the research question: *What are the public's understandings of the consequences associated with heat waves; and the emotional and psychological responses associated with heat waves?* It was a qualitative study since it is an extension of the previous article.

Chapter 5 presents the article that examined public attitudes towards heat waves in relation to climate change. The article describes participants' level of information about heat waves and their attitudes towards scientific uncertainty related to heat waves in a changing climate. It also examined participants' personal and societal concern for heat waves. The chapter addressed the research question: *What are the public's attitudes towards heat waves in relation to climate change*? The study was quantitative and used a cross-sectional study design.

Chapter 6 is an extension of the previous chapter and presents the article that identified the predictors of risk perception to heat waves and adaptive behaviours during a heat wave. This was a quantitative study that quantified the level of knowledge, and a socio-cognitive theory known as the health belief model was used to assess risk perception using a heat wave scenario. The chapter addressed the research question: *What are the predictors of risk perception to heat waves and adaptive behaviours during a heat wave under a changing climate?*

Chapter 7 presents the article that explored a multi-stakeholder process in the development of an adaptation strategy for heat waves in Adelaide. The study drew upon the concept of multi-stakeholder processes in public policy planning and situates it within the context of health adaptation to climate change. The article focused on the policy environment, the decision-making processes, transparency and accountability during the process. The chapter addressed the research question: *What were the institutional arrangements and governance mechanisms that were in place during the development of the heat wave early warning system and response plan in Adelaide?* The study was a qualitative study that used a case study research design.

Chapter 8 is an extension of the previous chapter and explored the concept of inclusiveness in multi-stakeholder processes and relates it to the participatory process during the development of the adaptation strategy for heat waves. The paper also explores the major challenges or discussions that emerged during the participatory process and how these discussions were successfully managed. The chapter addressed the research question: *What were the main challenges faced by stakeholders during the participatory process and how representative was the policy process?*

Chapter 9 presents the conclusions of the research project. It summarises the key findings of research project. It also describes some of the strengths and limitations/challenges of the research project. It presents some areas for future research and outlines some policy recommendations based on the research findings.

Appendix A includes some additional materials related to the methodology applied in the different studies which could not be incorporated into the chapters due to word count limitations by journals.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides a comprehensive literature review on heat waves in the context of climate change. This chapter has been organised into six sections. Section 2.2 examines what constitutes a heat wave and reviews episodes of heat waves recorded over the past in Australia and overseas. Section 2.3 presents a review of human vulnerability to extreme heat and outlines the underlying factors that increase vulnerability to heat-related illnesses and deaths. Section 2.4 includes a review of public knowledge and understanding of climate change and later explores public perception of heat waves. Section 2.5 presents a review of risk perception of environmental hazards and the determinants of risk perception. It also summarises the concept of risk communication and relates it to heat waves. Section 2.6 reviews the concept of adaptation to climate-related risks and more specifically adaptation to heat waves. It outlines both short and long-term adaptation strategies to reduce the impacts of heat waves on human health. Section 2.7 provides an overview of the development of strategies and policies that facilitate adaptation. It also focuses on the concept of multi-stakeholder processes which has proven to be relevant in developing strategies to protect humans from the social, economic and environmental challenges posed by climate-related risks.

2.2 Heat waves and climate change

2.2.1 Concept and definition of a heat wave

Heat waves result from the interaction of land surface, oceanic and atmospheric processes that produce either prolonged periods of stable weather with high inputs of solar radiation leading to hot dry conditions or warm air masses and cloudy days that produce hot humid conditions (Luber & McGeehin 2008; McGregor et al., 2007). One of the challenges in studying heat waves is centred on the definition of a heat wave. There is currently no standard acceptable definition for heat wave which can be applied universally (Díaz et al., 2002; Hajat et al., 2006; Michelozzi et al., 2005) because climate conditions vary across different geographical locations. Since heat waves are usually determined by daily temperatures, the temperature that may be considered as a heat wave in one country or region may not be considered a heat wave in another region. As a result, each geographic region defines a heat wave based on local weather and climatic conditions.

A heat wave in lay terms could be defined as a prolonged period of exceptional hot weather. Koppe et al (2004) carried out a review of some national meteorological stations in Europe. They found that the operational definition for heat wave was based on country-specific conditions which relied on either an air temperature threshold and a minimum duration, or the indices based on a combination of air temperature and relative humidity (Koppe et al., 2004).

Many approaches have been used to define a heat wave. For example, Koppe et al (2004) define a heat wave based on either the absolute or relative thresholds of weather variables or as a combination of both (Koppe et al., 2004). Robinson (2001) defines a heat wave as "an extended period of unusually high atmosphere-related heat stress, which causes temporary modifications in lifestyle and which may have adverse health consequences for the affected population" (Robinson 2001). He argues that although heat wave is a meteorological event, it cannot be assessed without reference to human impacts as a combination of weather elements related to human sensation of heat must be used. Consequently, appropriate thresholds must be established that considers both daytime high and overnight time low temperatures. He argues that these thresholds have the advantage of accounting for local differences in the perception of heat (Robinson 2001). Table 2.1 presents selected definitions of heat waves applied by researchers in certain regions around the world. Although this list is non-exhaustive, it is intended to illustrate how complex and challenging it is to come up with a standard definition of a heat wave.

It should be noted that the Australian Bureau of Meteorology defines a heat wave in Adelaide as a period of maximum temperatures of 35 ^{o}C or over for five or more consecutive days; or three or more consecutive days of temperatures of 40 ^{o}C or above. This definition is also adopted in this thesis. However, participants in the studies described in the thesis were not provided with a specific heat wave definition because these studies sought to explore participants own interpretations and perceptions of heat waves.

Table 2.1: Selected definitions of a heat wave

Source	*Definition of heat wave*	*Location of the study*
(Huynen et al., 2001)	A period of at least 5 days, each of which has a maximum temperature of at least 25°C, including at least 3days with a maximum temperature of at least30°C.	Netherlands
(Kysely 2004)	A period of at least 3 consecutive days with daily maximum temperatures of at least 30^{o}C.	Czech Republic
(Nitschke, Tucker & Bi 2007)	A period in which the daily maximum temperature was ≥ 35°C for 3 or more consecutive days.	Adelaide, Australia
(Mayner, Arbon & Usher 2010)	A period with a maximum temperature of 35 °C or over for a duration of five or more consecutive days or three or more consecutive days of temperatures of 40 °C or above.	Adelaide, Australia
(Son et al., 2012)	A period of at least two or more consecutive days with daily mean temperature at or above the 98th percentile for the warm season.	Korea
(Revich & Shaposhnikov 2010)	A time period during which the daily mean temperature is above the 97th percentile of the historic distribution of daily mean temperatures for 9 consecutive days or more, of which at least 3 days had average daily temperatures above the 99th percentile.	Siberia

2.2.2 Heat-related morbidity (illnesses)

Heat-related illnesses range from minor heat oedema to a more complicated and life threatening heat stroke (Grubenhoff, du Ford & Roosevelt 2007; Lugo-Amador & Rothenhaus 2004). These illnesses are mainly as a result of the disruption of the mechanisms that regulates body temperature due to excess heat from the environment (Grubenhoff, du Ford & Roosevelt 2007). Although heat-related illnesses are more common during heat waves and high environmental temperatures (Dematte et al., 1998), they can also occur in temperate environments among patients with chronic conditions, mental illness (Hermesh et al., 2000), occupational exposure to high temperatures (Brake & Bates 2003) or due to poor acclimatization (Epstein et al., 1999). The following section reviews some of the most common heat-related illnesses; beginning with the least threatening to the most life threatening heat-related illness (heat stroke).

Prickly heat is a minor form of heat-related illness and is common among infants and young children when they are exposed to heat (Grubenhoff, du Ford & Roosevelt 2007). Prickly heat occurs when the ducts of the sweat glands are blocked (Lu & Wang 2004) leading to macupapular rash among infants (Grubenhoff, du Ford & Roosevelt 2007).

Heat oedema occurs when there is cutaneous vasodilation in the extremities of the body, resulting in swelling of the hands and feet (Grubenhoff, du Ford & Roosevelt 2007; Lu & Wang 2004). The swelling is a result of the accumulation of interstitial fluid in the extremities due to vasodilation and venous stasis (Grubenhoff, du Ford & Roosevelt 2007). This may result due to prolonged sitting or standing (especially while exposed to heat) leading to the accumulation of interstitial fluid in the lower extremities. This swelling is generally minimal with little or no functional impairment and generally resolves when the individual leaves the hot area (Allen & Segal-Gidan 2007) and the symptoms may also disappear after a few days (Tek & Olshaker 1992).

Heat syncope occurs when an individual faints as a result of insufficient cerebral perfusion during and after excess exposure to heat (Grubenhoff, du Ford & Roosevelt 2007).This mainly occurs due to blood volume depletion, peripheral vasodilatation, pooling of fluid and decreased vasomotor tone which increases blood flow to the periphery of the body while decreasing central venous return (Lu & Wang 2004). Heat syncope is more common in the elderly and those who are not well acclimatised to excess heat (Lu & Wang 2004).

Heat cramps are sporadic, often severe muscle spasms which commonly occur in the voluntary muscles of the extremities and abdomen mainly after vigorous exertion (Ewald & Baum 2006). Heat cramps tend to occur during rest after work is complete or while showering and are believed to result from electrolyte depletion (Ewald & Baum 2006). Cramps are common during and after sporting events or physical labour when individuals profusely sweat (Grubenhoff, du Ford & Roosevelt 2007).

Heat exhaustion is the most common form of heat-related illness and is characterised by relatively vague and non-specific symptoms (Grubenhoff, du Ford & Roosevelt 2007). It is usually caused by prolonged exposure to high ambient temperatures when blood circulation is unable to adequately meet the demands of physical work and thermoregulation (Donoghue, Sibnclair & Bates 2000). Heat exhaustion can be classified as either *water depleted* or *salt depleted* heat-exhaustion (Lugo-Amador & Rothenhaus 2004).The former occurs among individuals working in hot environments who are unable to replace lost water from their body, where as the latter occurs when people working in hot environments sweat profusely and replace their fluid loss with hypotonic solutions (Lugo-Amador & Rothenhaus 2004). Symptoms which are characteristic of heat exhaustion are irritability, fatigue, weakness, light-headedness, headache, increased thirst, nausea and faintness (Donoghue, Sibnclair & Bates 2000; Grubenhoff, du Ford & Roosevelt 2007). In fact, those suffering from heat exhaustion usually have a core body temperature of 40°C upon examination and will not present signs of severe nervous system damage. However, such patients may present with tachycardia, orthostatic hypotension and clinical evidence of dehydration (Lugo-Amador & Rothenhaus 2004).

Heat stroke is the most life-threatening form of heat-related illnesses and can be classified as either *classic or exertional* (Lu & Wang 2004; Wexler 2002). Heat stroke is characterised by a core body temperature above 40°C (Lee-Chiong & Stitt 1995) and a dysfunction of the central nervous system (Bouchama & Knochel 2002). The classic form of heat stroke is common among debilitated patients, those with chronic conditions and the elderly (Lu & Wang 2004). Also, individuals with cardiovascular or cerebrovascular disease, diabetes, nervous system disorders, the poor, alcoholics, persons who do not have access to air conditioning and persons who are socially isolated are at risk of hospitalization from heat stroke (Lugo-Amador & Rothenhaus 2004; Semenza et al., 1999). Individuals with the classic form of heat stroke present with hyperpyrexia, anhydrosis and changes in the mental status (Sandor 1997; Shahid et al., 1999). When heat stroke leads to central nervous system dysfunction, it is usually characterised by delirium, seizures or coma with other manifestations such as hallucinations or cerebellar dysfunction being common (Lugo-Amador & Rothenhaus 2004). Exertional heat stroke is more common among poorly acclimatized young persons involved in physical activity during hot weather such as military personnel, miners and athletes, especially when their body is depleted with water (Lu & Wang 2004).

2.2.3 Heat-related deaths: definition

What constitutes a heat-related death has been a challenge for research on health and heat waves. Donoghue et al (1997) defined a heat-related death based on three categories; (a) if pre-mortem or post-mortem evidence of a body temperature equal to 40.6°C or higher;(b) if the body temperature is lower, evidence of changes in mental status and increased liver and muscle enzyme levels; and (3) when body temperature is not available, evidence of high environmental temperature at the time of death and exclusion of other causes of death (Donoghue et al., 1997). On the other hand, Klinenberg considers a death as heat-related if it meets any one of the following criteria: (a) a measured body temperature of 105^{o}F at the time of the death or immediately after death, (b) substantial environmental or circumstantial evidence of heat as a contributor to death, (c) descendent found in a decomposed condition without evidence of other cause of death who was last seen alive during the heat wave period (Klinenberg 2002).

It has been argued that defining heat-related death based on core body temperature at or near the time of death underestimates the magnitude of heat-related deaths (Shen et al., 1998). Following the 1995 Chicago heat wave, consideration for heat-related deaths was based on both body temperature and the occurrence of death during the heat wave with the exclusion of other causes of death, although it was believed more heat-related deaths were estimated with this definition (Shen et al., 1998).

Assessing heat-related deaths is a challenge that explains why it is quite difficult to come-up with a reliable estimate of the number of heat-related deaths associated with any heat event. This is because heat-related deaths are not well defined and heat is usually not listed on death certificates as causing or contributing to death (Keatinge 2003). Consequently, some deaths occurring during a heat wave are not clinically associated with the heat, with high ambient temperature playing an indirect role by precipitating failure of already compromised body systems (Keatinge 2003). Assessing excess mortality is widely used to estimate heat-related mortality. Excess mortality is determined by the number of deaths occurring (during a heat wave) over and above what would normally be expected for a particular population during a given time period (Kovats & Hajat 2008; World Health Organisation 2003). Expressing excess deaths as a proportion relative to a calculated baseline provides a more useful measure with which to compare different heat wave mortality effects since it helps to control for the demographic characteristics of different populations (Whitman et al., 1997).

2.2.4 Heat waves in Australia

In Australia, heat waves have been reported to claim more lives than any other natural disaster (Coates 1996) and their occurrence is projected to increase in a warming climate. It has been estimated that about 4,336 people died as a result of heat waves between the years 1803 and 2002; a number which is twice that of the fatalities caused by cyclones or floods over the same period (McMichael et al., 2003). Approximately 1,115 heat-related deaths occur in Australia every year, and this number may double by 2020 (Whetton et al., 2005). Another projection estimates that there will be over 2,600-3,200 heat-related deaths per year by 2100 and most victims would be the elderly (Woodruff et al., 2007).

The relationship between ambient temperature and mortality has been studied using epidemiological methods in a number of Australian cities. McMichael et al (2003) used data from 10 cities in Australia to determine the number of heat-related deaths among the elderly (>65 years), assuming no change in population size or structure. They found that the estimated number of annual heat-related deaths for all the temperate cities (Perth, Adelaide, Brisbane, Melbourne, Canberra, Sydney, and Hobart) in the study at baseline was 1,115 per year; while the estimated number of heat-related deaths for the three tropical cities (Darwin, Cairns and Townsville) at baseline was estimated to be six per year (McMichael et al., 2003). Figure 2.1 shows a time series of average number of hot days across Australia between 1910-2012.

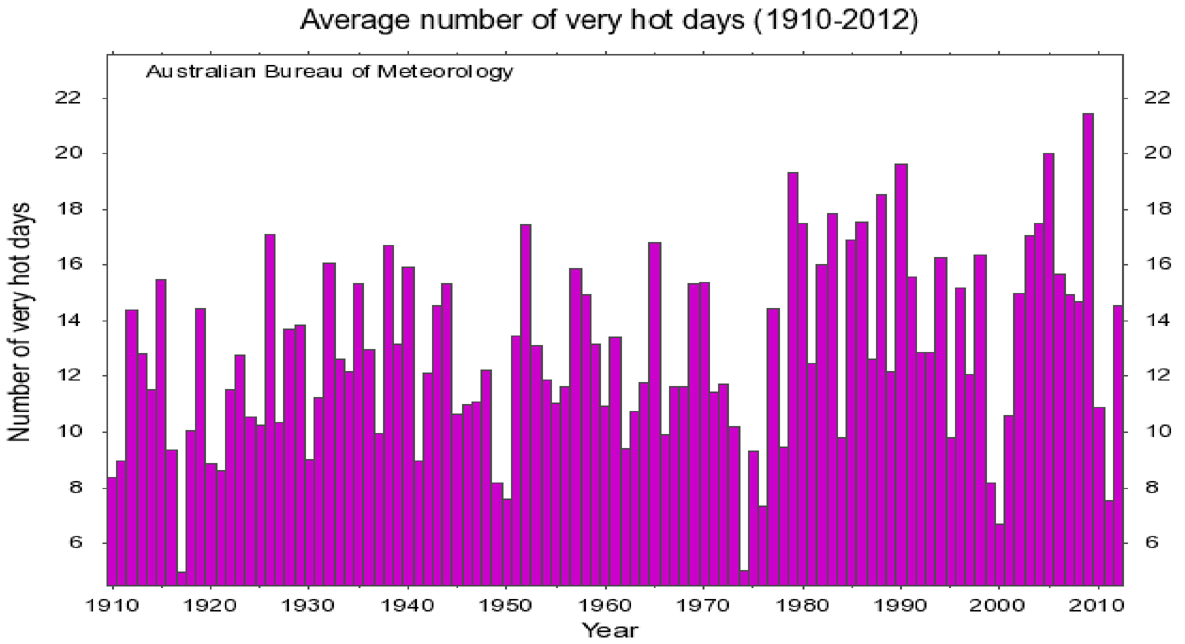

Figure 2.1: Time series of average number of hot days in Australia

Source: (Australian Bureau of Meteorology 2013a)

A number of Australian cities have experienced unprecedented heat waves in recent years. For example, in Brisbane, the January 2000 heat wave resulted in over 22 excess deaths and 350 hospitalisations while the heat episode observed in the following year caused 287 hospital admissions and 12 deaths (Queensland Government: Queensland Health 2004). In the period 7-24 February 2004, Brisbane experienced a heat wave; the highest temperature reached 42°C as compared to 34°C recorded in the same period between 2001and 2003. It was estimated that there were 116 heat-related deaths during the 2004 heat wave in Brisbane (Tong, Ren & Becker 2010) with over 221 hospitalisations (Queensland Government: Queensland Health 2004).

Nicholls et al (2008) reported that daily minimum temperatures were the strongest predictors of heat-related death and excess deaths in the elderly population (>65 years) in Melbourne and estimated a threshold for minimum temperatures of 24°C (Nicholls et al., 2008). Furthermore, they found that an increase of 15-17% in average daily mortality of people aged 65 years or older was observed to be associated with mean daily temperature exceeding a threshold of 30°C (Nicholls et al., 2008). Loughnan et al (2010) using data for the period 1999-2004 in Melbourne, found that the number of hospital admissions for heart disease during the summer increased by about 10.8% on days when mean daily temperatures exceeded 30°C and these were mainly observed among adults younger than 70 years of age (Loughnan, Nicholls & Tapper 2010). Between late January and early February 2009, there was a heat wave across the state of Victoria with Melbourne experiencing three consecutive days of temperatures above 43°C (Australian Government: Bureau of Meteorology 2009). During this heat wave there was a 62% increase in the total all-cause mortality with 374 excess deaths reported (Victoria Government;Department of Human Health Services).The total number of heat-related deaths was 980 and individuals above the age of 75 years were most affected (Victoria Government;Department of Human Health Services).

In Adelaide, Faunt and his colleagues examined emergency department admissions during a 10-day exceptional heat wave occurring in Adelaide in 1993. Their results showed that the number of heat-related illnesses that were observed in four emergency department units in the city was estimated at 94; a majority (78%) of the patients presented with heat exhaustion (Faunt et al., 1995). Other researchers used data for the warm period between 1993-2006 and found that the number of ambulance call-outs during heat wave days in Adelaide increased by 4% when compared to non-heat wave days (Nitschke, Tucker & Bi 2007). Further studies in Adelaide reported an increase in hospital admissions for kidney disease, acute renal failure, mental and behavioural disorders during days of heat waves compared to non-heat wave days (Hansen et al., 2008b; Hansen et al., 2008c). Hospital admissions for people aged 15-65 years with heart conditions were also reported during recent heat waves in Adelaide (Nitschke, Tucker & Bi 2007).

In the summer of 2008 and 2009, there were severe heat waves recorded in Adelaide. Two heat waves were recorded in 2009, the first in early 2009 (January-February) and the second in November 2009 (Mayner, Arbon & Usher 2010). The 2008 and early 2009 heat waves were unique in terms of their duration (15 days and 13 days respectively), and the 2009 heat wave was also remarkable in its intensity as there were six consecutive days with temperatures over 40^{o}C and one day with a maximum temperature of 45.7°C (Australian Government: Bureau of Meteorology 2012; Nitschke et al., 2011). In early 2010, there was another heat wave recorded in Adelaide in which there were five consecutive days in which temperatures exceeded 35°C with four of these days in excess of 40°C (Australian Government: Bureau of Meteorology). It has been estimated that Adelaide currently has 17 days with temperatures above 35^{o}C and the number of hot days during summer could increase to about 22-46 days by the year 2070 using low and high climate scenarios (Suppiah et al., 2007). Figure 2.2 shows a time series of daily mean temperatures for Adelaide for the period 1910-2013.

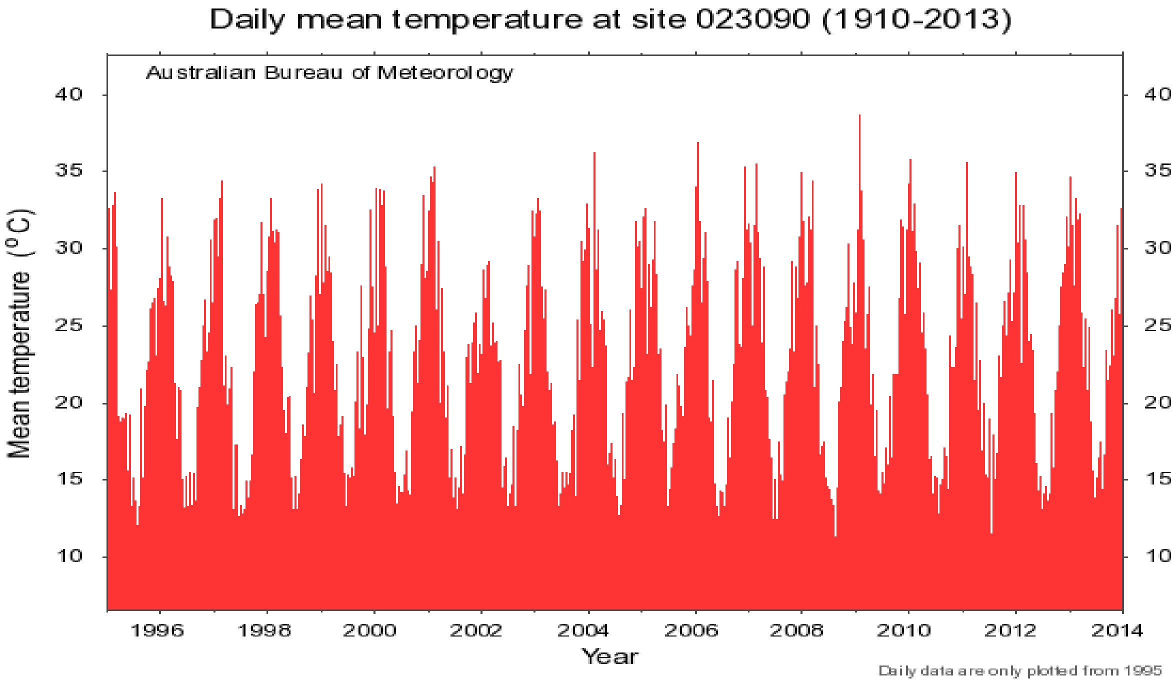

Figure 2.2: Time series of daily mean temperatures for Adelaide

Source: (Australian Bureau of Meteorology 2013b)

Williams et al. (2012) used daily maximum and minimum temperatures, mortality, emergency department (ED) presentations and hospital admissions data for Perth between the period 1994 to 2008; to examine the relationships between high temperatures and adverse health outcomes. They found that the temperature thresholds for mortality were estimated at 34–36 °C (maximum) and 20 °C (minimum). Furthermore, morbidity and mortality outcomes increased with a 10^{o}C rise in temperature. Also, daily mortality and ED presentations increased while total hospital admissions decreased on heat wave days (Williams et al., 2012).

Scientific projections maintain that the number of heat waves will increase and that Australians will be facing more extreme hot weather in the next couple of decades (Preston & Jones 2006). Table 2.2 and Table 2.3 show temperature projections for selected Australian cities. As a result of the increase in the number of hot days in Australia, the number of heat-related illnesses and mortality will certainly increase over the years and will affect mostly the elderly (Agho et al., 2010). Nonetheless, some researchers maintain that the number of the heat-related deaths would vary across the major cities in the country (Bambrick et al., 2008).

Table 2.2: Projected annual number of days with temperatures over 35°C for selected Australian cities

City	Year						
	Present	2030		2050		2070	
		L	H	L	H	L	H
Melbourne	10	10	15	11	21	12	31
Darwin	11	18	73	23	177	31	305
Adelaide	17	19	25	20	32	22	46
Perth	27	29	38	31	48	33	68
Charleville	65	72	105	77	135	82	177

L refers to low climate change scenario; H refers to high climate change scenario

Table 2.3: Projected annual number of days with temperatures over 40°C for selected Australian cities

City	Year						
	Present	2030		2050		2070	
		L	H	L	H	L	H
Melbourne	1	1	1	1	5	2	11
Darwin	0	0	0	0	0	0	5
Adelaide	2	3	5	3	8	3	15
Perth	4	5	8	5	13	6	13
Charleville	6	8	22	9	46	11	91

L refers to low climate change scenario; H refers to high climate change scenario

Source: adapted from: Australian climate change projections derived from simulations performed for the IPCC 4th Assessment Report (Suppiah et al., 2007).

2.2.5 Episodes of heat waves in other regions of the world

2.2.5.1 Heat waves in North America and Western Europe

In the United States of America (U.S.A.), heat waves are the leading cause of weather-related deaths with an estimated 688 deaths reported to be directly related to heat each year (US Centre for Disease Control 2006). In 1980, a heat wave recorded across the United States claimed the lives of an estimated 10,000 individuals (National Climate Data Centre 2011). Later in 1988, a record-breaking heat wave was reported in the Central and Eastern parts of the U.S.A. with deaths estimated at between 5,000 and 10,000 (National Climate Data Centre 2011).

One of the most well studied heat waves within the literature was the July 1995 Chicago heat wave. Daily maximum temperatures ranged from 33.9^{o}C to 40.0^{o}C between July 12-16 (Donoghue, Kalelkar & Boehmer 1995). During the heat wave, an estimated 739 heat-related deaths were reported (Semenza et al., 1999); although a re-analysis of the number of deaths later carried out found that 697 heat-related deaths was the actual number (Kaiser et al., 2007). There were more than 3,000 excess emergency department visits (Dematte et al., 1998) with more than 1,000 hospital admissions compared to previous years (Semenza et al., 1999). Most of the hospital admissions were due to dehydration, heat stroke and heat exhaustion among people with pre-existing illnesses such as diabetes and renal disease (Semenza et al., 1999). After the heat wave, studies reported that the urban heat island effect, the aging population, the lack of ventilation and the high dew points were among the contributing factors for the death toll recorded (Kunkel et al., 1996).

The 1995 Chicago heat wave drew widespread international attention and was described as a natural disaster (Klinenberg 2002). Four years after the 1995 Chicago heat wave, another major heat wave was experienced in the city which resulted in an estimated 119 heat- related deaths (Palecki, Changnon & Kunkel 2001). The number of deaths reported as a result of the 1999 heat wave was quite low compared to that recorded in 1995, possibly because of an effective heat wave response that was put in place.

In mid-July 2006, a heat wave affected California. The heat wave began around 14 July and was experienced across most parts of the state. In the Central Valley region and the urbanised area of Los Angeles, daily average temperatures exceeded 32.2^{o}C (Ostro et al., 2009). The heat wave was unique, breaking 10-day records for average temperatures in some parts of the state and continued to 21 consecutive days in other areas (Kozlowski, Edwards & Reno 2007). The county coroner estimated that there were approximately 147 excess deaths attributed to the heat, although it was estimated that this under-reported heat-related deaths by two or three times (Ostro et al., 2009). In 2012, a severe heat wave hit parts of the Mid-west and East coast of the United States. Temperatures soared across most of the cities especially in St. Louis which recorded a high of 42°C degrees (Murphy 2002). The heat wave resulted in heat-related deaths in Chicago, Maryland, Kansas city, Tennessee, Alabama, Missouri (Mattews 2012; Yang 2012). In addition, the heat wave damaged crops, buckled railway lines, caused train derailments (Eligon & Santora 2012) and left thousands of people without electricity due to power outages (Yang 2012).

Although heat waves have been reported in Canada, heat-related morbidity and mortality in the country is not as severe as in other regions of the world (Kalkstein & Smoyer 1993; Smoyer, Rainham & Hewko 2000). A number of research studies have been conducted in Canada to examine the relationship between ambient temperatures and health outcomes. For example, a study was conducted to examine the relationship between deaths and ambient temperatures across 10 Canadian cities using data for the period 1958-1988. Both a threshold temperature (based on the temperature at which mortality dramatically increases for a given location) and an air mass-based approach were used. The study found that only three of the cities (Montreal, Toronto and Ottawa) analysed had increased mortality associated with hot weather. There was a statistically significant increase in mortality above 29^{o}C in Montreal and above 33^{o}C in Toronto. There was no significant increase in heat-related mortality for St. John’s, Quebec, Calgary, Winnipeg or Vancouver (Kalkstein & Smoyer 1993).

Some researchers analysed morbidity data from 1954-2000 and found that the number of heat-related deaths that occurred every year was 120 in Toronto, 121 in Montreal, 41 in Ottawa and 37 in Windsor (Cheng et al., 2005). They also found that between 1980 and 1996, the temperatures in Toronto ranged from 30°C-35°C which was accompanied by heat-related deaths especially among the elderly (Cheng et al., 2005). The fact that most heat-related deaths occurred among the elderly in Canada was supported by findings from a study conducted across five cities in South Ontario (Smoyer, Rainham & Hewko 2000). Other researchers reported that the highest summer temperatures associated with heat waves were common in the Prairies, South Ontario and the St. Lawrence River valley (Smoyer-Tomic, Kuhn & Hudson 2003). They also found that residents in the city of Montreal were more vulnerable to summer temperatures as a result of the growing number of the elderly population in the city (Smoyer-Tomic, Kuhn & Hudson 2003). A severe heat wave was reported in Canada in July 2010 with temperatures ranging between 30°C-35°C (Toutant et al., 2011). In Ontario and Québec, maximum temperatures reached 30^{o}C or more between July 4th to July 9th with a high humidity. In Quebec, crude daily rates showed a significant increase of 33% for deaths and 4% for emergency department admissions in relation to comparison periods (Bustinza et al., 2013).

In August 2003, Western Europe experienced one of its worst heat waves which resulted in an estimated 70,000 heat-related deaths (Robine et al., 2008). France was the worst affected country with over 14,800 heat-related deaths recorded (Dhainaut et al., 2004; Pirard et al., 2005). Among the deaths in France, 29% were due to heatstroke, dehydration or hyperthermia; 21% were associated with diseases of the circulatory system and 8% were associated with diseases of the respiratory system (French National Institute of Public Health Surveillance Annual Report 2003). The death toll in France as a result of the 2003 heat wave was attributed to the lack of preparedness by the emergency services in the country to deal with heat waves(Lagadec 2004). Other European countries including Spain (Simon et al., 2005), the Netherlands (Fischer, Brunekreef & Lebret 2004), Italy (Michelozzi et al., 2005; US Centre for Disease Control 2004), England (Stedman 2004), and Portugal (Nogueira et al.,2005) also reported excess mortality during the 2003 European heat wave.

In the summer of 2006, a number of Western European countries experienced another heat wave (Struzewska & Kaminski 2008). During this period, heat-related illnesses and deaths were reported in Belgium, Germany, Poland, France, Switzerland, Netherlands (Rebetez, Dupont & Giroud 2008; Struzewska & Kaminski 2008). In France, this heat wave resulted in an estimated 2,065 heat-related deaths across the country, half among those aged 75 years and over (Fouillet et al., 2008). There was a reduction in the number of heat-related deaths in France during the 2006 heat wave and this was attributed to a reduction in population vulnerability, increase in public awareness of the risks and the effectiveness of prevention plans that were put in place after the 2003 heat wave (Fouillet et al., 2008).

2.2.5.2 Heat waves in Eastern Europe and Asia

Sustained periods of extreme heat are sometimes experienced in Russia during the months between July and August of each year. Revich and Shaposhnikov (2008) estimated daily mortality in Moscow, from all non-accidental, cardiovascular and respiratory causes using data for the period between January 2000 to February 2006. They identified four heat waves during this period (one in mid-July 2001 and three in 2002) and found that the heat wave in July 2001 was exceptional in duration and temperatures. Daily average temperatures during the heat wave exceeded 25^{o}C for nine consecutive days; for which the norm is three days per year. The total excess daily mortality from non-accidental causes among all age groups from 15th July to 27th July was 33% or about 1200 deaths. Increased deaths were reported for respiratory (80%) and cardiovascular (51%) disease and about 45% of deaths were reported among the elderly. During the three heat waves of 2002, there was an estimated 560 excess deaths from non-accidental mortality with a majority of deaths related to cardiovascular disease (Revich & Shaposhnikov 2008).

There was another record-breaking heat wave experienced in Russia between June-August 2010 as the country recorded one of its hottest summers in history. In many cities across the country, temperatures exceeded 40^{o}C for over 30 consecutive days. Moscow recorded temperatures of 16^{o}C to 18°C higher than what is normally expected for the months of July and August (Grumm 2011). There was an estimated 15,000 heat-related deaths reported as a result of the heat wave in the entire country which also resulted in severe social and environmental consequences (Dole et al., 2011). Of the total deaths in the country, there were approximately 10,935 heat-related deaths alone recorded in Moscow (Associated Press 2010). The high ambient temperatures in this region during the summer of 2010 also affected Finland, Ukraine and Belarus (Barriopedro et al., 2011; Grumm 2011; World Meteorological Organisation 2010).

Heat waves are a normal occurrence in some parts of Southeast Asia, although they seemed to have gained little attention like those in the western countries. In the Indian sub-continent for example, heat waves are common during summers (March-June). The state of Orissa in 1998 experienced an unprecedented heat wave which resulted in an estimated 2,042 heat-related deaths (Saudamini 2010). There was an extended period of 28 days of extreme temperatures beyond the normal average during this period (Saudamini 2010). In 2002, an estimated 1,030 heat-related deaths were reported in India with increased hospital admissions due to heat and most affected were those with a low socio-economic status (Haran 2003). Furthermore, India experienced 28 consecutive days of abnormal temperatures in 2003 with daily temperatures between 45°C to 50°C recorded which was about 10 degrees above what is normally expected (Haran 2003). The heat wave in 2003 affected mainly the state of Andra Pradesh where more than 3,000 heat-related deaths were reported (Government of Andhra Pradesh 2004) and the victims were mainly women, children and the elderly (Haran 2003).

India experienced another heat wave in 2007 and over 72 heat-related deaths were reported in some parts of the country; temperatures were 7°C above normal (SAARC Disaster Management Centre). In 2010, more than 250 people died as a result of heat waves in India, mostly in the state of Gujarat. There was an overload of hospital and emergency services reported with some health facilities receiving an estimated 300 cases of heat stroke each day (Burke 2010). The 2010 heat wave was attributed to a lack of atmospheric humidity and the hot dry winds blowing across the south-western Thar desert coupled with the El-Nino effect (Burke 2010). Table 2.4 shows the death toll due to heat waves in the state of Orissa.

Table 2.4: Death toll due to heat waves in the State of Orissa, India since 1998

Year	Number of heat-related deaths	No. of heat wave days
1998	2042	28
1999	91	25
2000	29	18
2001	25	12
2002	41	21
2003	68	28
2004	45	8
2005	236	29
2006	21	4
2007	47	8
2008	68	12
2009	85	29
2010	61	38

Adapted from: "Adaptation to Heat Waves: Evaluating the role of Awareness Campaign as an effective strategy to avert health risk" (Saudamini 2010).

Source: Indian Meteorological Department, Bhubaneswar and Orissa State Disaster Mitigation Authority, 2010

In Pakistan, the months of June and July are usually hot with heat-related deaths quite common. For example, in 2003 over 230 heat-related deaths was reported in the country (Ahmed 2006) and in 2005, over 175 people died as a result of a sweltering heat wave when temperatures exceeded 45°C for over a week (Yousafzai 2005). The heat-related deaths were mainly attributed to dehydration and heat stroke (Yousafzai 2005). In 2007, the mercury level soared to over 50°C and the heat wave recorded in the country resulted in 232 heat-related deaths (NASA 2007). Recently in 2010, temperatures rose to over 53.7°C in the city of Larkana which resulted in the death of four people with many fainting as a result of dehydration (Vidal & Walsh 2010). The extreme heat triggered a power outage in several cities across the country (Vidal & Walsh 2010). Like most other developing countries, there have been few epidemiological studies conducted and published in peer reviewed journals about heat waves in Pakistan although heat kills in this country.

Heat waves have also been reported in China. For example, in the summer of 1998, the city of Shanghai recorded an extreme heat with deaths reported which were three times higher than those of previous summers (Tan et al., 2004). Later in the summer of 2003, Shanghai recorded the highest summer temperatures that had been recorded over the last 50 years (Tan et al., 2004). There was an estimated 258 heat-related deaths during the 2003 heat wave (Huang, Kan & Kovats 2010). Ma et al. (2011) using hospital admission data for the period January 1, 2005 to December, 31 2008 estimated the impact of temperature on health outcomes in Shanghai. Based on the definition of heat wave they used, they found about 2%, 8% and 6% increase in total, cardiovascular and respiratory hospital admissions respectively, associated with the heat wave during the period (Ma et al., 2011).

Despite its geographic location, sustained periods of high temperatures have been reported in Japan. For instance, an unusually hot weather was recorded in the summer of 1994 with temperatures for the months of July and August exceeding those in previous years (Bai et al., 1995). Daily temperatures recorded for Osaka, the capital over a 75-day period exceeded 30°C. The number of deaths attributed to the heat in Osaka between July and August was estimated to be 1,388; surpassing the number of death over the same period during the previous 5 years (Bai et al., 1995). These excess deaths were attributed to the extreme heat during that period and most of the deaths were among people aged 75 years and over (Bai et al., 1995).

In the Hokkaido prefecture, an abnormal increase in temperatures was observed in 1999 which was more than any that had been reported over the previous years. In August 1999, there were 14 days with temperatures over 30°C which resulted in an increase in heat-related deaths. The age-adjusted mortality rate was significantly higher compared to previous years (Qiu et al., 2002). In July 2004, temperatures were as high as 39.5°C in Tokyo, a value which had not been reported for many years. During this period, at least 12 people were hospitalised as a result of the heat (Terra Daily: 20 July 2004). In 2010, over 170 heat–related deaths were reported in Tokyo with more than 54,000 others rushed to the hospital in one of the hottest summers that the country had ever experienced (The Strait Times September 2010).

2.2.5.3 Heat waves in South America and Africa

In subtropical South America, episodes of heat waves that have occurred have mainly been associated with the activity of synoptic scale (Cerne, Vera & Liebmann 2007). In early 2003, an intense and prolonged heat wave hit sub-tropical South America affecting Uruguay, central and western Argentina, Paraguay, southern Bolivia and southern Brazil. Highest temperatures across the region rose to more than 40°C in certain cities (Seluchi et al., 2006).There were nine consecutive days in Argentina where temperatures were above the normal (Cerne, Vera & Liebmann 2007). Another heat wave was recorded in Argentina in January 2009 with temperatures reaching 40°C across certain cities of the country (Grumm 2009). Brazil experienced a heat wave in 2010 when mean daily temperatures soared to over 40°C and in just a two-day period, with over 32 heat-related deaths reported (Latin American Herald Tribune 2010). During this heat wave, over 220 ambulance call-outs were recorded in two days. The elderly and those suffering from chronic conditions such as diabetes, hypertension and heart difficulties were the most affected during the heat wave (Latin American Herald Tribune 2010).

In Africa, daily temperatures across most parts of the continent can sometimes be high and humid, although most of these have not been classified as a heat wave *per se* as in developed countries. Climatic variables are hard to capture in most of these African countries due to the absence of adequate meteorological technology. It is therefore difficult to obtain high quality data that could be compared over time to determine the trend in climatic variables which may indicate changes in temperature values and to describe temperature ranges to be considered as a heat wave.

There is a dearth of published studies that have been conducted to determine the association between temperature and health outcomes in African countries. Nonetheless, countries in North Africa and those closer to the Sahara desert are those that mostly experience severe periods of extreme heat (NASA Earth Observatory 2008). A heat wave occurred in Mauritania in 2010 and two heat-related deaths were reported which were mainly the elderly who were unable to cope with the heat (Disaster Alert Network 2010). In 2010, daily temperatures in a Chadian city rose to 47.6°C while a record temperature of 47.1°C was recorded in the city of Bilma (Climate Signals 2010).

2.3 Human vulnerability to heat waves

The term vulnerability originated from the field of geography and natural hazards and while some authors explain vulnerability as a result of either internal or external factors (Brooks 2003; Füssel 2007), others classify vulnerability in terms of socio-economic and bio-physical factors (Ellis 2002). Nonetheless, vulnerability has recently been extensively used across disciplines including ecology, climate change, sustainability and public health. Vulnerability has been defined as the degree to which a system (e.g., an individual, community, population) is likely to experience harm when it is exposed to a hazard (Turner et al., 2003).

The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability to climate change as "the degree to which a system is susceptible to, or unable to cope with the adverse effects of climate change, including climate variability and extremes" (IPCC 2007). Based on this definition, vulnerability to heat wave may refer to the extent to which an individual or community would be affected and unable to adequately adapt or cope with the impacts of heat waves. The degree of human vulnerability to heat waves may be determined by factors within the natural and human systems (Wilhelmi & Hayden 2010).

Vulnerability of individuals and communities to heat waves is a function of the level of exposure, the physiological sensitivity of individual/community to the impacts, and their capacity to adapt and cope with the impacts of heat waves (Brooks, Adger & Kelly 2005; Smit & Wandela 2006; Yohe & Tol 2002). Hence, vulnerability to extreme heat could be expressed as:

$$\text{Vulnerability} = f\ (\text{level of exposure, sensitivity, adaptation})$$

The factors that influence human vulnerability to heat waves include socio-economic factors, the regional climate, the population health status, the state of local infrastructure, knowledge of health risks, behavioural factors, the presence or absence of a heat response system as well as the strength of social networks and agencies (Health Canada 2011; Rinner et al., 2010). Figure 2.3 shows a framework for heat vulnerability. It has also been argued that although the impacts of heat waves may be attributed to the variety of these factors, awareness is an important factor that determines community vulnerability to the impacts of heat waves

(Saudamini 2010). In effect, vulnerability assessment uses analysis of data and expert knowledge to identify the factors that may place a community at risk to the health impacts of extreme heat. Such information would be useful to health workers and decision-makers in designing effective programs to reduce community vulnerability and increase their resilience to extreme heat (Health Canada 2008).

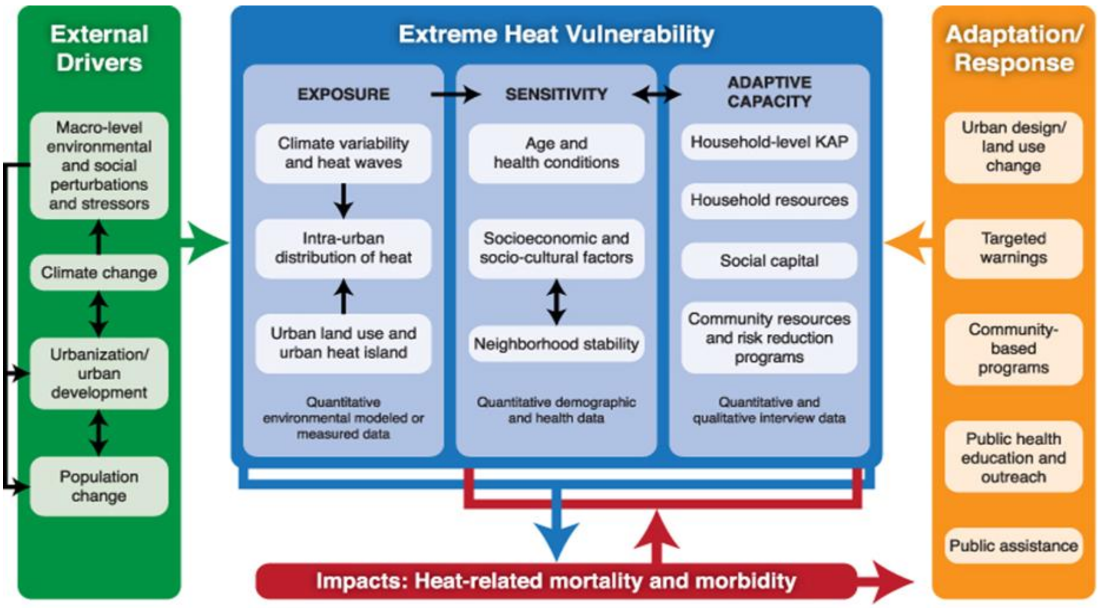

Figure 2.3: A framework for extreme heat vulnerability (KAP refers to knowledge, attitude and practice).

Source: (Wilhelmi & Hayden 2010)

2.3.1 Exposure to extreme heat

Exposure to heat depends on a number of factors, and may occur either indoors or outdoors (Wilhelmi & Hayden 2010). The heat hazard is a function of the magnitude and duration of a period of anomalous heat (McGregor et al., 2007) and its intensity may depend on the degree of urbanisation. An increase in urbanisation leads to the urban heat island effect, a situation where the temperatures in the urban environment are higher than those in the surrounding areas as a result of anthropogenic activities, social and built environment which eventually heats up and effectively retains heat (Shahmohamadi et al., 2010). Many techniques have been used to estimate population exposure and health outcomes related to extreme heat (Basu, Dominici & Samet 2005; Curriero et al., 2002; Keatinge et al., 2000; Stafoggia et al., 2009). These techniques have provided a better understanding of how exposure to extreme heat affects population health (O'Neill & Ebi 2009). For example, a study conducted in the U.S.A. to examine exposure to ambient temperature among the elderly showed that the body temperature of the elderly increased when ambient temperature rises (Basu & Samet 2002).

2.3.2 Sensitivity to extreme heat

Sensitivity to heat is the degree to which individuals are susceptible to heat exposure and this could be influenced by the body's thermoregulatory function (Niemeyer, Petts & Hobson 2005). Hence, those who have impaired thermoregulatory mechanism would be more likely to be sensitive and vulnerable to extreme heat. This probably explains why the elder and those with pre-existing conditions are more sensitive to extreme heat (Worfolk 2000).

2.3.3 Adaptive capacity to extreme heat

The adaptive capacity is the ability of a system (in this case individuals and communities) to adapt to potential impacts of extreme heat, taking advantage of opportunities to cope with its consequences (Kovats, Ebi & Menne 2003).There are a number of frameworks that have been developed to investigate the adaptive capacity of individuals to cope with the impacts of climate risks. In the case of extreme heat, it has been shown that the adaptive capacity of individuals and communities to respond to the impacts of extreme heat depends on several factors including knowledge and awareness of heat (Saudamini 2010), attitudes and practice regarding preventive actions, social capital (including household income networks) and resources at household and community level designed to reduce the risk of heat-related mortality (Wilhelmi & Hayden 2010).

Undoubtedly, social capital and community resources influence the ability of individuals and communities to respond to heat waves. This was supported by studies conducted in the aftermath of the 1995 heat wave in Chicago where only a few Latinos died as compared to African-Americans. The few deaths reported among the Latinos was attributed to the stronger social networks and family bonds that existed among them compared to the African-American community (Klinenberg 2002). Nevertheless, the idea that social capital increases adaptive capacity was not supported by Wolf et al (2010) after their study among the elderly in the United Kingdom. They found that the presence of social networks and bonds decreases adaptive capacity, probably because neither the elderly nor their social networks perceive the risks of heat waves and as a result do not communicate or act upon the perceived risks (Wolf et al., 2010).

2.3.4 Factors affecting heat vulnerability

Although extreme heat may affect the entire population, there are specific groups within the community who are more vulnerable to extreme heat. It is therefore important to identify the underlying factors that put them more at risk to the impacts of heat waves. In the following section, the different groups identified in the literature to be more vulnerable to heat waves are discussed along with the factors associated with human vulnerability to heat waves.

Age: Studies have showed that age is a risk factor for heat-related illnesses, given that the young (LoVecchio , Stapczynski & Haffer 2005) and the elderly (Bell et al., 2008; Foroni et al., 2007; Stafoggia et al., 2008) are most vulnerable to the impacts of heat waves. The elderly are more vulnerable to heat exposure as a result of their reduced thermoregulatory capacity and the fact that many of them have chronic diseases (Faunt et al., 1995; Van Someren 2007). A study conducted in Australia found that other potential factors that increase vulnerability among the elderly during heat waves include living alone, social isolation, poor health, mental illness, being unable to speak English as well the lack of suitable public transportation especially during weekends (Ibrahim et al., 2008). In the United States, heat-related deaths were analysed using data for the period 1979-2002. The study found that close to 50% of heat-related deaths were among those aged 65 years and above (LoVecchio , Stapczynski & Haffer 2005). Other studies have also reported a relationship between heat vulnerability and the elderly who live in institutional settings (Belmin et al., 2007; Klenk, Becker & Rapp 2010).

Infants and young children are at increased risk during a heat wave due to certain physiological characteristics that put them at a thermoregulatory disadvantage. In the U.S.A., of the 4,780 heat-related deaths that occurred over the period 1979-2002, 6% six percent of the cases were among children aged ≤ 16 years (LoVecchio , Stapczynski & Haffer 2005). Anecdotal evidence has also reported heat-related deaths among children who are left unattended inside parked cars by their parents. In the United States, an average of 29 children per year died of heat stroke from being left unattended in motor vehicles between 1998-2002. The number increased to 42 deaths in 2003 and 35 in 2004. It is also estimated that annually hundreds of children in the U.S. experience various forms of heat-related illnesses from being left in cars (McLaren, Null & Quinn 2005; Null 2012).

It has also been reported that children are more susceptible to heat-related illnesses while in bedroom environments because of their high metabolic rate and their inability to remove clothing and blankets (Krous et al., 2001). Other studies have reported that children's vulnerability to heat-related illnesses is associated with physical activity, although the reason for this is not yet clear. It has however been hypothesized that this has to do with their lower cardiac output, greater surface area to body mass than adults, and the production of more metabolic heat per kilogram of body weight (Bytomski & Squire 2003). In contrast, it has been maintained that there is no difference in heat dissipation among adults and children, and that the greater risk of heat-related illnesses among infants and young children is probably related to their dependency and pre-existing illness (Rowland 2008).

Gender: There has been contrasting evidence regarding heat vulnerability in relation to gender. While some studies show that there is no significant difference in heat vulnerability between men and women (O'Neill, Zanobetti & Schwartz 2003; Tan 2008), others have reported such differences (Donoghue, Kalelkar & Boehmer 1995). For example, a study conducted in three cities across Latin America to assess heat vulnerability by gender revealed that men were more susceptible to heat than women in the cities of Santiago and Sao Paolo. However, in Mexico city, women were more susceptible than men (Bell et al., 2008).

Other studies which have found women to be more vulnerable to heat waves have been reported in Italy (Michelozzi et al., 2005); Seville (Díaz et al., 2002); London (Rooney et al., 1998) ; Barcelona (Borrell et al., 2006) as well in South Korea (Son et al., 2011). A study conducted in the aftermath of the 2003 European heat wave found that women were more vulnerable because of social isolation and their low economic power (Vandentorren et al., 2006). It has been suggested that increased risk of heat-related illnesses among females is related to thermoregulatory responses since females have higher core temperatures, skin temperatures, heart rates, blood pressure and set points for sweating compared to males. Furthermore, the two female processes of menopause and menstruation affect thermoregulatory processes among females which increases their risk (Havenith 2005; Havenith et al., 1995).

Marital Status: Marital status as a risk factor has not been widely reported in the literature. However, in the 2003 heat wave in France in 2003, those who were unmarried were reported to be at a higher risk of heat-related mortality (Cadot , Rodwin & Spira 2007). Similar findings have been reported in Italy (Caranci et al., 2006). Another study in France found that the risks of heat-related mortality were higher for unmarried men than unmarried women (Canoui-Poitrine et al., 2006).

Living alone: Evidence from the U.S. has shown that those who live alone or who don't move outside during periods of extreme heat are at higher risk of heat-related deaths (Klinenberg 2002; Naughton et al., 2002; Semenza et al., 1996). Other research have found that the lack of social contacts is a major risk factor for heat-related mortality (Bouchama et al., 2007; Naughton et al., 2002). An analysis of several observational studies examining the risk and protective factors in heat-related deaths found that not leaving home daily was associated with an increased risk of dying during periods of heat waves (OR 3.35; 95% CI, 1.6-6.9) while having social contact provided a protective effect (OR=0.4; 95%CI, 0.2-0.8) (Bouchama et al., 2007). Another analysis found that living alone was one of the risk factors for heat-related mortality during the Chicago 1995 heat wave (Klinenberg 2002; Naughton et al., 2002), while being involved in group or social activities with friends were protective effects (Naughton et al., 2002; Semenza et al., 1996).

Similar findings have been reported in Australia where living alone and social isolation were among the factors that increased heat-related mortality especially among the elderly (McInnes & Ibrahim 2010). However, contrasting findings have been reported in studies conducted in Italy (Foroni et al., 2007) and England/Wales (Hajat, Kovats & Lachowycz 2007) where living alone was not a risk factor for heat-related deaths. Yardley et al (2011) posit that while living alone may not be directly equated with social isolation, changes in the social and built environment may be a contributing factor that has led to an increase in the number of people living alone; who are also socially isolated (Yardley, Sigal & Kenny 2011) and most of them are likely to be seniors (Kramarow 1995). Most of these seniors who live alone might be unable to care for themselves, which further increases their risk for heat-related illnesses and mortality (Semenza et al., 1996).

Pre-existing chronic conditions: Individuals with chronic medical conditions have been reported to be susceptible to heat waves (Bouchama et al., 2007; O'Neill et al., 2009; Shendell et al., 2010). The main significant pre-existing conditions that increase vulnerability to heat wave include, cardiovascular disease (Naughton et al., 2002; Stafoggia et al., 2006); diabetes (Schwartz 2005); renal disease (Hansen et al., 2008c), nervous disorders (Khalaj et al., 2010); emphysema (Semenza et al., 1999); pulmonary conditions (Semenza et al., 1996); and mental health conditions (Hansen et al., 2008b).

Medication & drug use: There are certain medications and drugs that interfere with thermoregulation and these increase an individual's susceptibility to heat-related illnesses (Baker & Kenney 2007; Havenith 2005). Drugs such as antihistamines, anticholinergics, beta-blockers and barbiturates are among the common drugs that interfere with the body's physiological response to extreme heat exposure (Koppe et al., 2004). A study conducted in Kansas city and St. Louis, U.S.A. found that the use of tranquilizers was an important risk factor for heat-stroke (Kilbourne et al., 1992).

Low socio-economic status: Many studies have shown that individuals with a low socio-economic status are disproportionately affected during a heat wave (Naughton et al., 2002; O'Neill, Zanobetti & Schwartz 2003; Vandentorren et al., 2006). For example, in Italy there were more heat-related deaths in neighbourhoods with a lower socio-economic status during the 2003 heat wave (Michelozzi et al., 2005). Those who are poor may not be able to afford to take necessary action to protect themselves from the effects of a heat wave. They may not be able to afford an air conditioner or not turn it on for fear of electricity costs. The lack of air-conditioners has been associated with poverty in the United States (Curriero et al., 2002; Semenza et al., 1996). Furthermore, those with a low socio-economic status are more likely to live in poor housing conditions, which might increase their vulnerability during a heat wave (Semenza et al., 1996).

An individual's level of education (a good indicator for socio-economic status) has been reported to be a risk factor for heat-related illness (O'Neill, Zanobetti & Schwartz 2003). Studies have reported that those with lower levels of education are more vulnerable to heat waves (Borrell et al., 2006; O'Neill, Zanobetti & Schwartz 2003; Son et al., 2011). For example, a study conducted across 50 cities in the U.S. for the period 1989-2000, covering a total of 7,789,655 deaths found that those without a degree above high school diploma were more likely to die from heat-related illnesses than those with more education (Medina-Ramón et al., 2006). Nevertheless, a study conducted in Latin America found variation in heat susceptibility and educational level across three cities (Sao Paolo, Santiago, Mexico city). In Sao Paolo, those with less education were more susceptible; whereas no distinct pattern was observed in the other cities. The authors of the study concluded that the differences in heat vulnerability across these cities highlight variations in the role of socio-economic factors in heat-susceptibility even within the same region of the world (Bell et al., 2008).

Possibly also related to socio-economic status, studies in the U.S. have shown that African-Americans (Curriero et al., 2002; O'Neill, Zanobetti & Schwartz 2003; Semenza et al., 1996) and non-white racial groups (Reid et al., 2009) are found to be more vulnerable to extreme heat than their white counterparts. During the 1995 Chicago heat wave, mortality among Africa-American was 50% higher than among the whites (Whitman et al., 1997). It has been hypothesized that the increased vulnerability to heat waves among African-American probably depends on their low socio-economic and medical conditions as well as the fact that they reside in inner-city neighbourhoods (McGeehin & Mirabelli 2001).

Living in an urban area: There has been recent emphasis on examining population vulnerability to heat waves by taking into account both the physical and social environment (Voogt & Oke 2003). Temperatures in urban areas are usually higher than rural areas due to urbanisation and the increase in human activities. This difference in temperature gradient between urban and rural areas constitutes the urban heat island effect (Voogt & Oke 2003).

Some studies suggest that heat-related illnesses and mortality is greater in urban areas than surrounding regions due to the urban heat island effect or the underlying higher rate of chronic diseases that people in urban areas suffer (Smoyer, Rainham & Hewko 2000; Tan et al., 2010). One study found that living in a neighbourhood with high settlement density, sparse vegetation and the lack of an open space are factors that increase heat vulnerability (Harlan et al., 2006). However, a study conducted in Taiwan to identify the regions that were vulnerable to heat revealed that those living in urban areas were at a lower risk of heat-related deaths than their counterparts in rural areas. This was attributed to the higher socio-economic status among urban dwellers and the availability of medical facilities in the urban regions of the country (Wu et al., 2010). The above study finding was somewhat consistent with a previously conducted research in Ohio, U.S.A. which suggested that sub-urban and rural counties experienced a higher proportional increase in heat-related deaths than urban counties, although there was no statistically significant difference (Sheridan & Dolney 2003).

2.4 Climate change and heat waves: public perception

2.4.1 Public perception of climate change

This section reviews some of the most recent studies on public attitudes towards climate change conducted in the developed world. A review of public perception of climate change has been conducted for two main reasons. Firstly, because this thesis examines heat waves in the context of climate change. Secondly, public perception of climate change may influence public perception of heat waves since scientific evidence links an increase in heat waves to climate change (Confalonieri et al., 2007; Hansen, Sato & Ruedy 2012). Results from studies on public perceptions of climate change in the developed countries are somewhat consistent. Many of the studies have found that there is general awareness, interest and concern about climate change among the public (Lorenzoni, Pidgeon & O'Connor 2005; Reynolds et al., 2010).

Although awareness and concern exist, public views about climate change have been mixed, polarised, and politicised, with a proportion of the population who have even rejected the science (Krosnick, Holbrook & Visser 2000; Lorenzoni, Pidgeon & O'Connor 2005). Indeed, scepticism about climate change exists within a given population. For example, a study was conducted in the U.S. to segment the population based on their beliefs and views about climate change. Study participants were segmented along a continuum from those strongly engaged to those completely dismissive of climate change (Leiserowitz, Maibach & Roser-Renouf 2009). Table 2.5 shows a summary of the six different groups that emerged from the study.

Other surveys conducted in the U.S. in the past years have found a shift in public attitudes towards climate change. For example, a survey conducted in May 2011, found only 64% of the U.S. respondents believe that climate change is occurring and 47% believed that if global warming exits, it is manmade. A repeat survey conducted a year later showed in May 2012, 66% (a 2% shift from the previous survey) of the U.S. population believed that global warming is happening, while 46% of the respondents thought global warming is caused by human activities (Leiserowitz et al., 2012). Other recent polls conducted in the U.S. have also found a shift in public attitudes towards climate change. Borick and his colleagues conducted a survey to gauge public perception about climate change in 2012. Their results showed that 81% Democrats, 42% Republicans and 72% Independents accepted that there was solid evidence that climate change was occurring. However, the percentage of respondents who agreed that climate change was occurring was somewhat lower than the results obtained in 2008 (Borick, Lachapelle & Rabe 2012).

Table 2.5: Segmentation of the U.S.A. population based on climate change beliefs

Group	Proportion	Description
Alarmed	18%	They are worried about global warming, convinced that it is happening and believe that there is scientific agreement that global warming is real and that it is human induced.
Concerned	33%	Their belief is similar to the alarmed, but they worry less about it and consider global warming a lesser threat to them, their families, local communities, and people in the US or other countries.
Cautious	19%	They believe global warming is a problem, although they are less certain that it happening than the "alarmed" and "concerned". About 50% of them believe there is scientific consensus that climate change is happening. They don't view global warming as a personal threat, but believe it may harm people in the future.
Disengaged	12%	They haven't thought much about global warming at all, know very little about it and are most likely to change their minds about global warming.
Doubtful	11%	Most of them believe that if global warming is indeed happening, it is caused by natural changes in the environment, believe global warming won't harm people for many decades into the future, if at all, and say that America is already doing enough to respond to the threat.
Dismissive	7%	The majority believe that global warming is not happening, is not a threat to either people or human nature and strongly believe it is not a problem that warrants any societal response.

Proportion of the U.S. adult population (n=2,129)

Source: Adapted from (Leiserowitz, Maibach & Roser-Renouf 2009)

Although there has been near agreement among scientists that global warming is human induced, there seems to be a general lack of awareness among the U.S. public about the extent of scientific agreement. It is known that at least 97% of scientists conducting research in the area agree that global warming is occurring and human-induced (Anderegga et al., 2010). Nonetheless, public perception on scientific agreement about climate change is likely to influence people's view about climate change. A recent study in the U.S. found that 66%

of the total respondents indicated either that "there is a lot of disagreement among scientists about whether global warming is happening", or "most scientists think that global warming is not happening", or they "don't know enough to say". Only 34% indicated that there was consensus among scientists about global warming. Those who believed that there was scientific disagreement among scientists were therefore less likely to agree that global warming was happening (Ding et al., 2011). However, given that people's view are subject to change, a recent study conducted indicated an increase in the proportion of the population (39%) who believe that most scientists think global warming is happening (Leiserowitz et al., 2011).

Studies conducted in the UK have found an increase in awareness among the population about climate change. A survey conducted in 2001 reported that over three-quarters of respondents had heard about climate change. However, those who had not heard about climate change had heard of either global warming or the green house effect. An estimated 99% of respondents had heard about at least one of either climate change, global warming or greenhouse effects (DEFRA 2002). This finding was supported by another study which found that 81% of respondents had heard about climate change. The same study found that 90% of respondents believed that the UK climate will be affected by global warming (BBC / ICM 2004).

In relation to climate change beliefs, previous studies conducted in the UK have shown that the majority of respondents believe that climate change is happening, with only a minority remain sceptical about climate change. In a 2002 survey conducted in the UK, 71% of respondents agreed that climate change was attributed to human activities, 13% did not accept that it was linked to human activities, while the rest did not know (DEFRA 2002). Another survey conducted in 2004 showed that 64% of respondents identified human activities as contributing to climate change (BBC / ICM 2004). The above findings were supported by another study which found that an overwhelming majority of respondents (91%) believed that climate change was happening (Poortinga, Pidgeon & Lorenzoni 2005). Nonetheless, in the 2004 survey conducted, 52% of respondents believed that climate change will have little or no effect on them personally, as it appeared at the bottom of priority issues. The three main priority issues which participants identified were health, crime, and education (BBC / ICM 2004).

Although there is awareness about climate change in the UK, people don’t particularly view climate change as a primary concern. In fact, it has been shown that people have more pressing issues to deal with rather than be so concerned about climate change. One study found that people were more concerned about personal issues such their health, partner and family, personal safety, being independent, finance, friends, comfortable life, while concern for climate change was secondary (Poortinga, Pidgeon & Lorenzoni 2005). Studies have suggested that one possible reason why climate change is not considered a primary concern for most people in the developed world is the belief that it is a distant issue both in space and time. The public tend to regard those in geographically distant places to be more vulnerable to climate change, expecting people in such places to be concerned. Furthermore, some have the perception that it is only people in future generations that should be concerned about climate change (Lorenzoni & Pidgeon 2006).

Across the European Union (EU) there have been studies commissioned to examine public attitudes relating to climate change. Among the key variables that have been examined in these surveys is the concern and worries about environmental issues affecting the EU. The initial survey conducted across the EU in 2002 showed that 72% of respondents were concerned about climate change (European Commission: Directorate General 2002). A survey conducted in 2009 revealed that climate change was seen as a serious problem by respondents in Sweden (82%), Cyprus (76%) and Greece (71%). However, those in four countries (Poland, Czech Republic, Turkey and Portugal) did not consider climate change as a very serious problem (European Commission: Directorate General 2009).

In Australia, a review was conducted to assess the state of the public’s views about climate change and examined if there were any change in attitudes or beliefs compared to those in previously conducted studies. The review found that most Australians believe that climate change was happening, but a few accepted that climate change was attributed to human activity. Respondents’ belief in climate change and the fact that human activities are responsible for it dropped as compared to their views in previous years (Leviston et al., 2011). Another survey conducted in 2010 in the country to examine climate change perception revealed that 82.8% of respondents believed that climate change was happening. About 50.4% of them thought that human activity was causing climate change, while 42.2% indicated that climate change was happening due to natural variability (Leviston et al., 2011). In a follow-up survey conducted a year later among 5,030 Australians, the results showed that

77% of respondents thought that climate change was happening. However, opinion varied about whether it was happening as a result of human activity or natural variability. Compared to the study conducted in 2010, there was no significant shift in attitudes and belief about climate change among Australians (Leviston & Walker 2011).

In a separate survey conducted in 2011 among 3,096 Australians, the findings revealed that 74% of respondents believed that climate change was happening and 90% of respondents believe that humans were partly responsible for climate change. More than half of the respondents (78%) believed that if there was no action taken to combat climate change there is likely to be serious consequences for the country. Only 5.8% of the survey's respondents where dismissive or sceptical about climate change (Reser et al., 2011).

2.4.2 Perception of heat waves

As a result of the link between increasing heat waves and climate change (Confalonieri et al., 2007; Hansen, Sato & Ruedy 2012), the extent to which individuals perceive climate change may influence how they perceive the risks associated with heat waves; which may determine their behavioural responses. It is well understood that risk perception is important in shaping individual response to natural hazards and is relevant for policy makers who design public policies to respond to these risks (*see Section 2.5.1 for more details).* While there have been numerous studies published about public perception of climate change, there are limited studies that have been conducted to explore public perception to heat waves. One study conducted across four north American cities found that most of the participants did not consider heat waves as a potential risk to them (Sheridan 2007). Similar findings have been reported in the U.K. where the elderly did not perceive themselves as being at risk during a heat wave. Although participants acknowledged that older individuals were more vulnerable to heat waves, they did not consider themselves vulnerable since they perceived not being old (Abrahamson et al., 2009; Wolf et al., 2010). Similar findings have been reported in Australia where caregivers reported that the elderly did not consider themselves vulnerable (Hansen et al., 2011a). In another study, some participants said they were not bothered by heat as they had lived with it throughout their lives (Banwell et al., 2012).

2.5 Risk perception of environmental hazards and risk communication

2.5.1 Risk perception and its determinants

Risk may refer to the probability of an adverse effect resulting from exposure to a threat/hazard; the hazard could be considered as the “risk event” which may lead to danger or harm (Pidgeon, Kasperson & Slovic 2003). Based on our understanding and in the context of this research, a heat wave is considered as a “risk event” and the probability of adverse effects (on humans or society) as a result of heat wave exposure could be considered as “risk”. Heat waves pose a serious health threat and the manner in which people perceive the risks is an important consideration in the development of risk communication strategies. The following section presents a review on the background of the concept of risk perception from a broader perspective of hazards and the factors that shape risk perception to hazards. Next, it examines the concept of risk communication to hazards and relates it to heat waves.

Previous research has suggested that people’s socio-demographic characteristics can play an important role in shaping risk perception of natural hazards (Chauvin, Hermand & Mullet 2007; Peacock, Brody & Highfield 2005). For example, age has been found to be positively correlated with risk perception to hazards (Lindell & Hwang 2008), although negative correlations have also been reported (Botzen, Aerts & van den Bergh 2009). A study conducted to investigate the relationship between age and risk perception to 14 health-related behaviours found differences in risk perception among the participants as teenagers minimised the harm associated with the involvement of health threatening activities (Cohn et al., 1995). Another study was conducted to examine the Australian public’s perceived risks on human reproductive health from a number of environmental hazards. The study found that age was a significant predictor of perception of risk, as participants aged over 35 were more likely to rank “Lead” as a harmful hazard compared to those below the age of 35 years (Shepherd et al., 2012).

Studies have found that women perceived risks associated with environmental hazards more than men (O’Connor, Bord & Fisher 1999; Shepherd et al., 2012). There have been several hypotheses to explain gender differences in risk perception and most of them are supported by the more theoretical feminist literature on gender and science. Among these hypotheses, the main five that have received attention in the literature relate to gender differences in knowledge, in levels of institutional trust, in the salience of economic, safety and parental roles (Davidson & Freudenburg 1996; Flynn, Slovic & Mertz 1994).

The number of individuals present in a household (i.e., household composition) may also influence risk perception of natural hazards- especially with the presence of children. For example, it was found that the presence of children in a household increased risk perception to a nuclear threat (Houts et al., 1984). Similar findings have been reported in relation to volcanic risk perception (Perry & Lindell 1990). However, contrasting results were observed in earthquake risk perception (Lindell & Prater 2000) and hurricane risks (Peacock, Brody & Highfield 2005) as the presence of children did not have significant effect on perceived risk.

It has also been found that those who are educated, have a higher income and an overall higher socio-economic status are less likely to perceive risk to a hazard (Frewer 1999; O'Connor, Bord & Fisher 1999). The above finding has been supported by studies which have found that lower levels of income, education and knowledge about a risk (causes, properties and effects) are associated with higher risk perception (Armas & Avram 2009; Lopez-Marrero & Yarnal 2010; Savage 1993). Home ownership has also been reported to influence risk perception to natural hazards. For example, research on flood risk perception conducted in the United Kingdom suggested that owning a property was associated with higher levels of perceived risk than renting a residence (Burningham, Fielding & Thrush 2008; Grothmann & Reusswig 2006).

Other studies have examined how proximity to natural hazards influences risk perception. For example, some researchers found a relationship between hurricane risk perception and high-risk wind zones among homeowners in Florida. Households located in high-risk wind zones of the city had a higher risk perception than those not located in high-risk zones (Peacock, Brody & Highfield 2005). Similar correlations between risk perception and hazard proximity have also been found for technological hazards (Gawande & Jenkins-Smith 2001) and for natural hazards such as earthquakes (Lindell & Perry 2000) and floods (Miceli, Sotgiu & Settanni 2008). These findings suggest that people who are far away from these hazard sources may believe that they are less vulnerable to the hazard. Also residential characteristics may influence risk perception (Siegrist & Gutscher 2008).

Some authors have suggested that previous experience to a hazard may influence people's risk perceptions (Chauvin, Hermand & Mullet 2007; Grothmann & Reusswig 2006). In relation to previous hazard experience, a distinction is usually made between direct personal experience and vicarious experience (Lindell & Hwang 2008). The former relates to an individual's experience of a hazardous event, the damage he/she experienced and the recency of the hazardous event (Lindell & Hwang 2008). The latter relates to a situation where an individual is not directly affected by the hazard but gets information about the effects of the hazard on his/her friends, relatives or neighbours (Paton et al., 2001). Some authors maintain that only direct experience can influence risk perception (Sjoberg 1999), while others argue that vicarious experience also affects risk perception (Lindell & Perry 1992). Research was conducted to examine the role of direct and vicarious experience on risk perception in relation to volcanic hazards. The findings revealed that participants' direct experience of volcanic eruption influenced their risk perception while vicarious experience did not (Paton et al., 2001).

In all, research conducted to examine how previous experience of a hazard shapes risk perception has generated mixed findings. For example, a study in New Zealand found that those with previous experience had a higher risk perception and the feeling of personal vulnerability in the aftermath of a volcanic eruption (Becker et al., 2001). However, another study found that individuals who have experienced a natural hazard perceive that they are less susceptible to harm from future events than their less experienced counterparts (Halpern-Felsher et al., 2001). Peacock et al. (2000) suggest that this may be because many people think that if they have experienced a hazard, this will make them to be less vulnerable to any future events (Peacock, Brody & Highfield 2005). Lindell and Perry (2000) posit that the extent of previous experience to a hazard and how it may determine future risk perception depends on how individuals interpret previous events. This is because they may be a difference between "public" and "personal" experience where the latter may have more of an "affect" on heightening individual perception (Lindell & Perry 2000). It is worth noting that there is an increase awareness about a hazard among those who have experienced it than those who have not experienced a hazard (Lindell & Hwang 2008).

Studies have shown that risk perception is influenced by a number of factors including social, cultural moral, psychological factors and institutional processes (Dessai et al., 2004). Other scholars have found that public perception of risk is influenced by personal experience, affect and emotion, imagery, trust, values and world views (Finucane et al., 2000; Leiserowitz 2005; Slovic 2000; Slovic et al., 2002). Earlier research conducted in the area of hazard risk perception found that an individual's intuitive judgements are important in determining risk perception. These intuitions are heuristics which represent the common-sense reasoning strategies that have evolved over time (Breakwell 2007; Slovic et al., 2002). Heuristics are used by people to simplify complex problems and to make informed decisions without using all of their cognitive capacities. That explains why some researchers have criticised the use of heuristics because it is subject to systematic biases (Kellens, Terpstra & De Maeyer 2013).

Another factor found to shape public risk perception of a hazard is human cognition. Cognition describes what people believe is true about a risk and guides the attribution of those qualities associated with a risk, the effectiveness of the perceived seriousness of the risk and the judgements people make about them (Slovic et al., 2002). It has been argued that earlier studies on risk perception focused more on the role of cognition (Breakwell 2007). However, recent studies have examined how "affect" influences public risk perception. "Affect" refers to the positive or negative feelings that people have about a particular stimulus, the good or bad judgements. It may influence how individuals receive, process information about a risk and determine whether individuals will react to the good or bad side of the risk (Leiserowitz 2005).

Previous research has shown that risk perception is influenced by people's world views, since risk perceptions are socially and culturally framed. Individuals are part of a social system whose context shapes their attitudes, values and world views (Douglas & Wildavsky 1982). Those world views are the social, economic and political attitudes that enables individuals to interpret the world and are mediated by their day-to-day societal interaction (Dake 1992). For example, those who view heat waves as threatening may be more likely to support policies to reduce vulnerability to heat waves.

Risk perception is also influenced by a combination of cultural factors. Deckers and colleagues maintain that people from different cultural background would perceive the same risk differently (Decker et al., 2010). The cultural theory is based on the premise that risks are socially constructed in various domains including that: they form part of individual's social interaction, and they empower the views, values and beliefs held by individuals (Douglas & Wildavsky 1982). As a result, people could be classified into various groups based on their beliefs and this determines their extent of risk perception, how they would make judgements and take appropriate decisions. Since cultural factors are affected by an individual's intuitive judgements, they can significantly affect whether people in a community rely on their intuitive judgements as opposed to the systematic processing of a risk. Furthermore, individuals tend to activate their judgements if they develop such judgements before the hazard event occurs (Gilovich, Griffin & Kahneman 2002).

The relationship between cultural background and risk perception originated from the cultural theory which posits that individuals decide on what to fear based on the cultural and social context in which they are embedded (Douglas & Wildavsky 1982). Although the cultural theory is extensively mentioned in the literature, opinion among researchers about its validity is mixed. For example, it has been argued that this theory is only useful in explaining some of the differences experienced in risk perception (Slovic, 2000). A study conducted to examine the role of culture in influencing risk perception for a number of different hazards found differences in risk perception among citizens of the United States and Japan, although a few similarities were observed. In fact, the Japanese were more concerned about all the risks than the Americans. Furthermore, where as Americans had little knowledge about the risks and thought they were new, the Japanese thought they had much knowledge and believed that the risks were old (Hinman et al., 1993).

Members of the public typically receive news about hazards through a variety of sources including the media, their families, and friends. The way in which people receive information about a risk may shape their risk perception. For example, peoples' attitudes towards a risk may be influenced by reading a newspaper article or watching news on television (Breakwell 2007). The media influences risk perception because it serves as a link between the authorities or experts who design and deliver those messages and the public that consumes them (Gregory 1989). A study was conducted in the United Kingdom to examine how press coverage influences risk perception and attitudes towards genetically modified food. The results suggested that differences in attitude towards journalism were correlated with attitudes and risk perception (Vilella-Vilaa & Costa-Font 2008).

Studies have also shown that trust influences how people perceive risk, although the acceptability of the relationship between trust and risk perception is still debated among researchers (Viklund 2003). A cross-national study among four European countries was conducted to examine the relationship between trust and risk perception. Its findings suggested that trust was a significant predictor of levels of perceived risks and a source of variation among these countries (Viklund 2003).Trust is especially important in risk communication because the public must consider the institution that delivers the messages to be credible before these messages are taken seriously. Some authors claim that the public tend to mis-trust authorities and experts on the information about risk that is being communicated to them (Poortinga & Pidgeon 2003). Trust has been shown to be associated with perception of accuracy, knowledge and concern about the society (Frewer 1999).

2.5.2 Risk communication

The way individuals perceive risks about a hazard is important in guiding the development and implementation of risk communication strategies. Therefore, effective risk communication has to address the range of perceptions that exist in a community. Risk communication could be defined as the exchange of useful information about health or environmental hazards (risk) between interested parties, which could be individuals, groups or organisations (Covello, von Winterfeldtm & Slovic 1986). Risk communication has been used as a concept where by authorities communicate complex information about a particular risk to the public to enable them make an informed decision to stay safe (Fischhoff 1995; Morgan et al. 2002). Other researchers have suggested that risk communication entails a lot of issues including stipulating public interest about a particular environment risk, increasing their knowledge about the risk, influencing their attitudes and behaviour and supporting the public to make informed decisions to respond to the risk (Boholm 2008; Kasperson et al. 2003).

The importance of adjusting risk communication to the specific needs of the public has been underscored in the past because it enables the public to make judgements about the risks in order to make informed decisions to take an appropriate response (Basic 2009). Other researchers have suggested that the success of any risk communication effort would largely depend not only on the characteristic of the risk but also on the nature of the message, how it is delivered and how the public receives, processes and interprets the message (Mileti & Fitzpatrick 1991). For an individual to make an informed decision about a risk, he/she must receive the message, understand what the message is about, interprets the message, share their understanding of the message with others and take necessary actions to protect themselves from the risk (Blanchard-Boehm 1998). Some researchers have argued that for risk communication to be successful, societal values and concern need to be taken into account (Okrent & Pidgeon 1998). Thus, it is important to explore opportunities to better understand the concerns and levels of awareness among the public in order to put in place a successful risk communication strategy.

Effective communication needs a two-way approach and has been widely used in risk communication efforts where the public does not only receive the messages but are the risk managers as well (Renn 2005). A two-way communication approach is useful because it enables authorities to take into account the public's knowledge base before developing and disseminating risk communication messages (Chowdhury & Haque 2008). This sort of communication promotes interaction between authorities and the public and contributes in building trust with the public. In this way, the public considers its self as a key partner in risk communication. For example, when risk is communicated through in a talk show, the public not only receives the messages but also provide feedback and ask questions for clarity. Good risk communication that takes into account these aspects can rally support, calm a nervous public, build trust, encourage cooperative behaviours and save lives (Ahmed et al. 2012).

2.5.3 Communicating health hazards: risks of heat waves

Experience from risk communication in other hazards, if properly adapted could provide guidance to authorities, public health officials and emergency management workers to appropriately develop and communicate risks associated with heat waves. Effective communication of risk associated with heat waves is part of a risk analysis process and is necessary for the public to make informed judgements about the risk and undertake appropriate behaviour change. During a heat wave, it is important for the public to be informed in ways that do not create panic, fear or stress among the population.

Although communicating health risks could be challenging, there are three best channels to target the public with health communication messages related to heat waves; i.e. the media (radio, TV, internet, newspapers, magazines), through interpersonal networks and community events (Dutta-Bergman 2004; Mileti 2006). Other channels could include via media fact sheets, pamphlets, posters, short message service (SMS), facsimile and email. These could be inserted into newspapers or mailed to peoples' homes (Dutta-Bergman 2004; Mileti 2006).

Interpersonal networks are known to facilitate the delivery of messages by community leaders, health care providers, educators, friends and relatives to others in order to influence behaviour change (Dutta-Bergman 2004). White-Newsome et al. (2012) conducted a qualitative study to explore how four major cities in the U.S.A have prepared for and the approaches used in communicating risks associated with heat waves to the public. They found that community networks were widely used as a means of communicating heat wave risks to the public. Furthermore, the different communication strategies used across the cities included using intergenerational messaging, testimonials and people sharing their personal stories to others as means of motivating them to stay safe during a heat wave (White-Newsome et al. 2012). However, these cities faced challenges in risk communication which included language barriers, the high illiteracy rates as well the visual and mental disabilities among the vulnerable population (White-Newsome et al. 2012). Box 2.1 outlines a summary of some strategies to communicate health risks associated with heat waves.

- Identify and analyse the target audience for the messages
- Ensure that warnings are timely communicated
- Tailor heat communication messages and advice to target populations
- Develop targeted and concise risk communication products and materials
- Use simple and clear language that the target population would understand
- Messages should include preventive actions/advice for the public
- Use both text and visual communication to transmit information to vulnerable groups
- Ensure proper coordination among the media channels disseminating the information

Box 2.1 : Suggested strategies to communicate heat wave risks

Source: adapted from (Lowe, Ebi & Forsberg 2011)

2.6 Adaptation to climate-related risks

The impacts of climate change on human and natural systems emphasize the need for the development and implementation of adaptation strategies to reduce climate-related risks. This section provides an overview of the concept of adaptation and later relates the concept to heat waves.

2.6.1 Background on adaptation

The term adaptation has extensively been used in the climate change literature but originated from the natural sciences where it broadly refers to the development of genetic or behavioural characteristics that enable organisms to cope with the changes in the environment or to survive and reproduce (Kitano 2002). Since then, the concept of adaptation has been applied to human systems and used in several other disciplines including the social sciences, public health, psychology and development studies (Adger 2003; Adger et al., 2003; Janssen et al., 2006). There are many definitions of the term adaptation in the climate change literature (Brooks 2003; Pielke 1998; Scheraga & Grambsch 1998; Smit & Wandela 2006).

The IPCC defines adaptation to climate change as an "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 2007). The aim of adaptation is therefore to reduce human vulnerability in response to present or future changes in climate variability and this involves changes in socio-ecological processes to reduce any potential harm (Gupta et al., 2008; IPCC 2007).

Some scholars distinguish between autonomous and planned adaptation to the impacts of climate change, with the former taking place without any preparation; occurring instantaneously in response to a threat (Osberghaus, Finkel & Pohl 2010).This form of adaptation does not constitute any conscious response to climatic impact but rather motivated by changes in the natural system (IPCC 2007). Examples of autonomous adaptation in the case of heat waves may include using an air conditioner or a change in recreational behaviour (Huq & Klein 2003). On the other hand, planned adaptation refers to those measures taken based on deliberate policy decisions (Huq & Klein 2003), on the awareness that climatic conditions are about to change or have changed and that actions are needed to maintain a desired state (IPCC 2007). Examples of planned adaptation in the context of heat waves may include the development of heat-health plans, establishing emergency response mechanisms to heat waves as well as changing building designs to reduce the urban heat island effect (Huq & Klein 2003). Adaptation can also be reactive or anticipatory; the former takes place in response to the impacts of climate change after they have already occurred (Smit et al., 2000), while the latter is implemented before any climate–related hazard occurs so as to reduce the consequences should they occur.

2.6.2 Adaptation to heat waves

The term "adaptation" in public health is synonymous to developing prevention interventions to protect humans from harm or disease (Ebi & Semenza 2008). There are generally three types of prevention approaches in public health (i.e. primary, secondary and tertiary). In relation to heat waves, primary prevention would be designed to reduce exposure during a heat wave; secondary prevention would aim at preventing the onset of adverse health outcomes and tertiary prevention would consist of measures to reduce the long-term impairment and disability and to minimize the suffering caused by heat waves (Ebi & Semenza 2008).

The aim of adaptation to heat waves is to put in place measures, strategies and actions designed to reduce population exposure and vulnerability with the aim of preventing heat-related morbidity and mortality (Ebi, Kovats & Menne 2006). Since adaptation can take place at different levels i.e. individual, community, national level (Gupta et al., 2008), the negative health outcomes from heat waves could be reduced at different levels. Below the different adaptation options for heat waves are described and are classified into three main groups.

2.6.2.1 Communication, education and behaviour change

Health authorities and emergency management officials could promote individual adaptation through public education and raising awareness about the dangers of heat waves. Adaptation measures at the individual level would entail behaviour modification for individuals through undertaking simple preventive measures during a heat wave; which is the most practical and cost-effective short-term adaptation strategy (Smoyer-Tomic & Daniel 2001). Behaviour modification would be effective if the public has adequate knowledge about heat waves, are fully aware about their impacts, recognise the risks in order to adopt simple actions which are recommended by health authorities and emergency management personnel (Smoyer-Tomic &

Daniel 2001). Individuals could modify their behaviour by seeking cool shelter, reducing physical activity, checking on elderly relatives and neighbours during heat events, avoiding excess alcoholic beverages, drinking lots of water, taking regular showers (Bouchama et al., 2007; Smoyer-Tomic & Daniel 2001). However, the effectiveness of some of these recommendations need evaluation (Bouchama et al., 2007). These messages will also need to be targeted for specific groups. For example, those with dialysis need to be informed about alternatives to drinking lots of water.

The use of air-conditioners has been recognised as one of the main protective factors against heat-related mortality (Naughton et al., 2002). It has been suggested that more than half of the race-related differences in heat-related mortality between 1986-1993 in four cities in the U.S. was attributed to the greater prevalence of air-conditioning among the white population in comparison to the black (O'Neill, Zanobetti & Schwartz 2005). Nonetheless, although air-conditioner use can reduce vulnerability during a heat wave, some argue that it's use is a classic example of "*maladaptation*"; because the use of air-conditioners generates small quantities of green house gases, which further contributes to climate change (Hallegatte, Lecocq & de Perthuis 2011; Kovats et al., 2006). Furthermore, the cost of running an air-conditioner may be a barrier for certain groups within the community (Luber & McGeehin 2008; Sheridan 2007).

The use of fans might be used with the aim of reducing health effects of a heat wave. However, research to provide the evidence-base about its effectiveness in reducing heat-related illnesses and mortality has been inconsistent. For example, results from two case-control studies conducted in France among the elderly in the aftermath of the 2003 heat wave suggested that there was some evidence of an increase risk of heat-related mortality when an electric fan was used, although there were mixed findings regarding the risk associated with using an electric fan (Lorente et al., 2005). A meta-analysis conducted found that the use of an electric fan had a slightly protective effect, although the results were not statistically significant (Bouchama et al., 2007). Fans usually increase the rate of heat loss from the body. However, increased sweating can lead to dehydration and electrolyte imbalances and if fluids/electrolytes are not replaced quickly it may lead to negative health outcomes (Gupta et al., 2012). As a result of the inconsistent results about electric fan use, it has been suggested that the effectiveness of fans in preventing heat-related mortality need to be further evaluated (Bouchama et al., 2007; Semenza et al., 1996).

Evidence from the field of health promotion has shown that education through the use of mass media or public awareness campaigns could encourage people to change their behaviour (Hornik 2001; Randolph & Viswanath 2004) and this could be applied to motivate behaviour change during heat waves. The public could be educated and made aware about the risks by disseminating information through the media and using other channels such as pamphlets, brochures, leaflets. A study was conducted to analyse deaths due to heat waves in Orissa, India and evaluate the impact of intensive awareness campaigns undertaken in some of the districts of the state. The study found reduction in heat-related deaths in districts where an awareness campaign was conducted compared to districts where there were no awareness campaigns. The author concluded that generating awareness on “what to do, and what not to do” during heat waves among the population would contribute to change their behaviour and reduce heat-related mortality (Saudamini 2010). Box 2.2 shows a set of preventive measures that was issued in 2009 for the South Australian population.

South Australia State Emergency System Heat Health Warning

The **State Emergency Service** (SES) and the South Australia (SA) Health are warning South Australians that the current heat wave is a threat to public safety.

There have been significant SA Ambulance call outs and an increase in people presenting to Adelaide metropolitan hospitals, some suffering from heat associated illness. Heat related illness can result in severe health issues and can be fatal.

The SES and SA Health urge the public to exercise extreme care during the heat wave and to take the following precautions:

- Make contact with elderly relatives, friends and neighbours.
- Drink plenty of water and avoid alcoholic and caffeinated drinks.
- Be aware of the symptoms of heat stress.
- Stay indoors and close curtains during the day. Open up your home at night if cooler winds occur.
- Use air-conditioners and fans wherever possible or visit public facilities such as shopping centres, cinemas and libraries.
- Take cold baths or showers and use ice packs or wet towels to cool down.
- Remember that cordless telephones do not work during power outages. Make sure you have alternative means of communication.
- Limit outdoor activities to mornings and evenings.
- Consider the safety of your pets and animals. Wet them down and ensure they have adequate shade and water.

  Stay tuned to this radio station on a battery powered radio for more information

Box 2.2 : Preventive measures issued during heat waves in South Australia

Source: Extreme Heat Plan; South Australia Department of Health (SA Health), 2009

2.6.2.2 Development of heat wave warning system and response plans

A public health adaptation strategy to reduce the adverse impacts of heat waves involves developing and implementing heat wave warning systems and response plans (Fouillet et al., 2008; Koppe et al., 2004; Poumadere et al., 2005). These systems are designed to predict hazardous hot weather and respond by warning the public about the dangers of impending heat, and then deliver health advice/messages that would reduce heat-related morbidity and mortality among the population. Overall, an effective heat warning system should consist of (i) preparations before the onset of extreme heat (ii) meteorology-based warning systems; (iii) rapid and coordinated actions during heat waves; (iv) criteria and procedures for de-activating the plan, (v) evaluations following the response activities and outcomes, and vi) reviewing of the plan (Kizer 2000; Kosatsky et al., 2009; McGeehin & Mirabelli 2001). It should be noted that heat wave warning systems are part of a broader heat wave response plan. Some researchers have suggested that in order to facilitate the development of such heat-health plans, it is important to have adequate knowledge and understanding of ambient meteorological conditions and know when these conditions can generate a health impact (Kalkstein, Sheridan & Kalkstein 2009). Others caution the importance of understanding the meteorological conditions hazardous to health before issuing heat alerts to the public (Smoyer-Tomic & Daniel 2001).

In fact, threshold conditions for defining a hazardous heat wave are among the challenges of operationalising a heat alert system (Kalkstein, Sheridan & Kalkstein 2009). For example, the lack of certainty of specific temperature thresholds to trigger a heart alert may result in heat alerts being sent out too often, which may later be realised as “false” alerts. When such alerts become “false”, the public may subsequently not take them seriously, for which the authorities will incur cost without any benefit (Smoyer-Tomic & Daniel 2001). It is therefore important for these meteorological conditions to be well defined and understood before a heat alert is triggered. Undoubtedly, temperature thresholds that guide the issue of heat alerts differ among regions as a result of differences in meteorological conditions and acclimatisation of the public. For example, the system in Toronto, Canada is based on the percentage likelihood of excess mortality; in which case an extreme heat alert is associated with a 90% likelihood of excess mortality, based on previous heat-health relationships, whereas a heat alert is associated with a 65% likelihood (Sheridan & Kalkstein 2004).

Most cities around the world have developed heat-warning systems which incorporate heat thresholds or triggers for specific actions, so that responses are appropriate to minimise health outcomes (Bernard & McGeehin 2004). In Melbourne, Australia, the heat alert system developed was based on the evidence that when mean daily temperature exceeds a threshold of 30°C the average daily mortality of people aged 65 years or more is about 15–17% greater than usual (Nicholls et al., 2008). In South Australia, the heat-health warning system and response plan (known as Extreme Heat Arrangements) was developed in 2009 and has three levels of action based on increasing temperature triggers (*see* Table 2.6). The plan aims to clarify extreme heat events within South Australia, define targets for action for government agencies and outline the associated communication and management strategies (The South Australian Extreme Heat Arrangements 2009). The plan has three levels of alerts (advice, watch and warning) which are based on a three day average of the Bureau of Meteorology’s

(BoM's) forecast average daily temperature (ADT). The ADT is an average of the minimum and maximum temperature occurring that day. The moderate (advice) level triggers pre-planned actions by various organisations including health followed by the beginning of public communication at the moderate (watch) level with very proactive information and assistance at the extreme — (warning) level (Mayner, Arbon & Usher 2010). The temperature settings for these triggers are supported by the evidence of adverse health outcomes associated with heat waves at each level (Williams et al., 2011). Events reaching the temperature triggers for an extreme heat warning were associated with a 44% increase in daily mortality, with a limited health impact for events at lower temperature triggers.

Table 2.6 Temperature triggers and action for Adelaide, South Australia

LEVEL	TRIGGER (Threshold)	COMMUNICATION
Moderate (Advice)	Adelaide forecast temperatures next 5 days Max ≥30°C on each day and Min ≥20 °C on each night (ADT 25°C)	-Heat advice to agencies to remind them of the possibility of excessively hot conditions -The control agency will issue a heat advice 3-5 days in advance of event where practicable
HIGH (Watch)	Adelaide forecast temperatures next 5 days Max ≥ 35°C for 3+ consecutive days and Min ≥ 21°C for 3+ consecutive nights (ADT 28°C)	-Heat watch to community and/ or agencies for heat wave conditions -State Emergency Committee briefing (as appropriate) -The control agency will issue a heat watch 2-3 days in advance of event where practicable
EXTREME (Warning)	Adelaide forecast temperatures next 5 days Max≥ 40°C for 3+ consecutive days and Min≥ 24 °C for 3+ consecutive nights (ADT 32°C)	-Heat watch to community and/ or agencies for heat wave conditions -State Emergency Committee -The control agency will issue a heat watch 2-3 days in advance of event where applicable

ADT refers to Average Daily Temperatures

Source: Adapted from the South Australia Extreme Heat Arrangement Plan (2009). Annex to the Extreme Weather Hazard Plan.

Most heat wave response plans developed in the U.S.A. and Canada were originally based on synoptic weather forecasts (Sheridan 2007). This type of system predicts hazardous weather categories based on historical evidence of the relationship between mortality and various aspects of weather such as temperature, cloud cover, humidity and wind. These relationships together with forecast meteorological data are then used for predictive purposes (Kalkstein et al., 1996; Sheridan & Kalkstein 2004). Most heat-health plans have temperature thresholds to trigger a heat alert. There are also media announcements through radio, TV, newspaper and sometimes brochures and leaflets are also distributed. Some also have a buddy system where volunteers, friends and neighbours are encouraged to check those who are vulnerable in the communities (Kalkstein, Sheridan & Kalkstein 2009). There can also be a telephone hotline service where people are encouraged to call to get useful advice on how to cope with the heat.

2.6.2.3 Reducing the urban heat island effect

In addition to short-term adaptation measures, there is also the need to develop long-term adaptation strategies to reduce the impacts of heat waves on human health. One important long-term adaptation option involves reducing the urban heat island affect (Chan et al., 2007). The urban heat island (UHI) effect is a phenomenon where temperatures in the urban areas are much higher than the surrounding rural areas as a result of increased urbanisation and a higher energy consumption which generates heat (Shahmohamadi et al., 2010). As a result, urban areas do not cool-off at night, which further intensifies the heat during heat waves. There are many factors that may lead to the UHI effect including low albedo of mineralised surfaces, urban districts with low vegetation cover, anthropogenic heat from man-made activities, excessive use of air conditioners, building design (Chan et al., 2007). Major infrastructural measures could be put in place to reduce the urban heat island effect and hence the negative health outcomes associated with heat waves. The measures that could be considered are described in the following sections.

2.6.2.3.1 Increasing the surface albedo

Surface albedo could be increased through the use of white asphalt on pavements instead of black asphalt. It is known that black asphalt temperatures can reach 63°C while white pavements reach only 45°C (Santamouris et al., 2001). Lowering the surface temperature of pavements would contribute to decreasing the temperature of the ambient air because the heat convection intensity from a cooler surface is lower (Santamouris et al., 2001).

2.6.2.3.2 Using cool roofs

Buildings with dark roofs are known to absorb more heat and this raises the cooling demand of the building (Akbari, Pomerantz & Taha 2001; Bretz, Akbari & Rosenfeld 1998). In combination with reduced vegetation cover this warms the air over the urban environment which generates UHI and leads to more energy consumption as a result of increased air-conditioner use (Che-Ani et al., 2009). Such situations put a burden on energy demand in terms of operating costs and the electric power grid (Che-Ani et al., 2009). Roofing materials with a high albedo will reflect more incident solar radiation. The use of solar-reflective urban surfaces has been reported to be an inexpensive measure that can reduce extreme temperatures within a building and hence reduction in air-conditioner use (Bretz, Akbari & Rosenfeld 1998).

Cool roofs have a number of advantages including enhancing the life expectancy of both the roof membrane and the building’s cooling equipment, improving thermal efficiency of the roof insulation, reducing the demand for electric power and increasing thermal comfort (Santamouris et al., 2001). Santamouris et al (2001) further argue that there is a direct association between ambient temperatures and that on the surface of materials (Santamouris et al., 2001). Therefore, increasing the albedo of materials used in the construction of buildings will reduce the amount of heat in the environment (Che-Ani et al., 2009).

2.6.2.3.3 Using green roofs

Roofs represent about 32% of the horizontal surface of built-up areas and are important determinants of energy flux and of buildings water relations (Frazer 2005). Green roofs use plants to develop a green surface on top of a man-made structure. A green roof system requires a high-quality water proofing and root repellent system, a drainage system, filter cloth, and a light weight growing medium for the plants (Oberndorfer et al., 2007). Green roofs can reduce the negative effects of buildings on local ecosystems and can reduce a building’s energy consumption. Other potential benefits for a green roof include green-space amenity, habitat for wildlife, air-quality improvement, and a reduction of the urban heat-island effect (Getter & Rowe 2006).

2.6.2.3.4 Other infrastructural changes

The urban-microclimate is determined by parameters such as temperature, humidity, air movements. During the day in summer periods, the high air temperatures and lower wind speed can bring about heat stress (Luber & McGeehin 2008). Urban planning and redesigning buildings, making them energy efficient could reduce the urban heat islands. Strategies such as promoting green spaces have shown to reduce the amount of heat stress by creating a cooling effect and providing fresh air supply to the city (Georgi & Dimitriou 2010; Oliveira, Andrade & Vaz 2011). Another strategy could be to make homes more energy efficient. Homes with an added roof insulation, reduced air infiltration, energy efficient appliances, double glazing, shade option can reduce the urban heat island effects (Ihm & Krarti 2012).

2.7 Multi-stakeholder processes in developing strategies and policies to reduce climate-related impacts

2.7.1 Background

Generally, public policies are designed to promote the well-being of any society and they comprise the decisions and the instruments used to respond to the diverse social, environmental and economic problems (Dovers & Hezri 2010). In responding to societal challenges, public institutions usually lead a policy making process by setting the agenda while other groups participate in making inputs into the policy. It has been recommended that the development and implementation of adaptation strategies should involve a broad range of relevant stakeholders through a multi-stakeholder process (IPCC 2007). Engaging stakeholders in policy and strategy formulation has been widely recognised as being critical in searching for appropriate solutions to deal with human development issues (United Nations 2006).

Multi-stakeholder processes (MSP) are used to ensure full participation of relevant stakeholders in the design and implementation of public policies. They are important in ensuring participatory equity, accountability and transparency, while fostering friendships, partnership and networks among the different stakeholders involved in a policy process (Hemmati 2002). They provide the platform for stakeholders to listen to each other's views, build confidence, trust and look for appropriate solutions to deal with societal challenges. These processes need to be inclusive in order to promote a sense of ownership, ensure transparency, accountability and thereby strengthen governance of the process (United Nations 2006).

2.7.2 Identifying stakeholders in the adaptation process

In the context of climate change, Conde and Lonsdale (2004) define stakeholders as policymakers, scientists, administrators, communities, and individuals who are affected by the risks posed by climate change (Conde & Lonsdale 2004). These are usually individuals or representatives of groups who have a vested interest towards a particular outcome of a process. The decision on which stakeholder participates in an adaptation process is very important and should be decided at the early stages of the process. This could be achieved through "stakeholder analysis", a process which is designed to identify relevant stakeholders who have an interest to participate in a policy process (Grimble 1998) and who can contribute to make it successful (Mehrizi, Ghasemzadeh & Molas-Gallart 2009).

The available time and resources may determine the scope in which stakeholder analysis takes place. When time and resources are available, the process can be conducted by the lead agency coordinating the engagement process (Varvasovszky & Brugha 2000) or through the use of an external consultant (Crosby 1991). It is argued that if an external consultant conducts the stakeholder analysis, this will make the process open and transparent since everyone would have the chance of being selected to take part in the engagement process (Crosby 1991). An effective stakeholder analysis process with all relevant groups represented ensures a broad-based and inclusive process may perhaps promote the meaningful involvement of stakeholders in all phases of the policy process (Backstrand & Saward 2004).

Another simple approach that could be used (given time and resource constraints) is to ask the initial group of stakeholders to suggest other stakeholders who are, in turn asked the same question until no more individuals can be identified (Keskitalo 2010). Overall, the major stakeholders identified should consist of representatives from the government, non-governmental organisations, local authorities, private sector, academics, researchers and other interested parties/individuals who could make the adaptation process successful. It is also suggested that those who are affected by the impacts of climate change should be represented in the adaptation process (Keskitalo 2010).

2.7.3 Techniques and strategies for stakeholder engagement

There are a number of techniques and approaches used to engage stakeholders in policy processes. The choice to use a particular approach may depend on the purpose of the engagement process and the complexity of the issues to be deliberated (Keskitalo 2010). Stakeholder engagement approaches vary from quite passive interactions, where the stakeholders provide information to self-mobilisation, where the stakeholders themselves initiate the design the process (Keskitalo 2010). Although, there are many techniques and strategies to engage stakeholders, most of these approaches originated from a concept known as the “ladder of citizen participation”. The concept was based on the premise that for any effective engagement of stakeholders, there should be different levels of participation of stakeholders in any policy process (Arnstein 1969). Since this concept was originally proposed, it has subsequently been modified and used in different context. The different levels of participation as encapsulated in the “ladder of participation” are illustrated in Figure 2.4.

Ladder of participation: Original Arnstein 1969, adapted from Perry (1994); ***Typology of Community Participation***

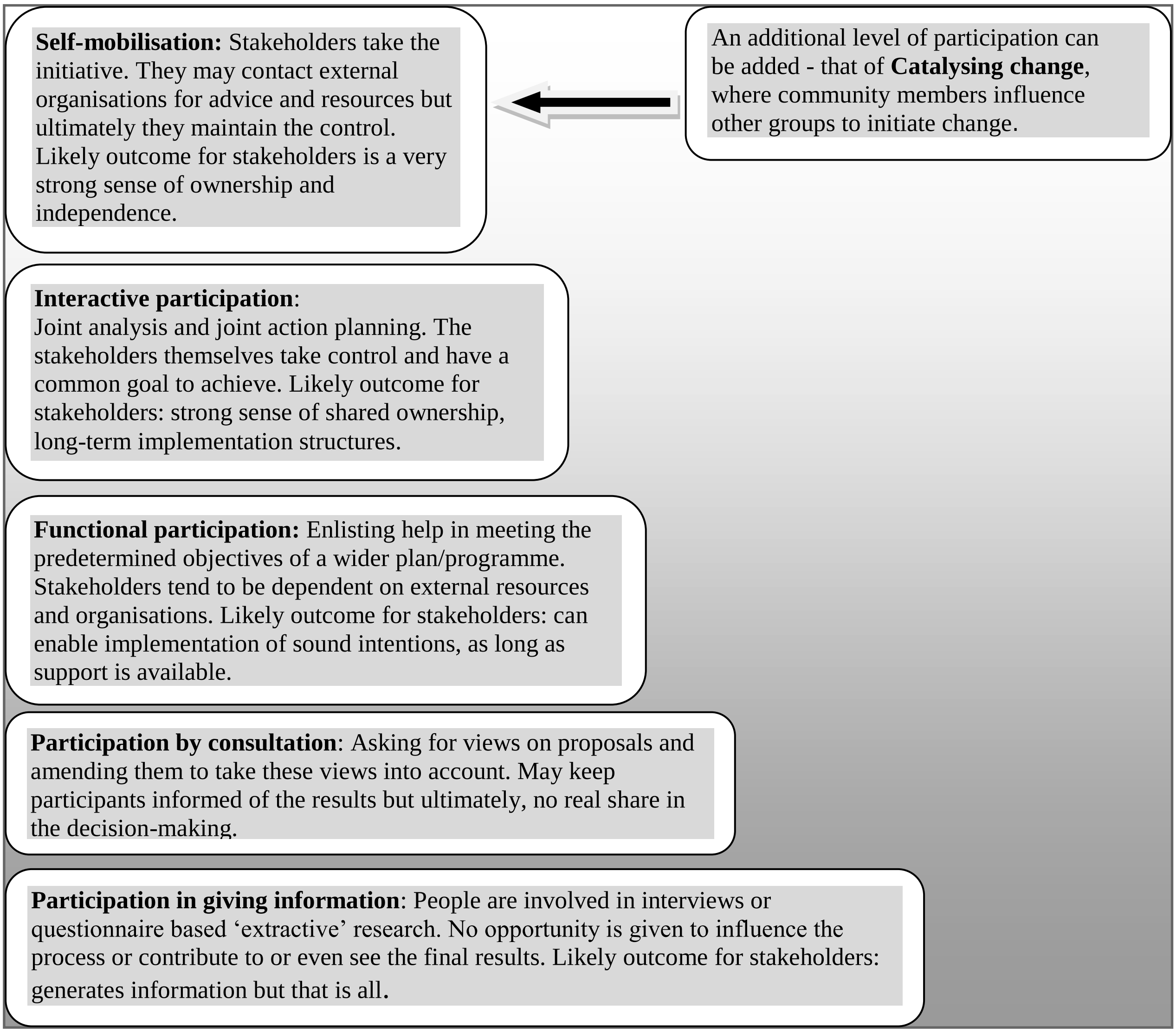

Figure 2.4: Ladder of participation

Source : Adaptation policy frameworks for climate change: developing strategies, policies and measures, New York: Cambridge University Press (Lim & Spanger-Siegfried 2004)

2.7.4 Managing the engagement process

It is important for a lead organisation to be identified who manages an adaptation process to ensure that all those involved in the process feel empowered to voice their concerns and make meaningful contribution. Effective stakeholder dialogues could be enhanced through promoting transparency and accountability, building trust, facilitating effective discussion and encouraging feedback among the different stakeholders during deliberations (Hemmati 2002). Box 2.3 shows some principles for effective stakeholder engagement. In addition, there should be plans to promote communication among all the different stakeholders in the process as this strengthens social cohesiveness and interaction between them (Depoe, Delicath & Elsenbeer 2004; Singh, Koku & Balfors 2007).

Clarity: The goals and objectives of the engagement need to be clear from the outset of the process. The process need to identify what it is intended to achieve and explore the different approaches that need to be used while making considerations whether they are most appropriate.

Time for the process: Ensure that there is enough time for the process that will ensure meaningful participation of all relevant groups, enough time for extensive deliberations and exchange of viewpoints among the stakeholders, partnership building and the strengthening of networks.

Understand the related process: Ensure that the engagement process is not isolated but related to other decision making processes. Conduct a stakeholder analysis to identify people, groups and structures that could provide support to ensure that the process achieves its goal.

Transparency: Promote transparency at all times from inception to closure of the engagement process. Relevant stakeholder groups need to be selected to be part of the process in an open, fair and transparent process. Deliberations during the process should be as transparent as possible.

Trust building: Ensure that the different stakeholders involved in an engagement process trust one another. People need to feel confident that their views and ideas are listen by everyone and taken into account during the process.

Feedback and Flexibility: Allow time to get feedback on how deliberations are taking place. There should be ongoing monitoring of the process to identify any challenges that may undermine the process. Challenges need to be identified and resolved in a timely manner such that the process will be successful. There should be respect for differences among the stakeholders.

Box 2.3 : Selected guidelines for effective stakeholder engagements

Source : Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures. New York: Cambridge University Press (Lim & Spanger-Siegfried 2004)

Effective engagement also depends on how decisions are made in the adaptation process. When decisions are made in an open and transparent manner, it may lead to a broader acceptance of any outcome and strengthen the governance of the process (Powley et al., 2004). Indeed, all stakeholders should listen to the views and opinions of their counterparts to ensure that their ideas are taken into account before decisions are made as this enhances trust, mutual understanding and consolidates the democratic nature of the adaptation process.

2.7.5 Benefits of stakeholder engagements

The participation of stakeholders in any policy process ensure broad support as this increases ownership and buy-in which will likely result in a successful outcome (United Nations 2006). Participatory processes usually bring together people with different background, knowledge and skills to share their views and perspective about a particular problem. It provides a platform for “mutual learning” where individuals learn from each other in order to enhance their knowledge and understanding about the issue which was under deliberation (Greenwood, Whyte & Harkavy 1993; Mathur, Price & Austin 2008; Wallerstein 1999). There are many benefits (see Box 2.4) that result if stakeholders from a broad range of sectors are involved in developing and implementing policies (Gardner et al., 2009; Patela, Kokb & Rothman 2007).

• Participatory processes are likely to be sustainable since they build on local knowledge and capacity. Since participants made an input throughout the process, it increases ownership of the process for which they would incorporate such processes with long term development plans.

• Community participation enables decision makers have a better understanding of those they serve and this might enable them to work more effectively to deliver results. Engagement of stakeholders is also an opportunity because it promotes learning and sharing of experience. Some stakeholders can learn how decision-making processes work and how they can influence it effectively.

• Engaging with different actors within the community can easily produce results, strengthen communities and build their adaptive capacity. Collaboration builds confidence, skills and capacity to cooperate, consciousness, awareness and critical appraisal. It empowers people more generally by enabling them to tackle other challenges, individually and collectively.

• Participation in the planning, learning about people’s priorities and preferences, and implementation of projects by stakeholders accord with people’s rights to participate in decisions that affect their lives.

Box 2.4 : Benefits of stakeholder engagement

Source: Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures. New York: Cambridge University Press (Lim & Spanger-Siegfried 2004)

2.8 Gaps in current literature and the basis for the research project

As evident from this literature review, there is an expansive body of international literature describing the adverse health outcomes associated with extreme heat and heat wave events. Studies have also estimated the potential health impacts of climate change, based on projected temperature increases and population demographics. However, there are few studies that have examined how populations may adapt to increasing heat exposure; and there has been limited research on public opinions, understandings, perceptions and capacity to adapt to this challenge. The following section highlights research gaps in this area.

Public opinion (views and attitudes) can either support or reject political, social or economic actions to reduce the societal challenges posed by climate change. There are limited published studies in the literature that have specifically investigated public opinion about increasing heat waves. Heat waves are a considerable threat in Australia and it is therefore important for studies to be conducted to understand public opinion (views and attitudes) towards heat waves in a changing climate.

Currently, there are limited studies that have examined peoples' emotional reactions and their understandings of the risks associated with heat waves. Consequently, studies are required to identify the cognitive and affective responses of the community, their understanding of the risks and consequences associated with heat waves. Such studies could be important to inform policy and practice in relation to heat waves. There is little information in the literature on peoples' risk perception (perceived threat) to heat waves, although there is evidence that understanding how people perceive the risks associated with environmental risks may inform the development of risk communication strategies (Morgan et al., 2002). Consequently, new approaches and methodologies should be developed to study public risk perception to heat waves.

The field of health promotion has not contributed as significantly as it might to the understanding of perceptions and behaviours related to environmental health hazards such as heat waves. As a result, studies are required to examine the cognitive factors that influence perception and the usefulness of health promotion theories in shaping behaviour change related to heat waves. In the context of health adaptation to climate change, there is a paucity of studies in the literature on participatory approaches in the development of adaptation strategies e.g., heat wave early warning systems and response plans. As a result, research is needed to shed light on participatory approaches in the development of a health adaptation strategy using a heat wave policy process as a case study; which explores issues including the governance, the norms and the institutional framework during such policy-making processes.

The knowledge gaps summarised here represent important areas for future adaptation research. Addressing these gaps will provide a better understanding of the range of public opinions and perceptions and how to engage different sectors of the public in heat adaptation. The research described in this thesis aims to address these research gaps.

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CHAPTER 3

PUBLIC VIEWS ABOUT HEAT WAVES IN RELATION TO CLIMATE CHANGE IN ADELAIDE, AUSTRALIA

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ABSTRACT

Introduction: Global climate change is projected to increase the frequency of heat waves in the future and unprecedented heat waves are already being recorded in many parts of the world. The purpose of this study was to explore the current views of heat waves in relation to climate change in Adelaide, Australia, where a series of heat waves have been experienced in recent years. Furthermore the study was designed to identify the measures and actions that the public undertakes to stay safe during a heat wave.

Methods: Semi-structured interviews were conducted among a convenience sample of 14 residents of Adelaide between December 2011 and January 2012 (during summer in the city). Informed consent was obtained and interviews were recorded, transcribed and analysed according to themes.

Results: Most of the participants did not associate recent increases in heat waves with climate change, although a few acknowledged that there have been observable changes in weather pattern in recent years. Among those who did not believe heat waves were associated with climate change, other factors including ozone layer depletion, air pollution, the geographic location and urbanisation were mentioned as being responsible for heat waves in Adelaide. While some participants agreed with climate projections that heat waves are likely to increase in the future, others disagreed, maintaining that there was a lot of uncertainty for scientists to accurately predict what would happen in the future. Participants mentioned undertaking actions such as drinking lots of fluid, staying in an air-conditioned environment, and modifying their daily routine as means of adaptation during a heat wave.

Conclusions: The study confirms that popular views about heat waves in the context of climate change can differ widely from scientific knowledge. Views about heat waves are influenced by personal judgement and experience rather than information about climate change. When the public has experienced heat waves over decades, they may be less likely to attribute severe heat events to climate change, preferring to view these events as typical for that location. Through their experience with extreme heat over time, participants had adopted a range of appropriate behaviours to cope. However, these strategies may be tested if heat waves become more severe in terms of temperature and duration.

Key words: climate change, global warming, heat waves, public views adaptation, Adelaide

3.1 Introduction

Global climate change poses a significant threat to human health and well-being (Confalonieri et al., 2007) and increased media coverage over recent years has increased public awareness of climate change and its impacts (Leiserowitz, Smith & Marlon 2010). At the same time, there has been controversy surrounding global climate change. For example, while an overwhelming majority of scientists agree that global warming is happening and attributed to human activity (IPCC 2007), a few scientists are not yet convinced (NIPCC 2009). Contributing to this controversy have been conflicting reports regarding the extent of warming. For example, some authors maintain that temperature increase has stalled over the last ten years (Kelly 2010) while others argue that there is substantial evidence that the world has been warming faster than predicted (Hansen, Sato & Ruedy 2012). Such scientific controversy adds to the political debate about climate change, providing a basis for opposing political views in relation to climate change policies. The media is an important player in transmitting scientific knowledge to the public (Boykoff 2010), but when such controversies emerge, the media tends to focus on the controversy and does not always present the facts accurately (Carvalho 2007; Corbett & Durfee 2004; Flynn, Slovic & Kunreuther 2001). The public then finds itself in a difficult situation not knowing whether to believe the information provided by different sources. This results in a lack of trust and a wide spread public misunderstanding about climate change and its impacts (Bord, O'Connor & Fisher 2000; Bostrum et al., 1994).

The lack of public understanding and scepticism about scientific and environmental issues has been described as the “deficit model” (Miller 2001), where the assumption is that the public is deficient in knowledge while the scientific community is sufficient (Gross 1994; Kempton 1991). As a result, differences have been reported to exist between “expert knowledge” and “lay knowledge” about scientific matters underlying climate change (Brechin 2003). However, the manner in which the public understands scientific concepts has also been shown to be mediated by societal values, personal experience, psychological and other contextual factors (Sturgis & Allum 2004; Weber & Stern 2011). Many studies have explored the public’s understanding of climate change (Akerlof et al., 2010; Bord, O'Connor & Fisher 2000; Bulkeley 2000; Krosnick, Holbrook & Visser 2000; Leiserowitz 2005). Most of these have found that the way the public understands climate change is important in shaping their responses, including their support for adaptation strategies and their willingness to modify their behaviour (Lorenzoni & Pidgeon 2006).

One of the direct threats to human health associated with climate change is the increased frequency and severity of heat waves (Dessai 2003; Hayhoe et al., 2010; Health Canada 2008; Meehl & Tebaldi 2004). Unprecedented heat waves have been recorded around the world in recent years. In the city of Adelaide, Australia, heat waves are quite common during the months of summer and a series of severe heat waves have been experienced in recent years. The most severe heat waves were recorded in 2008, 2009 and 2010 (Australian Government:Bureau of Meteorology 2010; Nitschke et al., 2011). The early 2009 heat wave was quite intense as there were six consecutive days with temperatures over 40^{o}C (Nitschke et al., 2011). In the 2010 heat wave, Adelaide recorded an unbroken run of five consecutive days in excess of 35 °C with four of these days exceeding 40 °C (Australian Government:Bureau of Meteorology 2010). Monthly average temperatures for Adelaide during summer and early autumn (December to March) range from 27.0°C to 29.4°C (Australian Government: Bureau of Meteorology 2012). Since Adelaide has had a long history of heat waves, with more severe events in recent years, it represents an ideal setting to explore public representations of heat waves in the context of climate change.

The aim of this study was to explore popular views, opinions and perspectives about heat waves in relation to climate change, and to describe the measure and actions that individuals usually undertake during a heat wave. Understanding popular beliefs and behaviours is an important foundation from which information and effective communication about heat waves can be developed. It may also inform policy makers in terms of risk communication and community engagement.

3.2 Methods

3.2.1 Study participants and recruitment

The study used a qualitative methodology, providing flexibility to explore ideas and to uncover new concepts. Ethics approval was obtained from The University of Adelaide Human Research Ethics Committee (No. H-061-2011) and The Queen Elizabeth Hospital Human Research Committee (No. 2011136). The detail approach used to recruit participants has been explained elsewhere (Akompab et al., 2013). Briefly, a convenience sample of participants was recruited from the North West Adelaide Health Study (NWAHS) cohort (www.nwadelaidehealthstudy.org). This cohort is representative of the population of north and western region of Adelaide and individuals have consented to being contacted for health research purposes. The chief investigators responsible for this cohort supported the conduct of this research study and with their permission individuals in the cohort were invited to take part in the study. A staff member of the NWAHS contacted a number of individuals in this cohort via telephone asking them if they would be willing to take part in a qualitative study (interview) about heat waves. We then selected a convenience sample of 24 individuals to take part in the study. Those selected were contacted by the same NWAHS to obtain permission for their telephone numbers to be passed on to the researchers since the NWAHS CIs advised that interviews would be more appropriate and cost-effective if conducted by telephone.

3.2.2 Timing and data collection

Data collection took place through semi-structured telephone interviews late December 2011 and January 2012 with the aid of a pre-tested interview guide. The timing of the interviews coincided with hot weather, for example, the first three days of 2012 recorded temperatures of 41.6 ^{o}C, 40.6 ^{o}C, 35.9 ^{o}C respectively (Australian Government:Bureau of Meteorology 2012) which was preceded by temperatures on New Year Eve (31st December 2011) of 38 ^{o}C. The temperature on January 1st 2012 was the hottest New Year Day on record for over 100 years (Weather Zone 2012). The interviews were open-ended in order to gather the participants' views about heat waves in relation to global climate change. Since interviews were semi-structured, questions were not necessarily posed in the same order as they appeared on the interview guide, rather the sequence changed based on how the interview progressed (Cooper et al., 2005).

After conducting 14 interviews it was apparent that there was considerable overlap in the data collected and it was decided that a point of data saturation had been reached (Auerbach & Silverstein 2003), and that further interviews were unlikely to yield new ideas or views. The similarity in responses across the set of interviews was not unexpected because of the common experiences of heat waves in one location. Hence, the remaining ten participants were not interviewed. Interviews lasted on average 30 minutes and were audio-digitally recorded with notes also taken throughout. At the end of each interview, basic socio-demographic characteristics were collected from the participants (see Table 3.1). A gift card of $20 was posted to each participant as a token of appreciation for their contribution to the study. Immediately after each interview, the notes were developed and cross-referenced with the audio-recordings. All interviews were transcribed verbatim, de-identified and codes used to identify participants.

3.2.3 Data analysis

The transcripts were read line-by-line, simultaneously listening to their respective audio recordings to examine their accuracy and integrity. The process was repeated several times to establish familiarity with the data (Braun & Clarke 2006). The data were imported into Nvivo 9 (QSR International, Melbourne, Australia) to facilitate coding. Data were analysed deductively through thematic analysis (Braun & Clarke 2006), guided by the interview questions. However, new categories were created as new ideas and concepts emerged from the data. Coding was done by the first author through reading each transcript and identifying text with relevant concepts, ideas and categories which were then coded into "Free Nodes" in Nvivo 9. Analytical memos were developed during the process and incorporated in the analysis. Certain relevant texts were assigned to more than one category. A second round of coding was conducted a week later to check the accuracy of the coding process. Later, all the categories were reviewed and similar categories were grouped into themes by creating "Tree nodes". The third author later reviewed carefully each theme to check for accuracy and any discrepancy was resolved.

Table 3.1: Socio-demographic characteristics of study participants

Characteristics	Number
Age group	
31-49	3
50-69	6
70+	5
Gender	
Male	8
Female	6
Education level	
Tertiary degree	2
High School diploma	6
Other training	6
Marital Status	
Never Married	2
Married	12

3.3 Results

Four broad themes were identified from the analysis, with three guided by the interview questions while one emerged naturally from the data. These themes included: (1) understanding the science related to heat waves, (2) the uncertainty about scientific projections for heat waves, (3) observable changes in weather pattern and heat waves, (4) adaptation to heat waves. Each of these broad themes is discussed below and supported by relevant quotes. In the quotes, the ellipsis points (. . .) indicate materials that were deleted.

3.3.1 Theme I: Understanding the science related to heat waves

Participants were asked**:** "*Can you please tell me what you know about heat waves?"* This question was intended to get the participants' general understanding of heat waves and to determine if their responses would relate heat waves to climate change. However, most participants responded by defining a heat wave, suggesting that they commonly interpreted this question as: "What is a heat wave?" Although there were variations in the definition provided by participants, most of them described a heat wave to be characterised by a consecutive number of days with temperatures above a certain value as illustrated in the following quotes:

> *" Okay, I believe a heat wave is a period of over 30 or 35 degrees of five days in a row is considered a heat wave. And we had the longest heat wave last year or the year before; like thirteen days or something like that."(P-1)*

> *" (...) the official definition I think is five days over 35 degrees or three or four days over 40 degrees. I think that is what the government says." (P-12)*

> *"I believe heat waves are something like eight days or so of consecutive hot weather. I believe over a certain temperature. I think it might be like 30 or 35 degrees. I think that is classified as a heat wave."(P-2)*

> *" I think they say over three days and over 40 degrees or something like that is a heat wave. So,... then it can go three to five days or as long as it wants; that is what I think is a heat wave. You can have really, really hot days but that is not a heat wave. A heat wave is a combination of a lot of days." (P-6).*

One participant considered a heat wave as a drastic or sudden change in the daily temperatures, as illustrated in the following quote:

> *"Well a heat wave is going to be where the temperature goes up rapidly. Say if we are having 20 degrees today and then we have 40 degrees tomorrow. So it is a real change in temperature and that affects everyone in one way or another." (P-9)*

Participants were later asked "*What do you think has been responsible for the increase in heat waves observed in Adelaide over recent years?"* A few participants stated that they did not know what has been responsible for the increase in heat waves in Adelaide, while the majority of them indicated that they really did not think anything was responsible and that heat waves are just part of what is normally expected in Adelaide every summer. For example, as these participants noted:

> *"I just think that summer temperatures...pretty much. I think they are pretty normal usually. I mean, you usually expect one at least in summer."(P-2)*
>
> *" (...) the cause of it is probably just normal weather patterns for Adelaide. We get the hot northerly winds coming across at certain times of the year and that is what I think the heat waves are."(P-6)*
>
> *"We think it is seasonal. As soon as summer comes around our expectation is that we are going to have some hot weather. Of course, we know that it is going to move from one temperature to another. But, principally it is a seasonal issue that I think of. Of course, I look at the weather map and I understand that to some extent" (P-11)*

Three of the participants mentioned that global warming was responsible for the increase in heat waves that had been observed in Adelaide in recent years. These participants stated that there has been a considerable degree of climate variability in the past couple of years and that it was plausible that the heat waves recorded in Adelaide in recent years were associated with global warming. For example, these participants noted:

> *"We have only just experienced a couple of really hot days I have no doubt at all....that heat waves is associated with global warming." (P-14)*
>
> *"Well, the climate must be changing. (...) It must be that... like now we are getting summer later. I just believe that the climate is itself changing which means maybe hotter weather, longer summers..."(P-5)*

A follow-up question was then asked among the participants who did not associate recent heat waves in Adelaide with global warming. When asked: "*How do you then respond to scientific opinion that recent heat waves in Adelaide are consistent with climate change projections?"* These participants stated that there wasn't any link or association between heat waves and global warming because heat waves have always been a normal occurrence in Adelaide. The following quotes depict responses provided by some of the participants.

> *"Oh! no, I don't actually think so. Because we have always had heat waves. And for as long as I have lived in Adelaide, for fifty-odd years we have had huge heat waves. I don't think that it is anything out of the ordinary for Adelaide to have heat waves." (P-3)*
>
> *"No, I think that is completely false. I think the cause of it is probably just normal weather patterns for Adelaide. Well, you know forty years ago or fifty years ago when I was born, we were having heat waves then. You know,...the heat waves haven't got any worse in the last fifty years that I have been alive. So, I don't think global warming has got anything to do with it. I have been here my whole life and I don't know anything different; so we expect the heat waves." (P-6)*
>
> *"(...) not really. I mean sometimes when you are in the middle of a heat wave you do think about global warming. However, I also remember when I was a kid that we used to have heat waves as well. So, I am not really associating the two with each other at this point."(P-2)*

Two participants mentioned that despite growing public discussion, human activities were not responsible for global warming. They further indicated that heat waves were occurring as a result of a natural change of the earth system because systems are dynamic and not static, as one of participant's noted:

> *"I just think it has to do with the changing of times and nothing stays the same. I just think everybody gets old, things change and that is what I believe is happening."(P-7)*

Those participants who did not associate recent heat waves with global warming were then asked; *"What then do you think could have been responsible for the recent heat waves, if they were not associated with global warming?* They mentioned that the emission of carbon-dioxide (CO_2), air pollution from the burning of coal, the geographic location of Adelaide, the revolution of the earth around the sun, the depletion of the ozone layer and rapid urbanisation were probably responsible for heat waves observed in Adelaide. For example, the following quotes illustrate:

> *"I do think that carbon dioxide is a problem... and that it is plausible that it is happening, so we should be trying to stop global warming."(P-1)*
>
> *"The position of where we are in the country."(P-3)*
>
> *"I guess the deteriorating ozone layer has a bit to do with it." (P-4)*
>
> *"(...) it is something that happens with how the earth resolves around the sun and with other planets and how that happens. I think it also has to do with an increase of population in the world. Since the 19th century, the population has increased because medicines are more effective and less people die. People are living a lot longer. So that puts stresses on what happens in the planet."(P-14)*

3.3.2 Theme II: The uncertainty about scientific projections for heat waves

Participants were asked "What do you think about scientific projections that heat waves would increase with intensity and severity in Adelaide in the future?". There were differences in views expressed by the participants with some accepting the projections, while others believed that there was too much uncertainty for scientists to accurately predict what would happen with heat waves in the future. This is illustrated in the following quotes:

> *"No, because they can't predict that at the moment." (P-6).[Interviewer:* ***Why do you think scientists can't predict that at the moment?****] "Yeah, but I don't believe in what they predict. Well, they can predict the weather next week but they are not always right. They are predicting because some scientists believe that there is global warming and some scientists believe there is no such thing.... So, I don't think we have been on earth this long enough to be able to predict anything like that."(P-6)*
>
> *"I mean – primarily they talk about global warming and what have you. Yet, this year we have had lots of cooler weather and lots of rain and that sort of thing so I think it is just a cycle that the world goes through."(P-8)*
>
> *"This is a prediction and interestingly enough, the weather bureau put out a forecast the other day that we ....How they do this modelling I don't know because in my humble opinion they don't get the next day right. So I don't know how they are going to do for the rest of the summer. But they can't definitely say – I can't see them looking ahead." (P-14)*

Those participants who agreed with scientific projections about heat waves maintained that the heat waves that have been observed in recent years had been intense and have occurred for a longer duration, and therefore such an observable trend could support what scientists have predicted. For example, these participants cited:

> *"Well, I think that is going to happen because you need to just look at over the last five years. The number of heat waves has increased." (P-9)*
>
> *"It is probably true. The thing is we are getting more heat waves over the years. So I probably think the statement is true."(P-13)*
>
> *"I guess it is.... Just over the years you notice the heat waves are getting longer and it is the dramatic change in the weather really. You sort of get a really long heat wave." (P-14)*

A follow-up question was posed to one of the participants who concurred with scientific projections that heat waves would increase in future. When asked: "*What makes you believe in what scientists have projected?"* The respondent indicated that one of the reasons to believe in these scientific projections was because they were made by individuals who were well trained and had the scientific knowledge and skills. This participant had a deep trust in the work of scientists and firmly believed in scientific research, as illustrated in the following quote:

> *"Well, because I believe that people that do the research or people that hold those positions that deal with climate should know what they are talking about. Otherwise why would we believe them? I believe that is their job to do the research, to have the knowledge so that what they pass on is accurate. Obviously, they are more trained than say I am, in knowing about the climate because that is their job. So that explains why I would believe them because I believe that they wouldn't say the things if they haven't looked into it and researched it and made the information available without knowing what they are talking about".(P-5)*

3.3.3 Theme III: Changes in weather conditions and the pattern of heat waves

A major theme that emerged from participants' narratives was that there have been changes in weather conditions and the pattern of heat waves in Adelaide over recent years as summers are coming later than usual nowadays. For example, as cited by these participants:

> *"Well, when you go back, there is a lot of difference. The weather pattern has changed." (P-14)*
>
> *"It must be that...like now we are getting summer later. I just believe that the climate is itself changing; which means hotter weather, longer summers, longer winters." (P-5)*
>
> *"I think the summers now are lot later in the year.... When I was a child, it would get hot in November and it would just be hot, no cold bits. But now, we seem to be having cold bits...."(P-9)*
>
> *"I believe that the climate is varying a lot. Whether it is pollution doing it, opening of the hole and things are changing, I don't know."(P-10)*

Some participants also reported that the pattern of heat waves has also changed in recent times. While some participants indicated that the recent heat has been dry, others indicated the humidity associated with the heat waves of recent years have been as compared to those which occurred in the past. For example, these participants cited:

> *"I definitely think the temperature has changed from when I was a child. So I am fifty. So from when I was ten years old. So over forty years it has definitely changed."(P-9)*

> *" But now, the whole thing has changed. It is a different sort of heat. I don't miss that humidity heat. This is a very dry heat we have." (P-14)*

> *" Well, I think the heat waves from when I was a young boy are changing. It is a clearer heat. But down now the heat is getting hot and you are sweating. It is a different heat."(P-10)*

3.3.4 Theme IV: Behavioural adaptation

Participants were asked "*What do you normally do to protect yourself when there is a heat wave in Adelaide?".* Participants provided similar responses and all mentioned the need to take precautionary measures against heat-related morbidity or mortality during a heat wave. Most of the preventive actions mentioned were consistent with those that are generally recommended to the public during heat waves and examples of the actions which participants undertake during a heat wave are presented in Table 3.2. Some participants mentioned relocating to a nearby region outside Adelaide which is considered cooler. The participant noted that some individuals (especially retirees) have sold their property to permanently migrate to the cooler regions, as illustrated in the following quote:

> *"Oh!, everybody wants to keep cool don't they. I must admit, I go to Victor Harbor[1] because Victor Harbor is cooler and I even believe that as I'm aging, I will probably move there because of the climate. I have lived in communities where people in the street have sold their houses and gone to Victor Harbor because it is cooler."(P-5)*

[1] Victor Harbor is a coastal region about 70 kilometres from the city of Adelaide, in South Australia which has cooler weather.

Table 3.2: Adaptation to heat waves: selected quotes from participants' responses

Key adaptation areas	Quotes and participant ID
Stay indoors	*"I just don't want to go outside. It is too stinking hot and I just can't put up with it. As I said, I don't have to put up with it but, the point is I have got to stay inside because of the situation outside."(P-14)* *"And I try and stay indoors as much as possible." (P-2)*
Keep hydrated	*"I drink lots of water." (P-1)* *"I drink plenty. I do heed the warnings about being hydrated." (P-12)*
Keeping cool	*"I go to ...a really well air-conditioned place." (P-12)* *"I work full time so I can sit in an air-conditioned car at work or sit in an air-conditioned office at work."(P-6)* *"... and I guess use the air-conditioner." (P-4)*
Adapting while outdoors	*"Of course, when we are out we dress appropriately; hats and that sort of thing. Well, we have light dressing but we cover ourselves up fairly well." (P-11)* *"Yeah, if I go out in the sun, I will make sure I am wearing sunscreen and a hat" (P-2)* *"In the heat we cover up more and always wear hats." (P-6)*
Cooling down	*"I run a bath and I will sit in it." (P-14)* *"Keeping cool through showering more." (P-14)* *"I go to the beach." (P-2)* *"Fortunately we got a swimming pool at our house so I will cool off there on the real hot days." (P-2)*
Reduce physical activity	*"We always try to take it easy obviously in the heat waves, not to work too hard, play sport or do anything in the heat waves."(P-6)*
Shutting curtains	*"I have blinds inside and heavy curtains. So on a hot day I will close everything...to stop the sun from getting in." (P-7)*
Rely on weather forecast and modify daily activities	*"You have got to depend on the forecast of what is coming so you can plan yourself. This will enable you to plan your days or plan when you are going or...."(P-14)* *"Yes, if I got things to do, I do them either early in the morning or later." (P-3)* *"I do outdoor activities, like early in the morning or in to the evening when the sun is not as powerful, I suppose; not as strong."(P-8)* *"I find that my lifestyle has changed to the point where I now get up early in the morning to water the garden, sweep the leaves and do all the little necessaries around. At about 10 o'clock in the day I then have to come inside and I call it, I hibernate."(P-14)*

3.4 Discussion

This paper describes the public representations of heat waves in relation to global climate change in Adelaide, South Australia. Most participants described a long experience with heat waves and considered them to be normal part of the climate in Adelaide, often relating to their experiences from childhood. As a result, some participants did not consider that the extreme heat waves experienced in Adelaide in recent years were associated with climate change. However, a few expressed the view that heat waves had been more common in recent years and believed that climate change could provide an explanation for this observation.

Similar findings have been reported from a study among the elderly in Sydney, Australia where participants dismissed the notion that recent extreme heat events were linked to climate change (Banwell et al., 2012).

Some participants mentioned observable changes in weather pattern over the past couple of years in Adelaide. Interestingly, these participants had lived in Adelaide for a long period of time and as a result they might have observed these changes based on their personal experiences. Similar findings about changes in observable weather patterns have previously been reported by the lay public in the United States (Kempton 1991). The above findings are consistent with those of a study conducted in Bangladesh as most participants indicated that they had observed/experienced climate variability with an increase in the summer heat in the previous years (Haque et al., 2012). Research conducted in the UK explored public views about drought in relation to climate change. The findings show that most participants had noticed changes in the pattern of the seasons with milder winters and an increase in water shortages. However, participants' awareness of water shortages or their understanding of the impacts of climate change didn't influence their willingness to modify their behaviour (Dessai & Sims 2010). Our participants suggested a range of factors that could be associated with the occurrence of heat waves, which indicates that individuals may draw on their broad knowledge about the natural world to explain observed climate characteristics.

While some participants did not accept the phenomenon that recent heat waves were consistent with climate projections, they identified closely related factors such as carbon-dioxide (CO_2) emissions and the burning of coal as possible reasons for recent extreme heat events. Generally, lay people usually form their views, beliefs and understanding about a phenomenon through their every day experience and information they receive from various sources. Past research have shown that the manner in which lay people conceptualise climate change is differently from scientific understanding. For example, Bostrum (1994) found how the lay public conflated climate change with ozone depletion and how they failed to distinguish what causes climate change from environmental pollutants (Bostrum et al., 1994). This study found that one participant mentioned air pollution as a probable "cause" of heat wave. Previous studies conducted reported that most participants indicated air pollution as the probable cause of climate change (Brechin 2003; Poortinga, Pidgeon & Lorenzoni 2005). These findings indicate that there is some misunderstanding among the public about concepts such as greenhouse gases, global warming, heat waves and climate change; which necessitates further public education.

In relation to climate projections for increased heat waves, there was a common view that predicting the weather and climate was too uncertain to be reliable. For a number of participants, the perceived unreliability of weather forecast for the immediate future was a basis for their scepticism about climate projections. In fact, although climate projections have been made, there are fundamental challenges in estimating future weather and climate, exacerbated by the difficulties associated with rare events such as heat waves (Easterling et al., 2000; Meehl et al., 2007; Orlowsky & Seneviratne 2012). This finding may suggest that the distinctions between weather forecasting and climate projections are not clear among the general public.

Our participants described the actions they undertook to cope with heat waves, and these behaviours were largely consistent with the heat-health advice provided by health authorities including using air-conditioning, cooling off with water, modifying daily activities and staying hydrated. Similar findings have been reported in other studies were participants used some of these coping methods and behaviour change strategies to cope during periods of extreme heat (Abrahamson et al., 2009; Banwell et al., 2012; Bittner & Stößel 2012). The depth of knowledge in these responses suggest that recent heat-health advice has been effective or alternatively, that our participants had pre-existing awareness and common sense knowledge of appropriate behaviours because of their past experiences with extreme heat.

One of the more extreme actions described was relocation to a cooler region as a means of adapting to heat waves. This may be referred to as “adaptation through migration”, a phenomenon (associated with extreme temperatures) with a long history around the world. It is foreseeable that people may migrate from mainland Australia to Tasmania which is cooler to escape the heat during summer and vice versa, with either short-term or permanent migration. On the other hand, people in Europe have long migrated (through vacations) to warmer parts of the world (e.g., Africa, Australia) during winter to escape the cold and some return home when it gets warmer and vice versa.

We acknowledge that this study has a number of limitations. Firstly, we do not claim that results described here are representative of the wider population of Adelaide. Secondly, the fact that the phrases “global warming” and “climate change” were used interchangeably could have caused some misunderstanding among participants, although we were not aware of any of this issue during the interviews. Thirdly, the sample size may be considered a limitation; however, interviews were conducted until the point of data saturation. This study examined public views at a particular point in time and it is likely that these will evolve in response to changing representations of climate change in the media and political discourse, and in relation to personal experiences with extreme weather events such as heat waves. Therefore, it will be important for future work to re-examine public views at points in time, to gain an understanding of how views may be changing.

3.5 Conclusions

The findings indicate that there is general awareness among the public about heat waves and global climate change. Although participants described observations that there has been considerable change in the weather pattern in recent years, most considered recent heat waves to be a natural phenomenon which is usually expected every summer. The study findings indicate that people regard heat waves as a threat and undertake preventive measures to stay safe during periods of heat waves in Adelaide. The challenge will be to ensure that all sectors of the community are empowered to adopt these behaviours and to develop further strategies to safeguard health from the threats of future heat waves.

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3.7 Conflicts of Interest

The authors declare that they have no conflicts of interest

3.8 References

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CHAPTER 4

CLIMATE CHANGE, COMMUNITY UNDERSTANDING AND EMOTIONAL RESPONSES TO THE IMPACTS OF HEAT WAVES IN ADELAIDE, AUSTRALIA

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Author Contributions

By signing the Statement of Authorship, each author certifies that their stated contribution to the publication is accurate and that permission is granted for the publication to be included in the candidate's thesis.

Name of Principal Author (**PhD Candidate**)	Akompab Derick Akoku		
Contribution to the Paper	Conceived the study and designed the research protocol, gained ethics approval, developed data collection tool, collected data, analysed data and interpreted the findings. Conceptualise the manuscript structure, wrote manuscript and acted as corresponding author prior to publication. Revised the manuscripts based on reviewers comments and re-submitted for publica		
Signature		**Date**	02/09/2013

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Contribution to the Paper	Supervised the development of the work, helped in data interpretation and manuscript evaluation.		
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Contribution to the Paper	Contributed to the research protocol design, supervised data collection, assistance with data interpretation, read manuscript and provided feedback.		
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Contribution to the Paper	Provided guidance during data collection, assisted in data interpretation, read drafts of the manuscript and provided feedback.
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Contribution to the Paper	Contributed in data interpretation and manuscript evaluation.
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CHAPTER 5

AWARENESS OF AND ATTITUDES TOWARDS HEAT WAVES WITHIN THE CONTEXT OF CLIMATE CHANGE AMONG A COHORT OF RESIDENTS IN ADELAIDE, AUSTRALIA

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Author Contributions

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Name of Principal Author **(PhD Candidate)**	Akompab Derick Akoku		
Contribution to the Paper	Developed research protocol, gained ethics approval, developed questionnaire, lead data collection, analysis and interpretation. Conceived and conceptualise the manuscript, orientation and structure, wrote manuscript, identified suitable journal for submission and acted as corresponding author during the peer review stage, made corrections based on reviewer comments and re-submitted the manuscript for publication.		
Signature		**Date**	02/09/2013

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Contribution to the Paper	Supervised the development of the work, provided statistical guidance and manuscript evaluation.		
Signature		**Date**	4-9-13

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Contribution to the Paper	Contributed to the research protocol design, supervised data collection, assistance with data interpretation, read manuscript and provided feedback.		
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Contribution to the Paper	Facilitated ethics approval, assisted in recruitment of participants, read drafts of the paper and provided feedback.
Signature	**Date** 5/9/13

Name of Co-author	Iain A. Walker
Contribution to the Paper	Reviewed drafts of ~~the~~ manuscript and provided feedback.
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Name of Co-author	Martha Augoustinos
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Article

Awareness of and Attitudes towards Heat Waves within the Context of Climate Change among a Cohort of Residents in Adelaide, Australia

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Abstract: Heat waves are a public health concern in Australia and unprecedented heat waves have been recorded in Adelaide over recent years. The aim of this study was to examine the perception and attitudes towards heat waves in the context of climate change among a group of residents in Adelaide, an Australian city with a temperate climate. A cross-sectional study was conducted in the summer of 2012 among a sample of 267 residents. The results of the survey found that television (89.9%), radio (71.2%), newspapers (45.3%) were the main sources from which respondents received information about heat waves. The majority of the respondents (73.0%) followed news about heat waves very or somewhat closely. About 26.6% of the respondents were extremely or very concerned about the effects of heat waves on them personally. The main issues that were of personal concern for respondents during a heat wave were their personal comfort (60.7%), their garden (48.7%), and sleeping well (47.6%). Overall, respondents were more concerned about the impacts of heat waves to the society than on themselves. There was a significant association between gender (χ^2 = 21.2, df = 3, p = 0.000), gross annual household income (p = 0.03) and concern for the societal effects of heat waves. Less than half (43.2%) of the respondents believed that heat waves will extremely or very likely increase in Adelaide according to climate projections. Nearly half (49.3%) believed that the effects of heat waves were already being felt in Adelaide. These findings may inform the reframing and communication strategies for heat waves in Adelaide in the context of climate change.

Key words: climate change; heat waves; human health; attitudes; survey; Australia

1. Introduction

Climate change has been the subject of much discussion over the past decades and it poses a great challenge to human health and societal well-being [1,2]. There is a growing body of scientific research suggesting that extreme weather events (e.g., heat waves) will become more frequent as a result of climate change [3,4]. For example, in the United States about fourteen record-breaking weather and climate-related disasters which caused economic losses and loss of human life were reported in 2011. Heat waves were among these weather-related disasters and in March 2011, about 15,292 warm temperature records were broken across the United States [5]. Heat waves are a major public health concern in many temperate regions and episodes recorded around the world have shed further light on the health, social, environmental and economic consequences associated with heat waves [6–8].

Across Australia, a number of cities, including Adelaide, usually experience heat waves during the months of summer. The most recent and significant heat wave was recorded between late January and early February 2009 which affected most parts of south-eastern Australia [9], and is still fresh in the minds of many. The early 2009 heat wave (the South Australian Bureau of Meteorology—BoM—defines a heat wave as a period of maximum temperatures of 35 °C or over for a period of five or more consecutive days or three or more consecutive days of temperatures of 40 °C or above) resulted in an estimated 500 heat-related deaths in South Australia and Victoria in addition to the social, economic and environmental consequences [10,11]. Apart from the unprecedented early 2009 heat wave, Adelaide experienced other major heat waves in 2008 and 2010. The 2008 and 2009 heat waves were unique in terms of their duration (15 days and 13 days respectively), and the 2009 heat wave was also remarkable in its intensity as there were six consecutive days with temperatures over 40 °C and one day with a maximum temperature of 45.7 °C [12,13]. In the 2010 heat wave, Adelaide recorded five consecutive days in excess of 35 °C with four of these days exceeding 40 °C [14]. Monthly maximum temperatures for Adelaide during summer and early autumn (December to March) normally range from 27.0 °C–29.4 °C [13]. Climate models project that heat waves will increase in frequency and severity in Adelaide as a consequence of climate change [15].

Authorities in Adelaide and in other regions of the world are aware of the risks posed by heat waves. Epidemiological studies have shown that certain groups within the population are more vulnerable to heat waves because of a number of underlying physiological and contextual factors [16–18].

Climate-related impacts also cause emotional and psychological distress to many people, especially to those who are vulnerable [19,20]. By the same token, studies have reported that people are concerned about the impacts of climate change [21]. However, studies also show that individuals distinguish between the effects of climate change on their personal lives and on society. While some people have expressed more concerned for personal issues such as their health, finance, personal comforts and safety [22,23], others may be more concerned about societal impacts of climate change with the belief that the risks associated with these impacts are greater for people who are spatially or temporally distant [24]. It is also important to bear in mind that the link between heat waves and global climate change has been the subject of discussion among the public since the science of climate change is complex and still contested [25]. Furthermore, people's attitudes and beliefs about climate-related risks such as heat wave may be shaped by their pre-existing knowledge and information they receive from many sources and their every day interaction within the society [26].

There has been growing interest in understanding public views about environmental issues. For example, a number of studies have examined public perception and attitudes towards climate change [27–30] and most of these studies have found that public attitudes towards climate change have varied over the years. Other studies have examined perceptions about heat waves [31–35] and most of these studies found that some participants didn't belief that they were vulnerable to heat waves. Although heat waves are common in Australia, there are limited studies that have specifically examined public attitudes towards heat waves in relation to climate change.

The aim of this study was therefore to examine public attitudes towards heat waves in the context of climate change in Adelaide. Heat waves have been common recently in Adelaide, thus making it an ideal city for such a study to be conducted. Understanding public attitudes may be important as it would inform public education and communication strategies for heat waves under a changing climate. Furthermore, having an understanding of public attitudes may be important since any success to address potential consequences associated with heat waves may depend on public views about the phenomenon. This study draws insights from previous surveys on climate change and applies these to heat waves. The findings are part of a larger research study conducted in Adelaide.

2. Methods

A questionnaire was developed after a review of the literature on heat waves and climate change. Some questions and response options were informed by previous surveys on public attitudes towards climate change [27–30]. All the questions were however adapted to the context of heat waves, with some questions having both closed and open-ended responses. The draft questionnaire was validated by experts and piloted among a selection of 20 residents in Adelaide. Major revisions were made to the draft questionnaire to facilitate ease and understanding before it was finalised.

The study population from which the sample was drawn was the North West Adelaide Health Study cohort, a representative group of adults residing in the north and western region of Adelaide. This is a pre-existing group of individuals who have been participating in health research [36]. Ethics approval was obtained from The University of Adelaide Human Research Ethics Committee (No. H-061-2011) and The Queen Elizabeth Hospital Human Research Ethics Committee (No. 2011136); since the latter oversees any research study related to the cohort.

With support of the chief investigators of this cohort, and as part of a follow-up survey, study participants were asked if they would be willing to be contacted at a later date to take part in a questionnaire study on heat waves. Of the 1,185 approached, 818 expressed interest to participate in the heat waves study. Among those who expressed interest, 490 participants were selected. The selection criteria used was being aged between 30–69 years and having the literacy skills needed to self-complete a questionnaire. Questionnaires were mailed out to selected participants in late January 2012, together with the study information sheet and participants were requested to return their completed questionnaire using a supplied replied-paid envelope.

The questionnaires were mailed during the summer, following weeks of hot weather in Adelaide where temperatures were above 30 °C [37] which ensured that the hot weather was salient to respondents at the time. Completing the questionnaire was construed as providing consent to take part in the study. Of the 490 questionnaires which were mailed out, 272 were returned giving a response rate of 55.5%. No follow-up or reminder calls were made to the respondents. Due to missing data, five questionnaires were eliminated leaving 267 for final analysis.

Data were entered into an Access database and "imported" into Stata version 12 (Stata Corp, College Station, TX, USA) for analysis where descriptive and bivariate analysis was performed. In bivariate analysis, Chi square or Fisher's exact tests (expected cell frequencies less than or equal to five) were used to test for the inter-relationships among variables with a p-value < 0.05 considered to be statistically significant. No statistical weighting of the data was performed. Some categorical demographic variables (e.g., marital status, level of education, employment status) were dichotomized because of sample size constraints.

3. Results

3.1. Respondents' Demographic Characteristics

Table 1 shows selected demographic characteristics of respondents. The mean age of the respondents was 51 years, with a majority of them (61.4%) in the age group 50–69 years. More than half of the respondents (55.8%) were female. A majority of the respondents (89.1%) were married. In terms of level of education, more than half of the respondents (61.4%) did some training after high school or further education (bachelor or postgraduate degree).

Table 1. Selected demographic characteristics of respondents.

Variable	Number	Percent (%)
Age group (years) (n = 267)		
30–49	103	38.6
50–69 (Mean = 51 years)	164	61.4
Gender(n = 267)		
Male	118	44.2
Female	149	55.8
Marital status (n = 267)		
Never married	29	10.9
Married [1]	238	89.1

Table 1. *Cont.*

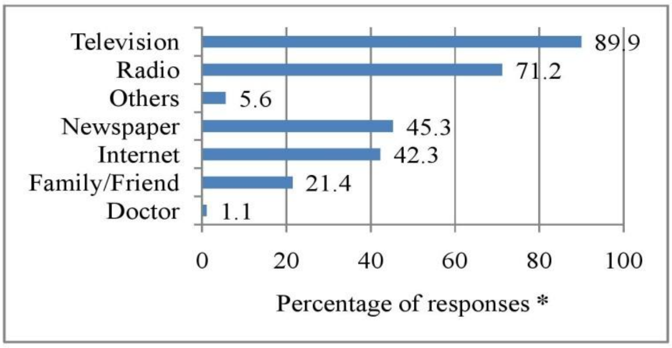
Variable	Number	Percent (%)
Level of Education (n = 267)		
Educated at or below high school level	103	38.6
Educated above high school level [2]	164	61.4
Employment Status (n = 267)		
Not employed [3]	43	16.1
Employed	224	83.9
Gross annual household income (n = 254)		
Less than $40,000	58	22.8
Between $40,000 and $59,999	53	20.9
$60,000 or more	143	56.3

[1] Married (individuals married at some point in life and include currently married, separated and widowed); [2] Referred to those who did additional training after high school (e.g., TAFE courses, bachelor or postgraduate degree); [3] Not employed referred to unemployed, retired and home duties.

3.2. Awareness about Heat Waves

Respondents were asked where they usually get information about heat waves. Television was the most commonly cited source of information (89.9%), followed by the radio (71.2%), newspapers (45.3%), the internet (42.3%). The other sources (5.6%) from which respondents indicated they obtained news about heat waves included: the Australian Bureau of Meteorology, mobile phone web applications, newsletters, leaflets and brochures. Further details are illustrated in Figure 1.

Figure 1. Sources of information about heat waves. Q1: Where do you normally get information about heat waves? (multiple responses).



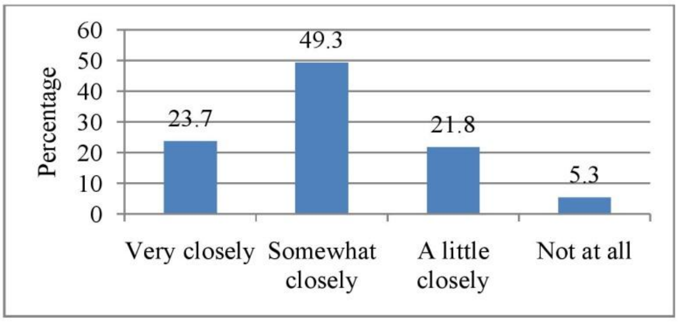
* Percentage total may add up to more than 100% as multiple responses were permissible.

3.3. Degree to Which Information about Heat Waves is Followed

Respondents were asked how closely they followed information from these sources during a heat wave. Nearly half (49.3%) indicated that they followed information "Somewhat closely", 23.7% followed information "Very closely", 21.8% followed information "A little closely" and 5.3%

indicated that they do not follow information about heat waves at all (see Figure 2). There was a marginally significant association between gender and the closeness to which respondents followed news about heat waves (p = 0.05), with women (62.0%) more likely to follow "Very closely" news about heat waves than men.

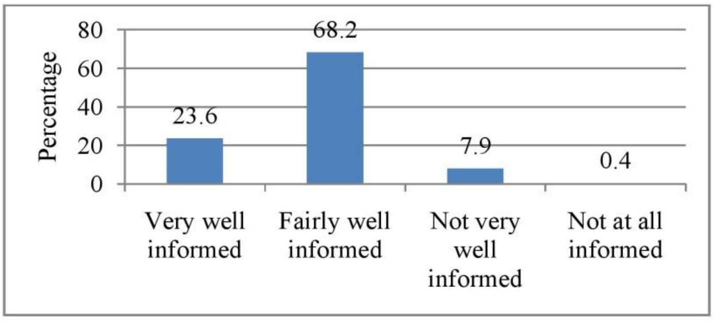
Figure 2. Degree to which respondents follow news about heat waves. Q2. How closely do you follow news about heat waves from these sources?



3.4. Level of Information about Heat Waves

Since most of the respondents indicated getting information from at least one of the above information sources, they were asked about how well informed they were about heat waves. More than half (68.2%) cited being "Fairly well informed"; followed by those who were "Very well informed" (23.6%). The rest of the respondents were either "Not very well informed" (7.9%) or "Not at all informed" (0.4%), as illustrated in Figure 3. There was a statistically significant association between the closeness to which news about heat waves was followed and the level of information about heat waves (p = 0.000). Those who were "Fairly well informed" about heat waves (57.1%) were more likely to follow "Very closely" news about heat waves.

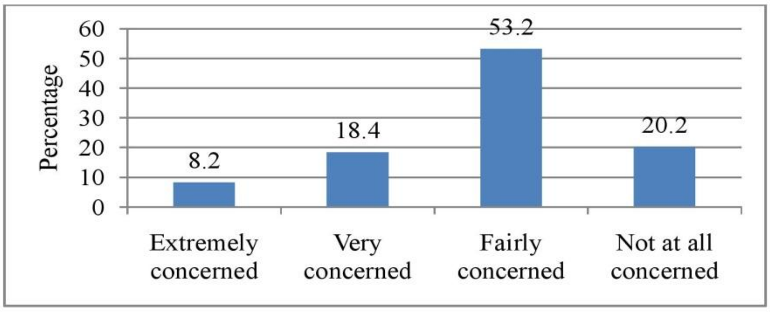
Figure 3. Extent to which respondents feel informed about heat waves and its consequences. Q3. How well informed do you think you are about heat waves and its consequences?



3.5. Personal Concern about the Effects of Heat Waves

Respondents were then asked how they were personally concerned about the effects of heat waves. A majority of them (53.2%) cited being "Fairly concerned", followed by those who were "Not at all concerned" (20.2%). While 18.4% of the respondents were "Very concerned", only 8.2% were "Extremely concerned" about the effects of heat waves on them personally (see Figure 4). There was no statistically significant association between the socio-demographic variables and personal concern for heat waves.

Figure 4. Extent to which respondents are personally concerned about the effects of heat waves. Q4. How concerned are you about the effects of heat waves on you (personally)?



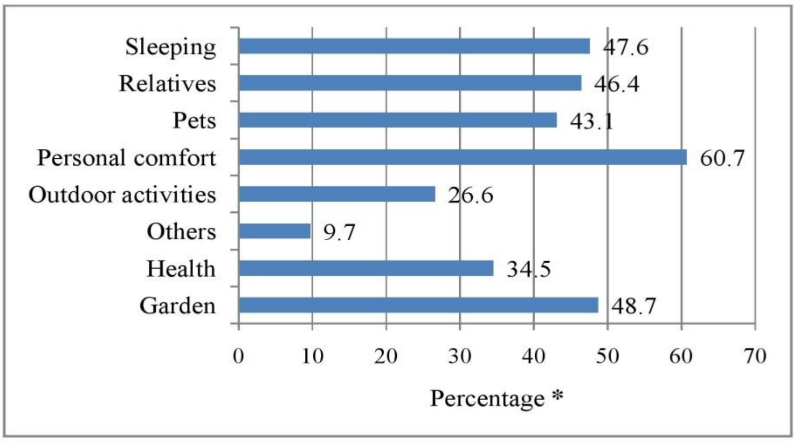
3.6. Issues That Are of Concern to Respondents during a Heat Wave

Those respondents who were either "Extremely, Very or Fairly concerned" (*i.e.*, approximately 213 or 79.8% of the total respondents) about the effects heat waves may have on them personally were asked what they were particularly concerned about during a heat wave. Respondents indicated being concerned about their personal comfort (60.7%), garden (48.7%), sleeping well (47.6%), relatives (46.4%), pets (43.1%), health (34.5%) and outdoor activities (26.6%). The other concern (9.7%) cited included the cost of running an air-conditioner as well as the possibility of developing sun burn during a heat wave (see Figure 5). There was a statistically significant association between gender and concern for their relatives ($\chi^2 = 4.73$, df = 1, $p = 0.03$) during a heat wave, with women (62.9%) more likely to be concerned about their relatives. There was also a marginally significant association between gender and concern over the safety of pets ($\chi^2 = 3.79$, df = 1, $p = 0.05$) during a heat wave, with women (62.6%) more likely to be concerned about their pets than men.

3.7. Extent of Concern about Societal Effects of Heat Waves in Adelaide

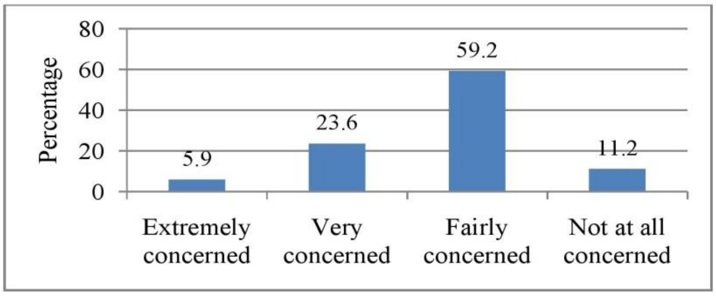
All respondents were asked how concerned they were about the effects of heat waves to the society at large. Only 5.9% indicated being "Extremely concerned" while more than half (59.2%) indicated being "Fairly concerned". The rest were either "Very concerned" (23.6%) or "Not at all concerned" (11.2%), as illustrated in Figure 6. There was a statistically significant association between gender ($\chi^2 = 21.2$, df = 3, $p = 0.000$), gross annual household income ($p = 0.03$) and concern for societal effects of heat waves. Women (80.9%) were more likely to be "Very concerned" about the societal effects of heat waves than men. On the other hand, men (52.5%) were more likely to be "Fairly concerned" about the societal effects than women. Respondents with a gross annual household income of ≥$60,000 (60.93%) were more likely to be "Fairly concerned" about the societal effects of heat waves. There was also a statistically significant association between level of information about heat waves and concern for the societal effects of heat waves (p = 0.005). Those who were "Very well informed" (25.4%) were more likely to be "Very concerned" about the societal effects of heat waves, while those who were "Fairly well informed" (63.3%) were less likely to be concerned about the effects of heat waves to society.

Figure 5. Respondents concerns during a heat wave. Q5. What are you concerned about during a heat wave? (multiple responses).



* Percentage total may add up to more than 100% as multiple responses were permissible.

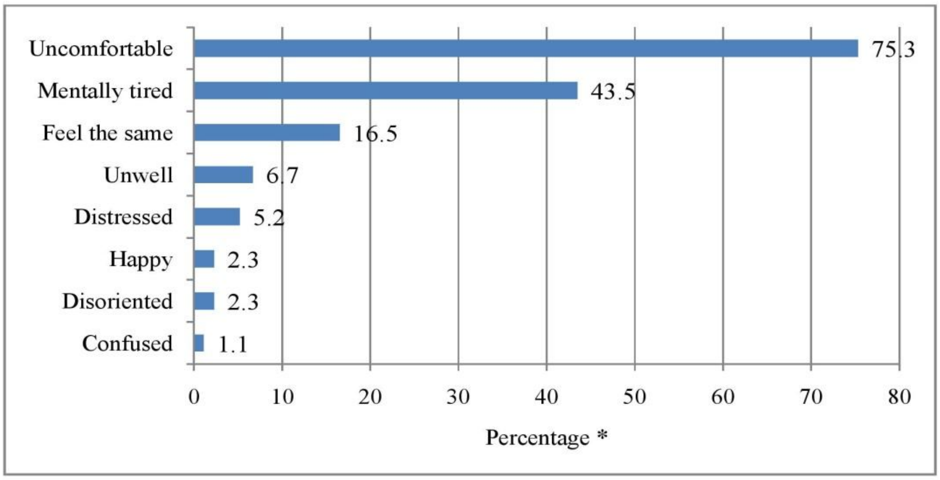
Figure 6. Extent of respondents' societal concern on the impacts of heat waves. Q6. How concerned are you about the effects of heat waves to society?



3.8. Effects of Heat Waves on Respondents' Wellbeing

Respondents were asked about how they feel during periods of heat waves in Adelaide. The most cited responses were feeling "uncomfortable" (75.3%), followed by "mentally tired" (43.5%), "feeling the same as usual" (16.5%) and feeling "unwell" (6.7%). The least common cited response was "feeling disoriented" (2.3%), happy (2.3%) and "feeling confused" (1.1%). These responses are illustrated in Figure 7. There was a statistically significant association between gender ($\chi^2 = 14.4$, df = 1, $p = 0.000$), gross annual household income ($\chi^2 = 10.38$, df = 1, $p = 0.006$) and being "mentally tired" during a heat wave, with women (68.9%) and those with a gross annual household income of ≥$60,000 (45.5%) more likely to be "mentally tired". There was a statistically significant association between age ($\chi^2 = 3.9$, df = 1, $p = 0.04$), gender ($\chi^2 = 5.9$, df = 1, $p = 0.01$) and feeling "unwell" during a heat wave, with those aged over 49 years (83.3%) and women (83.2%) more likely to feel "unwell".

Figure 7. Respondents' wellbeing during a heat wave. Q7. How do you feel during a heat wave? (multiple responses).



* Percentage total may add up to more than 100% as multiple responses were permissible.

3.9. Attitudes towards Scientific Projections of Increasing Heat Waves in Relation to Climate Change

Scientific projections hold that heat waves are likely to increase in frequency, intensity and duration as a result of global climate change. Respondents were asked how likely they believed heat waves will increase in the future according to these projections. Fifteen percent (15.0%) indicated that it would be "Extremely likely" for heat waves to increase in future according to scientific projections. The other respondents indicated that it will be "Very likely" (28.2%), "Somewhat likely" (42.9%), "Less likely" (8.7%) and "Not at all" (5.3%). These responses are illustrated in Figure 8. There was a statistically significant association between marital status ($p = 0.04$) and belief in the likelihood of increasing heat waves in Adelaide, with those married (80.0%) more likely to believe that it will be "Extremely likely" that heat waves will increase in future according to scientific projections. There was also a marginally significant association between employment status ($p = 0.05$) and belief in the likelihood of increasing heat waves in Adelaide, with those employed (67.5%) more likely to believe that it will be "Very likely" that heat waves will increase in future. There was no significant association between level of education and the belief in the likelihood of increasing heat waves in Adelaide.

3.10. Attitudes towards Potential Consequences of Heat Waves

Heat waves in Adelaide have been associated with morbidity and mortality as well as social, economic and environmental consequences. Respondents were asked how likely they believed that heat waves would have consequences if heat waves were to increase in future. Nearly half of them (48.1%) cited that the consequences would be "Very likely", 27.8% indicated that the consequences would be "Somewhat likely", followed by those who noted that it would be "Extremely likely" (21.8%). Only a minority indicated that it would be "Less likely"(1.5%), while 0.8% cited "Not at all", as illustrated in Figure 9.

Figure 8. Respondents' attitudes towards scientific projections about heat waves. Q8. How likely do you think heat waves in Adelaide will increase in the future as some scientists have projected?

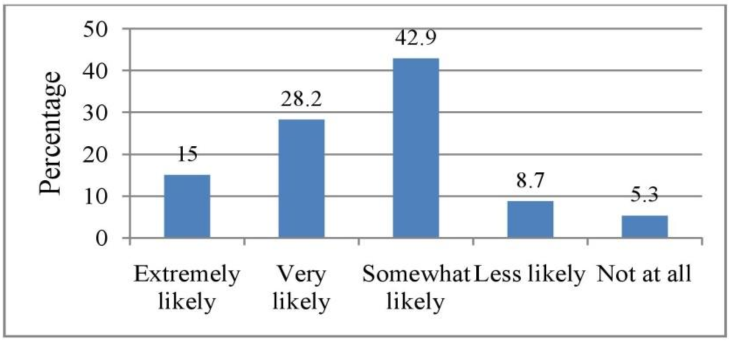
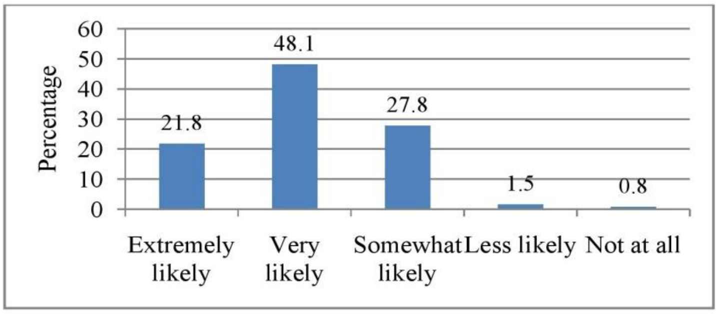


Figure 9. Respondents' attitudes towards potential consequences of heat waves. Q9. If heat waves were to increase in future, how likely do you think this will have consequences in Adelaide?

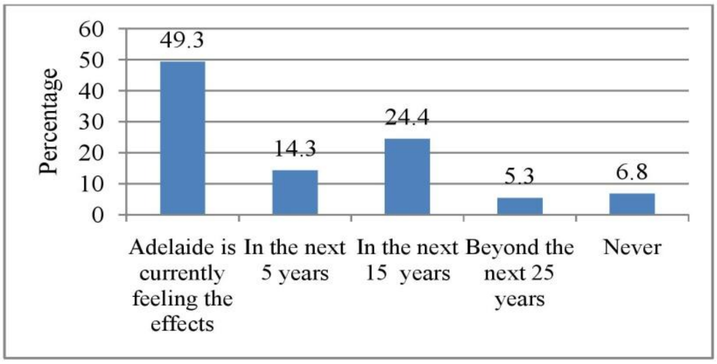


There was a statistically significant association between marital status (p = 0.03), employment status (p = 0.001) and the belief that future heat waves will have severe consequences. Respondents who were married (93.7%) and employed (84.4%) were more likely to believe that it will be "Very likely" that future heat waves will have severe consequences in Adelaide.

3.11. Immediacy of the Effects of Heat Waves in Adelaide

Respondents were asked to indicate when they believed the social and health effects of heat waves would be felt in Adelaide. Almost half of them (49.3%) indicated that heat waves were already causing social and health effects in Adelaide; 14.3% of the respondents indicated that the effects will be felt in 5 years time, 24.4% indicated that the effects will be felt in 15 years time, while 5.3% indicated that the effects will be felt beyond the next 25 years and 6.8% indicated that Adelaide will never suffer from any social or health effects associated with heat waves. These responses are shown in Figure 10. There was a marginally significant association between gender (p = 0.05) and those who believed that Adelaide was already feeling the effects of heat waves, with women (56.0%) more likely to believe that "Adelaide was already feeling the effects" of heat waves.

Figure 10. Respondents' attitudes towards immediacy of the impacts of heat waves. Q10. When, if at all, do you think Adelaide will start feeling the social and health effects of heat waves?



4. Discussion

The objectives of this study were to examine the perception and attitudes towards heat waves within the context of climate change. Overall, respondents reported that they were well informed about heat waves and concerned about the effects of heat waves. However, attitudes varied over some of the issues examined in the survey.

It was found that television (TV), radio, newspaper and internet were the main sources from which respondents obtained information during a heat wave. Similar findings were obtained in a study on heat awareness across four North American cities. However, in that study, the internet was relatively unused by respondents with only 3.0% reported using the internet as a source for heat advisories [31]. Another study conducted in the United States to assess the source of weather advisories found that TV, radio, and newspaper were the major sources of information [33]. This finding highlights the important role of the media as a source from which the public obtains information about heat waves and this likely has implications for policy. It underscores the need for policy makers and emergency services providers to make appropriate use of the media to disseminate information before, during and after a heat wave.

Less than a quarter of the respondents expressed being "Extremely concerned" (8.2%) and "Very concerned" (18.4%) about the threat of heat waves on them personally. Among those who were personally concerned, they indicated concern for their personal comfort, their garden, sleeping, relatives and their pets. Although heat waves may lead to heat-related illness and mortality, less than half (34.5%) of the respondents indicated health as a concern during a heat wave. This perhaps indicates that respondents did not consider heat waves as an immediate threat to their health. This study also found that the majority of respondents did not have a very high level of concern about the effects of heat waves on society. However, more than half of them (59.2%) indicated that they were "Fairly concerned" about the effects of heat waves on society. Overall, there appeared to be a higher level of concern for the effects of heat waves on society than on personal issues (*i.e.*, 20.2% *vs.* 11.2% "Not at all concerned" respectively for personal and societal effects of heat waves). Heat waves are an environmental threat and studies have generally found that women are more likely to be very concern than men about environmental issues which pose a risk for vulnerable groups [38–40]. We found that respondents with a gross annual household income of ≥$60,000 were more likely to be "Fairly concerned" about the societal effects of heat waves. However, some studies have found that income was negatively related to concern for environmental problems [39,40]. The study also found that women were more likely to be concerned about the safety of their relatives and pets, which could be explained by their family role and domestic responsibilities to provide care for children, elderly relatives and take care of household belongings.

The results of this study showed that heat waves have an impact on the wellbeing of residents in Adelaide. Some respondents cited being mentally tired and/or being distressed during a heat wave; which probably indicates that heat waves may likely affect the emotional wellbeing of certain individuals. For example, some individuals might be distressed when they watch apocalyptic images of bushfires associated with heat waves or be distressed when their garden dries-off or their pet dies as a result of a heat wave. The most common response cited was feeling uncomfortable during a heat wave. When people are uncomfortable during a heat wave, it may affect their mood; they may develop negative feelings, anxiety and worry because of the heat wave. Since heat waves are an environmental stressor, studies have found that women tend to be more emotionally or psychologically affected during a stressful event [41,42]. For example, there are studies that have shown that women are more vulnerable to the effects of heat waves [43,44] although contrasting findings have also been reported [18]. It has been suggested that gender differences in emotional or psychological distress may be explained by differences in the way women and men perceive and express distressful events [45].

A majority of the respondents indicated that there was a likelihood that heat waves will increase in future as some scientists have projected, although there was a variation in terms of the degree of likelihood. Only a minority of respondents indicated that the chances of heat waves increasing would either be less likely (8.7%) or "Not at all" (5.3%). It may be possible that respondents' responses to this question may have been influenced by either their past experience of heat waves or based on their scientific views about climate change as a whole.

Most of the respondents indicated that it would be quite likely that if heat waves increase in Adelaide, it would have severe health consequences. Only a minority (1.5%) stated that it would be less likely or not at all likely (0.8%) for any consequences to occur. A possible explanation could be that respondents had perhaps experienced or read reports of health impacts during recent heat waves in

Adelaide. A qualitative study was conducted to explore participants' mental model about the consequences of heat waves in Adelaide. Participants indicated that heat waves were associated with health, social, environmental, psychological and emotional consequences [46]. An interesting finding from this study was about the immediacy of the effects of heat waves. Almost half (49.3%) of the respondents indicated that the effects of heat wave were currently being felt in Adelaide. Again, this probably reflects their experiences during recent heat waves. For example, the early 2009 heat wave resulted in heat-related deaths, hospitalisation, closure of schools, disruption of public transport system and power black-outs [12,47,48]. As a result, some of the respondents may have either been affected or known someone who was affected during the heat wave. These experiences may have motivated them to believe that heat waves are already having an effect in Adelaide.

The present findings may be limited by this study's cross-sectional design and the results cannot be generalised to the entire Adelaide population since those who participated reside in a specific region. Despite this limitation, these findings are useful as they provide information about the attitudes that exist within a community about heat waves and identify the major concerns and psychological issues that affect residents during a heat wave. Such information may be useful for authorities during planning and responding to heat waves. Future studies should be conducted to examine public attitudes towards heat waves in relation to climate change in other cities or regions of the world that usually experience heat waves. This is because attitudes may vary according to climate and geographic locations. Lastly, repeated studies should be conducted to examine any change in attitudes over time.

5. Conclusions

The results of this survey suggest that people are well informed about heat waves and have experienced past episodes of heat waves in the city. The media was the main source from which respondents obtained information about heat waves. This finding indicates the important role that the media plays in disseminating information to the public. Some individuals are concerned over certain issues during a heat wave, with some concerned about the societal impacts of heat waves. Heat wave is a threat associated with certain emotional and psychological distress among certain groups in the community. The public's attitude towards certain issues related to heat waves may be influenced by their beliefs about global climate change.

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Conflict of Interest

The authors declare no conflict of interest.

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CHAPTER 6

HEAT WAVES AND CLIMATE CHANGE: APPLYING THE HEALTH BELIEF MODEL TO IDENTIFY PREDICTORS OF RISK PERCEPTION AND ADAPTIVE BEHAVIOURS IN ADELAIDE, AUSTRALIA

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Article

Heat Waves and Climate Change: Applying the Health Belief Model to Identify Predictors of Risk Perception and Adaptive Behaviours in Adelaide, Australia

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Abstract: Heat waves are considered a health risk and they are likely to increase in frequency, intensity and duration as a consequence of climate change. The effects of heat waves on human health could be reduced if individuals recognise the risks and adopt healthy behaviours during a heat wave. The purpose of this study was to determine the predictors of risk perception using a heat wave scenario and identify the constructs of the health belief model that could predict adaptive behaviours during a heat wave. A cross-sectional study was conducted during the summer of 2012 among a sample of persons aged between 30 to 69 years in Adelaide. Participants' perceptions were assessed using the health belief model as a conceptual frame. Their knowledge about heat waves and adaptive behaviours during heat waves was also assessed. Logistic regression analyses were performed to determine the predictors of risk perception to a heat wave scenario and adaptive behaviours during a heat wave. Of the 267 participants, about half (50.9%) had a high risk perception to heat waves while 82.8% had good adaptive behaviours during a heat wave. Multivariate models found that age was a significant predictor of risk perception. In addition, participants who were married (OR = 0.21; 95% CI, 0.07–0.62), who earned a gross annual household income of ≥$60,000 (OR = 0.41; 95% CI, 0.17–0.94) and without a fan (OR = 0.29; 95% CI, 0.11–0.79) were less likely to have a high risk perception to heat waves. Those who were living with others (OR = 2.87; 95% CI, 1.19–6.90) were more likely to have a high risk perception to heat waves. On the other hand, participants with a high perceived benefit (OR = 2.14; 95% CI, 1.00–4.58), a high "cues to action" (OR = 3.71; 95% CI, 1.63–8.43), who had additional training or education after high school (OR = 2.65; 95% CI, 1.25–5.58) and who earned a gross annual household income of ≥$60,000 (OR = 2.66; 95% CI, 1.07–6.56) were more likely to have good adaptive behaviours during a heat wave. The health belief model could be useful to guide the design and implementation of interventions to promote adaptive behaviours during heat waves.

Keywords: climate change; heat waves; health belief model; risk perception; adaptive behaviours; Australia

1. Introduction

Climate change has been projected to increase the frequency and severity of extreme weather events such as heat waves [1,2]. Heat waves, characterised by stagnant warm air masses and consecutive nights with high temperatures [3] are considered a public health problem since they are associated with heat-related morbidity and mortality [4]. In 2003, Western Europe experienced one of its worst heat waves which resulted in an estimated 70,000 heat-related deaths [5]. France was the worst affected country with over 14,800 recorded heat-related deaths [6,7]. Heat waves are the leading cause of weather-related deaths in the United States with an estimated 688 deaths reported to be directly related to heat each year [8]. In 2010, Russia experienced an unprecedented heat wave that resulted in approximately 15,000 heat-related deaths [9].

In Australia, a number of cities usually experience heat waves during summer, which are considered to have claimed more lives than any other natural disaster in the country [10]. It is estimated that over 1,000 heat-related deaths occur in Australia every year [11]. In the summer of 2009, south-eastern Australia experienced an extreme heat wave between 27 January and 8 February which resulted in an estimated 500 heat-related deaths in Adelaide and Melbourne [12]. During the early 2009 heat wave, there was an increase in direct heat-related hospital admissions, emergency department presentations for ischaemic heart disease and increased ambulance call-outs for cardiac-related diseases in Adelaide [13]. Most recently, between late 2012 and early 2013, Australia was gripped with an extreme heat wave that caused temperature rises across large parts of Western Australia, Queensland, Victoria, South Australia, New South Wales, the Northern Territory and Tasmania; daily maximum temperatures of over 40 °C were recorded in some of the cities across the country. The extreme temperatures resulted in widespread bushfires and the loss of livelihoods [14–16]. In South Australia, the Bureau of Meteorology defines a heat wave as a period of maximum temperatures of 35 °C or over for a period of five or more consecutive days or three or more consecutive days of temperatures of 40 °C or above [17].

There has been increasing concern among authorities on the dangers of heat waves to public health and safety. However, there is still a lack of recognition among the public about the social and health consequences associated with heat waves [18]. There are a number of factors that can increase human vulnerability to heat-related morbidity and mortality [19–22]. However, heat-related illnesses and deaths can be largely prevented if individuals recognise the risks and undertake simple behaviour modification measures such as seeking cool shelters, reducing physical activity, drinking sufficient water and staying in an air-conditioned environment [23,24].

Heat waves are an environmental hazard and there are a number of socio-demographic factors that may influence risk perception to natural hazards [25–27]. For example, age has been found to be positively correlated with risk perception to hazards [28], although negative correlations have also been reported [29]. Gender is often found to be an important determinant of risk perception as women perceive risks more than men [30]. In addition, individuals with a high income and education level have been found to have a lower perception of risks [31,32]. In relation to heat waves, the extent to which an individual perceives the risks associated with heat waves may determine how he/she takes action to prevent heat-related morbidity or mortality during heat waves. A study conducted in North America to gauge public perception of heat waves revealed that a majority of participants did not consider themselves as vulnerable [18]. Similar findings were obtained in the United Kingdom [33], where the elderly who are known to be vulnerable to heat waves did not perceive themselves as being at risk during a heat wave. This has implications for risk communication strategies during heat waves and could limit the effectiveness of current heat-health warning systems and advisories. It highlights the importance of understanding the social and cognitive factors that determine risk perception and behavioural adaptation during heat waves.

There is currently a growing interest in using socio-cognitive theories to study risk perception and motivation for adaptation to climate-related risks since knowledge and perceptions can drive behaviour change [34]. Despite the health risks that heat waves pose for Australians, there has been very limited research examining the social and cognitive factors that influence risk perception and behavioural response during a heat wave. There are a number of behaviour change models that could be used to examine how knowledge and perception can influence behaviour modification in relation to health risks. For example, the health belief model (HBM) could be applied as the theoretical framework to examine how cognitive factors shape an individual's perception and hence adaptive behaviours during heat waves. This model focuses on the beliefs of individuals to explain health behaviours [35] and has been used to guide the development of behaviour change programs [36]. The model is based on a value expectancy approach [37] and postulates that human behaviour depends mainly on the value that an individual places on a particular outcome and on the individual's estimate of the likelihood that a given action will achieve that outcome [38]. The model suggests that whether or not individuals take action to protect their health is a function of whether they believe that (a) they are susceptible to a particular threat (b) that such a threat would have severe consequences, (c) that they have options available to them to take preventive action, and (d) that the benefits of taking preventive action outweigh the costs [39]. The main constructs of the HBM used in this study are perceived susceptibility, perceived severity, perceived benefit of taking preventive measures, perceived barriers to the preventive action and cues to taking action (the presence of information and other triggers that motivates undertaking preventive action). A combination of perceived susceptibility and perceived severity has been termed "perceived threat" [40], which in this paper is known as risk perception. In this paper, we have used the phrase "perceived vulnerability" in place of "perceived susceptibility", since vulnerability is widely used in the literature on heat waves. Furthermore, the HBM was selected for this study because some of its constructs relate to perception, part of the focus of the study.

The objectives of this study were to: (a) to examine the usefulness of the constructs of the HBM in predicting the adoption of healthy behaviours during heat waves, (b) to identify the factors that will predict risk perception to heat waves, (c) to assess participants' knowledge related to heat waves. We hypothesised that if participants perceive heat waves as a health risk, then the constructs of the HBM might be able to predict adaptive behaviours during periods of heat waves. These findings could be important in improving risk communication and promoting behaviour change strategies during heat waves. This paper reports part of the findings of a larger study conducted in Adelaide. The results of the other part have been reported elsewhere [41].

2. Materials and Methods

2.1. Study Setting and Data Collection

This cross-sectional study was conducted in the city of Adelaide, the capital of South Australia. South Australia has an estimated population of 1.64 million inhabitants with over three-quarters of the state's population residing in Adelaide [42]. The city usually experiences hot dry summers, with the months of January to March being the hottest in the year and heat waves are quite common. Recently in early 2013, Adelaide experienced hot spells over a couple of days with a daily maximum temperature of 45 °C recorded on January 4th, 2013 [43]. However, the most recent severe heat waves occurred in 2008, 2009 and 2010 [13,17,44]. There were two heat waves recorded in 2009; the first between late January and early February and the second in November [17]. During the early 2009 heat wave, there were 13 consecutive days with temperatures above normal (monthly average temperatures normally range from approximately 27 °C to 29.4 °C during summer); six of these days had temperatures above 35 °C and a record temperature of 45.7 °C was recorded in one of the days [13,45].

The approach by which the participants were recruited and how data were collected has previously been described [41]. Briefly, participants for the study were recruited from the North West Adelaide Health Study (NWAHS) cohort, which is a random representative sample of residents in the north and western parts of Adelaide [46]. With support of the chief investigators of this cohort, and as part of a follow-up survey administered by the NWAHS in late 2011 among a sub-group of the cohort, study participants were asked if they would be willing to be contacted at a later date to take part in a questionnaire study on heat waves. The age profile of the sub-group approached did not include older participants. It should be noted that the representation of the elderly in the NWAHS cohort is decreasing, because of continual movement of this group to assisted care facilities due to health reasons. Of the 1,185 participants approached, 818 expressed interest to participate in the heat waves study. Among those who expressed interest, 490 participants were selected after excluding those with insufficient literacy skills or long term illness.

A package containing an approach letter, the study information sheet, the self-administered questionnaire and a reply paid envelope was mailed to the 490 individuals who were selected to take part in the study. Questionnaires were mailed out to selected participants during the third week of January 2012, following three weeks of hot weather in Adelaide. The timing was considered optimal because we wanted participants' responses to reflect their experiences of the hot weather. For example, the daily maximum temperature recorded in Adelaide on 1 January 2012 was 41.6 °C, making it the warmest start to the year for over a century [47]. The latter part of the month of January remained hot with eleven consecutive days of temperatures over 30 °C recorded between the 19th to the 29th including four consecutive days with temperatures above 35 °C from the 22nd to the 25th [48]. There were no follow-up or reminder calls made to participants. Ethics clearance was obtained from The University of Adelaide Human Research Ethics Committee (No. H-061-2011) and The Queen Elizabeth Hospital Human Research Committee (No. 2011136). Ethics clearance was obtained from the latter institution because it over sees any research study involving the cohort.

2.2. Measures and Classification

The questionnaire collected data on participants' demographic and household characteristics, knowledge about heat waves, perceptions of a heat wave and adaptive behaviours during a heat wave. Perceptions were measured in the context of a heat wave scenario using the HBM as the theoretical framework. Although it would have been ideal to conduct the study during a heat wave, the logistics of implementing the study to coincide with a heat wave was considered to be too difficult, so a hypothetical scenario was formulated.

Demographic and household characteristics: The questionnaire collected data on the following variables: age, gender, marital status, educational level, employment status, gross annual household income, living arrangements, fan and air-conditioner ownership.

Knowledge about heat waves: Knowledge about heat waves (Cronbach's alpha = 0.69) was measured with eight statements; four of which were negatively worded. The response choices were "True", "False" or "Don't know". For the positively worded statements, all the "True" responses were given a score of "1" while the "False" and "Don't know" responses were given a score of "0". For the negatively worded statements, all the "False" responses were given a score of "1" and the "True" and "Don't Know" responses were given a score of "0". The knowledge scores were then summed to obtain a "total knowledge score" with a maximum possible score of eight. We dichotomised knowledge about heat waves into low (1–4) and high (5–8) at approximately the "midpoint" of the total score as shown in Table 1.

Perception of a heat wave scenario (as applied in the HBM): A heat wave scenario with 45 °C for seven consecutive days was used to measure participants' risk perception. We used an extreme heat scenario since we wanted to evaluate how participants conceptualise the risk posed by a health threat. Nonetheless, the scenario could be considered plausible in comparison to the heat wave experienced in early 2009.

We provided participants with a number of statements about what might happen to them under such a heat wave scenario and they were requested to provide responses on a 5-point Likert scale (i.e., Strongly Disagree, Disagree, Unknown, Agree, Strongly Agree; scored from "1" to "5" respectively). There were a number of statements for each of the constructs of the HBM (perceived vulnerability, perceived severity, perceived threat, perceived benefit, perceived barrier and cues to action). We then added participants' total score for each of the constructs and later dichotomised (low/high) at approximately the "mid-point" of the total score (see Table 1).

Table 1. Range and classification of scores for heat wave knowledge, perceptions and adaptive behaviours.

Key variables	Range of total scores	Classification	
		LOW	HIGH
Knowledge about heat waves	1–8	1–4	5–8
Perceived vulnerability	5–20	5–12	13–20
Perceived severity	5–25	5–15	16–25
Risk perception [1]	70–500	70–251	252–500
Perceived benefit	15–30	15–22	23–30
Perceived barriers	4–16	4–10	11–16
Cues to action	8–25	8–16	17–25
Adaptive behaviours [2]	15–29	15–21	22–29

[1] Risk perception was computed by multiplying each participant's total score for perceived vulnerability and perceived severity. As shown in the table, the minimum score for risk perception was 70 because this participant had a total score of 5 and 14 for perceived vulnerability and perceived severity respectively. No participant had a total score of 5 for perceived vulnerability and perceived severity respectively, so the lowest value cannot be 25; [2] Also referred to as poor (low) and good (high) adaptive behaviours. Those with poor adaptive behaviours may be considered to be at risk since they have poor preventive behaviours during a heat wave; behaviour change programs should therefore target such group of individuals.

Perceived vulnerability (Cronbach's alpha = 0.75) to the effects of the heat wave scenario was measured by summing participants' responses on four statements e.g., "I think I may suffer from dehydration during such a heatwave period". Perceived severity (Cronbach's alpha = 0.74) of the effects of the heat wave was measured by summing participants' responses on five statements e.g., "If I get dehydrated during such a heat wave period, it may lead me to being hospitalised". We calculated risk perception by multiplying each participant's total scores for perceived vulnerability and perceived severity. We then dichotomised the total score for risk perception (low/high) using the median split to generate a dichotomous variable (see Table 1). Perceived benefit (Cronbach's alpha = 0.87) was measured by summing participants' responses on six statements, three of which were negatively worded. The scores of the negatively worded statements were reversed before the total scores were summed, e.g., "Staying in an air conditioned environment will reduce the chance of me suffering from dehydration". Perceived barriers (Cronbach's alpha = 0.73) to taking preventive action to the health effects of the heat wave was measured by summing participants' responses on four statements, e.g., "For security reasons, I would not open my windows at night to allow air to enter during such a heatwave". Cues to action (Cronbach's alpha = 0.83) was measured by summing participants' responses on five statements, e.g., "I will take precautionary measures if my doctor advises me about the dangers of the heat wave".

Adaptive behaviours during a heat wave: Participants were asked how often they undertook a number of behavioural adaptations during a heat wave. There were ten statements to assess adaptive behaviours (Cronbach's alpha = 0.60), three of which were negatively worded: "Wear-dark coloured clothes when going outside", "Drink a few cups of coffee to stay alert", "Do some outdoor gardening during the day". The statements related to adaptive behaviours had the scores and response choices (1 = Never, 2 = Sometimes, 3 = Always). We reversed the scores of the negatively worded statements and then added the total score for adaptive behaviours. We then dichotomised the total adaptive behaviours score into two levels at approximately the "mid-point": good (22–29) and poor (15–21) (see Table 1), generating a dichotomous variable for adaptive behaviours during a heat wave.

3. Data Analysis

Of the 490 questionnaires mailed out to participants, 272 were returned, giving a response rate of 55.5%. The questionnaires were checked for accuracy, consistency and completeness. Five were discarded due to missing data, leaving 267 for final analysis. Respondents and non-respondents differed only by age. Data were analysed with Stata version 12 (Stata Corp., College Station, TX, USA) and descriptive statistical techniques were used to determine frequency distributions while logistic regression was used to identify significant relationships among variables.

In order to identify the predictors of risk perception (low, high) to heat waves, the predictor variables were age as a continuous variable, gender, marital status, educational level, employment status, gross annual household income, living arrangements, fan ownership, air-conditioner ownership and knowledge about heat waves as a continuous variable. Risk perception was coded as a binary variable with "low" coded as "0" and "high" coded as "1". First, univariate logistic regression analyses were performed for all the predictor variables. Next, multivariate logistic regression analysis was performed to identify the independent predictors of risk perception to heat waves, controlling for confounding effects.

To examine the usefulness of the constructs of the HBM in predicting adaptive behaviours during heat waves, the dependent variable was adaptive behaviours in the dichotomous form (poor, good), while the predictor variables were risk perception, perceived benefit, perceived barrier, cues to action, with knowledge about heat waves as a continuous variable, demographic and household characteristics as covariates. Adaptive behaviours was coded as a binary variable with "poor" coded as "0" and "good" coded as '1". Initially, univariate logistic regression analyses were performed for all the potential predictor variables of adaptive behaviours. Next, a multivariate logistic regression model was performed that consisted of risk perception, perceived benefit, perceived barrier, cues to action and the demographic variables that were significant predictors in univariate analyses. We included only the significant demographic variables from univariate analyses into the multivariate model in order to avoid over fitting the model due to the limited data points in the lower category of adaptive behaviours. Due to sample size constraints some categorical demographic variables (e.g., marital status, level of education, employment status) were dichotomised. We used a two-sided $p < 0.05$ to determine statistical significance in all analyses.

4. Results

4.1. Demographic and Household Characteristics of Study Participants

Table 2 shows the demographic and household characteristics of the study participants. The mean age of the participants was 51 years (SD, 8.7). When collapsed into two groups, 61.4% belong to the older age group (50–69 years) while the remainders (38.6%) belong to the younger age group (30–49 years). More than half (55.8%) of the participants were females.

Table 2. Demographic and household characteristics of the study participants.

Variable	Number	Percent(%)
Age group (n = 267) (Mean = 51 years)		
30–49	103	38.6
50–69	164	61.4
Gender (n = 267)		
Male	118	44.2
Female	149	55.8
Marital status (n = 267)		
Never married	29	10.9
Married [1]	238	89.1
Level of education (n = 267)		
Partial or full completion of high school	103	38.6
Additional training after high school [2]	164	61.4
Employment status (n = 267)		
Not employed [3]	43	16.1
Employed (full/part time, self employed)	224	83.9
Gross annual household income (n = 254)		
<$40,000	58	22.8
$40,000–$59,999	53	20.9
≥$60,000	143	56.3
Living arrangements (n = 267)		
Alone	44	16.5
With others [4]	223	83.5
Fan ownership (n = 265)		
Yes	239	90.2
No	26	9.8
Air conditioner ownership (n = 267)		
Yes	250	93.6
No	17	6.4

N/B: This table is a modified and extended version of that originally published in a separate paper. See reference [41]. [1] Married referred to those who have been married at some stage in life and include those married at the time of the study, separated or widowed. [2] Training after high school, bachelor or postgraduate degree. [3] Not employed referred to unemployed, retired, home duties or other. [4] Living with others referred to living with partner, family, relatives or other people.

A majority (89.1%) were married while 10.9% had never married. In terms of level of education, 38.6% had completed or partially completed high school while 61.4% had additional training after high school (such as apprenticeship, a trade certificate, a bachelor or postgraduate degree). Most of the participants (83.9%) were employed while 16.1% were either unemployed or retired. With regard to self-reported gross annual household income, 56.3% earned ≥$60,000, 20.9% earned between $40,000 and $59,999, and 22.8% earned less than $40,000. Most of the participants (83.5%) were living with others (i.e., with either their partner, family or relatives); 16.5% were living alone. The majority of participants (90.2%) reported owning a fan, while 93.6% had an air-conditioner.

4.2. Knowledge about Heat Waves

A majority of the participants (91.4%) had good knowledge about heat waves. In terms of individual statements used to quantify knowledge, over half (51.7%) indicated that "High atmospheric pressure with less rainfall could be responsible for extreme heat events in Adelaide". More than two-thirds indicated that "Heat-related illnesses result from exposure to extreme heat". The detailed responses to the statements on knowledge about heat waves are shown in Table 3.

Table 3. Participants' responses to the statements regarding knowledge about heat waves.

Statements	Number (%)		
	True	False	Don't Know
High atmospheric pressure with less rainfall could be responsible for heat waves	138(51.7)	24(9.0)	105(39.3)
Heat-related illnesses results from extreme heat exposure	237(88.8)	20(7.5)	10(3.7)
Diabetes is an example of a heat-related illness	5 (1.9)	231(86.5)	31(11.6)
Excess sweating during a heat wave may be a sign of heat stress	154(57.7)	83(31.1)	30(11.2)
Individuals with heart conditions have a greater chance of becoming ill during a heat wave	196(73.4)	25(9.4)	46(17.2)
The elderly and young are the only ones vulnerable during a heat wave	23(8.6)	244(91.4)	0(0)
Heat-related illnesses are not known to cause deaths	29(10.9)	234(87.6)	4(1.5)
Heat waves may lead to bush fires	256(95.9)	8(3.0)	3(1.1)

4.3. Perception of a Heat Wave Scenario

Table 4 shows the overall classification of participants' perceptions of a heat wave scenario (seven consecutive days with temperatures of 45 °C). Overall, 67.4% of the participants had a "high perceived vulnerability" under such a heat wave scenario, 76.4% of the participants were classified as having a "high perceived severity", while 64.3% were classified as having a "high perceived benefit". A majority of the participants (84.6%) were classified as having a "low perceived barrier" and 74.1% as having a "high cues to action". In terms of risk perception, 50.9% of the participants had a high risk perception to the heat wave.

Table 4. Classification of participants' perceptions in the context of a heat wave scenario based on the HBM and using the cut-off points.

Level of perceptions	Low		High	
	n	%	n	%
Perceived vulnerability	87	32.6	180	67.4
Perceived severity	63	23.6	204	76.4
Risk perception	131	49.1	136	50.9
Perceived benefit	95	35.7	171	64.3
Perceived barriers	226	84.6	41	15.4
Cues to action	69	25.9	197	74.1

Table 5. Participants' responses to statements on perceptions in the context of a heat wave scenario using constructs of the health belief model.

Statements on perceptions (Five constructs of the HBM)		Percent * (%)				
		SA	A	U	D	SD
Perceived vulnerability	I think I may suffer from dehydration during such a heat wave	13.1	31.1	15.4	26.6	13.9
	I think my body temperature may rise abnormally during such a heat wave	13.9	38.2	19.5	21.3	7.1
	I think I may suffer from body weakness during such a heat wave	12.7	48.4	20.6	15.7	2.6
	I think I may suffer from sun burn if I get exposed during such a heat wave	43.6	40.8	5.9	6.7	3.0
Perceived severity	If my body temperature gets elevated during such a heat wave it may cause me to see a doctor	5.9	30.7	29.6	28.5	5.25
	If I get dehydrated during such a heat waves, it may lead me to being hospitalised	12.4	43.1	16.9	21.4	6.4
	Dehydration under such a heat wave may provoke long term damage to my health	13.1	42.7	24.7	16.9	2.6
	If I develop sun burn during such a heat wave, it may lead to skin cancer	29.2	52.8	12.4	4.1	1.5
	Hospitalisation as a result of dehydration during such heat wave may cause me to be absent from work	23.6	60.3	8.9	4.9	2.3
Perceived benefit	Eating hot meals during such a heat wave will enable me to cope with the heat	0.0	6.0	25.8	45.3	22.9
	Staying in an air conditioned environment will reduce the chance of me suffering from dehydration	31.5	47.9	8.2	10.1	2.3
	Using sunscreen will prevent me from developing sunburn during such a heat wave	25.1	51.7	8.6	13.1	1.5
	Wearing dark clothing outside during this period will reduce my chances of sweating	0.8	2.3	13.1	45.7	38.2
	Listening to daily weather forecasts would enable me to plan my outdoor activities	42.3	53.2	2.3	1.1	1.1
	Staying indoors during such a heat wave would be quite boring	8.7	29.3	19.6	34.6	7.7
Perceived barriers	Taking a cool shower from time to time at home during this period would waste water and increase my water bills	3.0	17.9	25.5	41.2	12.4
	For security reasons, I would not open my doors at night to allow air to enter during such a heat wave	5.6	15.7	10.1	49.8	18.7
	Due to my health, I will drink less water during such a heat wave	1.5	1.1	1.9	29.2	66.3
	Because of the cost of electricity, I would be reluctant to turn on the air conditioner during such a heat wave	2.6	4.5	4.1	41.6	47.2
Cues to action	A family member or friend tells me about the dangers of the heat wave	15.7	48.3	23.2	10.1	2.6
	I watch TV and see how an ambulance transports someone to the hospital due to dehydration from the heat wave	11.7	40.9	24.8	19.2	3.9
	I read a local news paper and get news about the health effects of the heat wave	11.3	53.0	23.3	10.5	1.9
	My doctor reminds me about the dangers of the heat wave	14.7	48.1	23.7	11.3	2.3
	As a result of my personal experience of heat waves in Adelaide, I would keep safe during such a heat wave	44.2	50.3	3.8	1.1	0.4

SA = Strongly Agree (5), A = Agree (4), U = Uncertain (3), D = Disagree (2), SD = Strongly Disagree (1); * Some percentages may not perfectively add up to 100% due to approximation to one decimal place.

Table 5 shows the details of the participants' responses to the statements on perceptions in the context of the heat wave scenario. For example, 31.1% agreed that they might suffer from dehydration during a heat wave with temperature of 45 °C for seven consecutive days. Furthermore, 38.2% agreed that their body temperature would rise abnormally during such a heat wave. Also, 52.8% agreed that if they suffer from sun burn during such a heat wave, it may lead to skin cancer. In terms of participants' responses to statements on "Cues to action" i.e., what would motivate them to protect themselves from the harmful effects of such an extreme heat wave, there was a high level of participant agreement for most of these statements. For example, 53.0% agreed that they would adopt healthy behaviours if they read on a local newspaper about the health effects of the heat wave. Furthermore, 50.3% agreed with the statement that: "As a result of my personal experience of heat waves in Adelaide, I would keep safe during such a heat wave".

4.4. Adaptive Behaviours during a Heat Wave

Table 6 shows the details of participants' responses to the statements used to quantify their adaptive behaviours during a heat wave. The first three adaptive behaviours with the highest percentage that were reported as "Always" performed were: drinking plenty of water to stay hydrated (83.8%), seeking protection of shady areas when outdoors (82.0%) and listening to daily weather forecasts (61.4%). The adaptive behaviour with the highest percentage that was reported as "Never" performed was: doing some outdoor gardening during the day (76.8%). A total adaptive behaviours score was calculated for each participant and their overall adaptive behaviour was classified as good (22–29) or poor (15–21) as shown in Table 1. Overall, 82.8% of the participants had "good adaptive behaviours" while 17.2% had "poor adaptive behaviours".

Table 6. Participants' responses to statements on adaptive behaviours.

	Percent (%)		
Statement(s)	**Always**	**Sometimes**	**Never**
Drink plenty of water to stay hydrated	83.8	15.4	0.8
Go for a swim to cool down	16.1	54.9	29.0
Wear-dark coloured clothes when going outside	1.5	30.7	67.8
Listen to daily weather forecast	61.4	35.6	3.0
Drink a few cups of coffee to stay alert	4.49	33.7	61.8
Wear a hat when going outside	56.2	32.6	11.2
Do some outdoor gardening during the day	0	23.2	76.8
Seek protection of shady areas when outdoor	82.0	16.9	1.1
Go to a shopping centre to cool down	6.0	64.0	30.0
Use an umbrella when walking outside	5.3	21.7	73.0

4.5. Predictors of Risk Perception to Heat Waves

Table 7 shows results of the univariate and multivariate logistic regression analyses for predictors of risk perception to the heat wave scenario. In univariate analyses, those who were married (OR = 0.29; 95% CI, 0.12–0.71), who earned a gross annual household income of ≥$60,000 (OR = 0.35; 95% CI, 0.18–0.67), without a fan (OR = 0.26; 95% CI, 0.09–0.66) were less likely to have a high risk perception to heat waves. In the multivariate model, age was a significant predictor of risk perception to heat waves (OR = 1.04; 95% CI, 1.00–1.07). In addition, those who were married (OR = 0.21; 95% CI, 0.07–0.62), those who earned a gross annual household income of ≥$60,000 (OR = 0.41; 95% CI, 0.17–0.94), and those without a fan (OR = 0.29; 95% CI, 0.11–0.79) were less likely to have a high risk perception to heat waves. However, those who were living with others (OR = 2.87; 95% CI, 1.19–6.90) were more likely to have a high risk perception to heat waves. We did not find any significant relationship between level of education or knowledge about heat waves and risk perception.

Table 7. Univariate and multiple logistic regression analyses for predictors of risk perception to a heat wave scenario.

Predictor variables	Category	Univariate		Multivariate	
		OR(95% CI)	p-value	OR (95% CI)	p-value
Age	NA, continuous	1.02(0.99–1.05)	0.071	1.04(1.00–1.07)	0.025*
Gender	Male	1(ref)		1(ref)	
	Female	1.01(0.62–1.63)	0.979	1.03(0.60–1.78)	0.897
Marital status	Not married	1(ref)		1(ref)	
	Married	0.29 (0.12–0.71)	0.007 *	0.21(0.07–0.62)	0.005 *
Educational level	≤HSD	1(ref)		1(ref)	
	>HSD	0.91(0.55–1.48)	0.699	1.13(0.63–2.04)	0.662
Employment status	Not employed	1(ref)		1(ref)	
	Employed	0.63(0.32–1.22)	0.175	1.04(0.45–2.39)	0.909
Gross annual household income	<$40,000	1(ref)		1(ref)	
	$40k– <60,000	0.69(0.32–1.48)	0.341	0.90(0.36–2.24)	0.823
	≥$60,000	0.35(0.18–0.67)	0.001 *	0.41(0.17–0.94)	0.037 *
Living arrangements	Alone	1(ref)		1(ref)	
	Others	0.94(0.49–1.79)	0.846	2.87(1.19–6.90)	0.019 *
Own a fan	Yes	1(ref)		1(ref)	
	No	0.26(0.09–0.66)	0.005 *	0.29(0.11–0.79)	0.015 *
Own an air-conditioner	Yes	1(ref)		1(ref)	
	No	0.71(0.26–1.92)	0.503	0.81(0.24–2.66)	0.733
Knowledge about heat waves	NA, continuous	1.01(0.56–1.80)	0.991	1.08(0.86–1.36)	0.461

* Significant at $p < 0.05$; ≤HSD refers to "partial or full completion of high school"; >HSD refers "additional training/education after high school"; $40k refers to $40,000 and OR refers to odds ratio; NA means "not applicable"; "ref" means "reference category".

4.6. Predictors of Adaptive Behaviours during a Heat Wave

Table 8 shows the results of the logistic regression analyses for the predictors of adaptive behaviours during a heat wave. In univariate analyses, perceived benefit, "cues to action" and knowledge about heat waves were significant predictors of adaptive behaviours during a heat wave. The results suggested that those who had a high perceived benefit (OR = 2.69; 95% CI, 1.40–5.18) and high "cues to action" (OR = 2.13; 95% CI, 1.09–4.16) were more likely to have good adaptive behaviours during a heat wave. Furthermore, those who were married (OR = 2.44; 95% CI, 1.03–5.78), who had additional training or education after high school (OR = 3.03; 95% CI, 1.57–5.83) and who earned a gross annual household income of ≥$60,000(OR = 3.07; 95% CI, 1.43–6.56) were more likely to have good adaptive behaviours during a heat wave.

Table 8. Univariate and multiple logistic regression analyses for predictors of adaptive behaviours during a heat wave.

Predictor variables	Category	Univariate		Multivariate	
		OR (95% CI)	p-value	OR (95% CI)	p-value
Risk perception	Low	1(ref)		1(ref)	
	High	0.68(0.36–1.30)	0.249	0.66(0.29–1.46)	0.305
Perceived benefit	Low	1(ref)		1(ref)	
	High	2.69(1.40–5.18)	0.003 *	2.14(1.00–4.58)	0.049 *
Perceived barriers	Low	1(ref)		1 (ref)	
	High	0.49(0.23–1.09)	0.081	0.82(0.31–2.13)	0.682
Cues to action	Low	1(ref)		1 (ref)	
	High	2.13(1.09–4.16)	0.027 *	3.71(1.63–8.43)	0.002 *
Knowledge about heat waves	NA, continuous	1.40(1.09–1.78)	0.007 *	1.22(0.91–1.62)	0.173
Age	NA, continuous	1.01(0.97–1.05)	0.426		
Gender	Male	1(ref)			
	Female	0.62(0.32–1.21)	0.160		
Marital status	Never married	1(ref)		1(ref)	
	Married	2.44(1.03–5.78)	0.042 *	1.67(0.59–4.66)	0.326
Educational level	≤HSD	1(ref)		1(ref)	
	>HSD	3.03(1.57–5.83)	0.001 *	2.65(1.25–5.58)	0.010 *
Employment status	Not employed	1(ref)			
	Employed	0.75(0.29–1.88)	0.536		
Gross annual household income	<$40,000	1(ref)		1(ref)	
	$40k–<$60,000	1.78(0.73–4.34)	0.203	1.74(0.65–4.68)	0.271
	≥$60,000	3.07(1.43–6.56)	0.004 *	2.66(1.07–6.56)	0.035 *
Living arrangements	Alone	1(ref)			
	Others	0.72(0.28–1.82)	0.491		
Own a fan	Yes	1(ref)			
	No	0.67(0.25–1.77)	0.420		
Own an air-conditioner	Yes	1(ref)			
	No	0.62(0.13–2.82)	0.541		

* Significant at p-value < 0.05; ≤HSD refers to "partial or full completion of high school"; >HSD refers "additional training/education after high school"; $40k refers to $40,000 and OR refers to odds ratio; NA means "not applicable"; "ref" means "reference category".

In the multivariate model, those with a high perceived benefit (OR = 2.14; 95% CI, 1.00–4.58), a high "cues to action" (OR = 3.71; 95% CI, 1.63–8.43), who had additional training or education after high school (OR = 2.65; 95% CI, 1.25–5.58) and who earned a gross annual household income of ≥$60,000(OR = 2.66; 95% CI, 1.07–6.56) were more likely to have good adaptive behaviours during a heat wave. Risk perception was not found to be a significant predictor of adaptive behaviours, a finding which did not support our hypothesis. However, the other constructs of the HBM: perceived benefit and "cues to action" were significant predictors of adaptive behaviours, which support the predictive value of some constructs of the HBM.

5. Discussion

Heat wave is an environmental hazard that poses a threat to human health and the extent to which individuals perceive risks associated with heat waves may influence their decision to modify their behaviour during a heat wave. This study used an extreme heat wave scenario to assess public risk perception and identified the factors that are associated with risk perception to heat waves. In addition, the study also tested the validity of the health belief model in predicting the adoption of healthy behaviours during a heat wave.

This study found that more than half (67.4%) of the participants had a high perceived vulnerability to the heat wave scenario. In 2009, Adelaide recorded two heat waves and during the first, daily maximum temperatures ranged from 35 °C to 45.7 °C and there were eight consecutive days with temperatures over 35 °C during the second heat wave [17]. As previously indicated, in early 2013, Australia sweltered under an unprecedented summer heat wave which set a new record temperature of 40.3 °C; the highest national daily average temperature ever recorded [16]. This is the first published study in which most participants reported feeling vulnerable to heat waves. Previous studies on perception of heat waves found contrasting results as most participants did not consider themselves vulnerable to heat waves [18,33], although the contexts in which these studies were conducted differed from the present study. A possible explanation for the present finding could be because participants felt that a heat wave characterised by 45 °C for seven consecutive days would be quite extreme. This finding could be important in public risk communication for heat waves under future climate scenarios. It has been projected that the number of days with temperatures above 40 °C in Adelaide will range from three to eight days by 2050 [49]. It is important to note that scenarios have widely been used in studies related to climate change and are extremely useful in studying the uncertainties that surrounds climate change [50].

Our study found that age, marital status, gross annual household income, living arrangements and fan ownership were significant predictors of risk perception. This finding is somewhat consistent with those of previous studies that reported an association between age and risk perception to environmental hazards [28,51]. Generally, age is an important factor for vulnerability to heat waves since those who are older are known to be at risk during a heat wave [52]. A study conducted to examine the Australian public's perceived risks on a number of environmental hazards found that older participants had a high risk perception [30]. Nonetheless, contrasting findings between age and risk perception to environmental hazards has been reported in another study [53]. Our results suggest that those who were married were less likely to have a high risk perception to heat waves. Those who are married may believe that they have social contacts and bonds which they consider to be a protective effect against heat-related morbidity and mortality [19,24]; and this could explain why they were less likely to have a high risk perception to heat waves. Some studies have found that those who are married are less likely to suffer from heat-related illnesses and mortality [54,55].

Our study also found that those with a higher household income were less likely to have a high risk perception to heat waves. This finding is consistent with those of other studies which have found that individuals with a higher income and an overall higher socio-economic status are less likely to perceive risks as threatening [31,32]. Studies have found that those living alone are at higher risk of heat-related morbidity and mortality during a heat wave [22,56]. However, our study found that those who were living with others were more likely to perceive a high risk to heat waves. Although there is no ready explanation for this finding, one may hypothesise that those who lived with others could have expressed a high risk perception because they may also be concern about the safety and well being of their immediate family members (e.g., partner, children) and relatives [41] during such an extreme heat wave.

With regard to adaptive behaviours, we found that two of the constructs of the HBM were significant predictors of adaptive behaviours during a heat wave. Individuals with a high perceived benefit were more likely to have good adaptive behaviours during a heat wave. This group of individuals actually recognised the benefit of taking preventive measures to stay safe during a heat wave. It was also found that "cues to action" was a significant predictor of adaptive behaviours during a heat wave. For example, a majority of the participants either strongly agreed or agreed that as a result of their personal experience of heat waves in Adelaide, they would take preventive actions to keep themselves safe during such a heat wave. This finding may suggest that previous experience from an environmental event (e.g., a heat wave) that inflicts damage may precipitate heightened risk perception and can act as a trigger for future preventive actions [57]. However, our study did not find any significant relationship between risk perception and adaptive behaviours during heat waves. A possible explanation could be because the context in which the two variables were measured was not the same. It further highlights that risk perception alone does not necessarily predict preventive behaviours [58,59] but that other factors need to be taken into consideration. Nevertheless, it is important to note that while some individuals may have a heightened risk perception to heat wave, there may be certain barriers that may hinder them from adequately adapting during a heat wave. This assertion could be supported by the finding from this study that participants who had high perceived barriers (although not a significant predictor) were less likely to have good adaptive behaviours during a heat wave.

In addition to level of education, household income was found to be a significant predictor of adaptive behaviours during a heat wave; as those with a higher income were more likely to have good adaptive behaviours. It could be inferred that individuals with a higher income are more likely to run their air-conditioners while at home during a heat wave to stay cool without the fear of electricity costs. Previous studies have reported that the high costs of running an air-conditioner may act as a barrier for certain individuals to properly adapt during a heat wave [3,18].

Overall, this study has generated some important findings about risk perception and adaptation to heat waves under a changing climate. The study is novel because it is the first to apply the HBM in assessing risk perception to heat waves within the context of a scenario; and to identify the predictors of risk perception and adaptive behaviours during heat waves using logistic regression analyses. Nonetheless, it is important to acknowledge some limitations from this study. Firstly, the present results should be interpreted with caution as they cannot be generalised to the entire Adelaide population, since the sample comprised of a sub-group of the NWAHS participants who voluntarily expressed interest to participate in the study. Secondly, the questionnaires were self-completed and therefore the analysis was based on self-reported data, for which there may have been response bias. Thirdly, although the constructs of perception (applied in the HBM) were used as explanatory variables to predict adaptive behaviours, the conditions under which the statements to assess perception of heat waves and adaptive behaviours were not the same. While the statements to assess perception were posed within the context of a scenario, those statements regarding adaptive behaviours were not under the same context. Fourthly, the study may have been limited by selection bias; the fact that some categorical demographic variables were dichotomised due to sample size constraints might have affected the results. Lastly, non-response bias might have affected the results since respondents and non-respondents differed by age.

Despite these limitations, these findings are useful for emergency service providers, health officials, local authorities and policy makers in the design and implementation of risk communication and behaviour change promotion strategies related to heat waves. This is particularly important given that climate models project more frequent heat waves in the future. The study is also useful for researchers as it serves as the basis for similar studies to be replicated in other cities and regions around the world that usually experience heat waves. Such studies would shed light on any differences in risk perception to heat waves that exist across regions. Future research should examine how participants' threat appraisal and coping appraisal (self-efficacy) to heat waves could better predict adaptive behaviours during heat waves. More research is also needed to understand the relationship between risk perception and risk communication in the context of heat waves.

6. Conclusions

There is considerable uncertainty about the magnitude of future climate change impacts. However, scientific projections maintain that heat waves will likely increase in frequency, intensity and duration [1,2]. This research has enabled us to estimate risk perception of a heat wave scenario through perceived vulnerability and perceived severity. By examining risk perception in the context of a heat wave scenario, this paper increases our understanding on the extent to which individuals evaluate the risk associated with an extreme heat wave. Although the context applied in this research was hypothetical, it may be likely that such a scenario could be experienced in future. After all, climate models project temperature rises across most Australian cities with an increase in duration of heat waves [49]. Our finding that age, marital status, gross annual household income, fan ownership and living arrangements were significant predictors of risk perception in the context of the heat wave scenario supports the existing scholarship that there are certain socio-demographic factors that influence risk perception to environmental hazards [25–27]. In our study, we did not find any significant association between risk perception and adaptive behaviours during heat waves. Nevertheless, this research has provided emergency management agencies with relevant information about the factors that must be considered when they develop and disseminate risk communication messages related to heat waves both for current and future climate scenarios.

Our research is particularly useful in the sense that it applied a behaviour change theory to identify the factors that could predict the adoption of healthy behaviours during a heat wave. The study has demonstrated that factors such as knowledge about heat waves, marital status, level of education, gross annual household income are significant predictors of adaptive behaviours during a heat wave.

In addition, the findings that perceived benefit and "cues to action" were significant predictors of adaptive behaviours further suggest the usefulness of the HBM in behaviour change programs for heat waves. As a result, health promotion specialists must take into account these factors and predictor variables during the design and implementation of concise and targeted health messages intended to motivate behaviour change during heat waves. Moreover, it is important that those behaviours that increase an individual's risk to heat-related morbidity and mortality are identified such that they are effectively targeted. The perceived barriers to appropriate adaptive behaviours should be targeted by providing information to the public on the available options, providing incentives, offering reassurances and dispelling any misconceptions [38]. This will greatly determine the success of any behaviour change program for heat waves.

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Conflict of Interest

The authors declare no conflict of interest.

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CHAPTER 7

ENGAGING STAKEHOLDERS IN AN ADAPTATION PROCESS: GOVERNANCE AND INSTITUTIONAL ARRANGEMENTS IN HEAT-HEALTH POLICY DEVELOPMENT IN ADELAIDE, AUSTRALIA

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Name of Principal Author **(PhD Candidate)**	Akompab Derick Akoku		
Contribution to the Paper	Developed research study, gained ethics approval, developed data collection tool, contacted and recruited stakeholders, collected data, analysed data and interpreted the findings. Conceived and conceptualise the manuscript, orientation and structure, wrote manuscript and acted as corresponding author prior to publication.		
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CHAPTER 8

INCLUSIVENESS IN AN ADAPTATION PROCESS: REACHING CONSENSUS IN A MULTI-STAKEHOLDER PARTNERSHIP IN HEAT-HEALTH POLICY FORMULATION IN ADELAIDE, AUSTRALIA

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ABSTRACT

Introduction: As a result of climate change, many multi-stakeholder processes are currently taking place in the formulation and implementation of adaptation strategies. One example is the development of heat wave early warning systems and response plans, which aim to reduce the health impacts associated with more frequent and severe heat waves. This paper describes the inclusiveness, the major discussions that emerged, and how these discussions were successfully managed in a participatory process during the development of an adaptation strategy for heat waves in Adelaide, Australia.

Methods: Semi-structured interviews were conducted (between June and August 2011) among 18 stakeholders who were involved in developing the adaptation strategy for heat wave. Interviews were digitally recorded, transcribed verbatim and analysed by the framework approach. Analysis of relevant documents associated with the process was also conducted.

Results: The study found that although the participatory process was not fully inclusive, stakeholders nonetheless perceived the process of developing the heat-health policy as successful. There were three issues that raised much discussion within the diverse group of stakeholders. These included: (1) the definition of a heat wave; (2) the geographical area to which the definition would apply, and (3) the temperature thresholds that would guide the triggering of a heat-health alert. Nonetheless, these issues did not undermine the participatory process as a common ground was reached that led to the successful formulation of the heat-health policy.

Conclusions: This study highlights the importance of bringing together stakeholders for a collective goal. It is also important for differences in opinion to be adequately resolved in order to move partnership processes forward. Despite the fact that the participatory process reported in this paper was subject to time constraints, limited scientific evidence and was not fully inclusive, it was considered to be successful by all the stakeholders interviewed.

***Key words*:** adaptation, climate change, early warning system, heat waves, multi-stakeholder partnership

8.1 Introduction

Climate change is one of the greatest challenges that the world is currently facing by virtue of its impacts on both natural and human systems (IPCC 2007). Scientific evidence holds that climate change would result in more frequent and severe extreme weather events such as heat waves (Easterling et al., 2000; Meehl & Tebaldi 2004). Around the world, heat waves are currently recognised as a public health problem because past episodes of heat waves have led to heat-related illnesses and deaths (Luber & McGeehin 2008; Poumadere et al., 2005; Tong, Ren & Becker 2010). Heat waves are also associated with emotional and psychological distress to many vulnerable groups (Akompab et al., 2013a). Moreover, heat waves have led to other social, economic and environmental consequences (Dole et al., 2011; Parliament of Victoria 2010; UNEP 2004).

In recognition of the current and potential impacts associated with climate variability, efforts are currently underway to reduce population vulnerability through putting in place adaptation strategies (Adger et al., 2003; Brooks, Adger & Kelly 2005; Burton, Diringer & Smith 2006). The development of heat wave early warning systems and response plans to reduce population vulnerability to heat waves could be considered as an adaptation strategy in the context of human health (Ebi 2011; Fouillet et al., 2008; Koppe et al., 2004; Kovats & Ebi 2006; Lowe, Ebi & Forsberg 2011). Heat wave warning systems and response plans are designed to identify and forecast heat events that may affect human health, predict possible health outcomes and implement mechanisms for issuing warnings when temperatures could adversely affect health, thereby preventing heat-related illnesses and deaths among the population (Ebi & Schmier 2005; Koppe et al., 2004).

The development of adaptation strategies such as heat wave warning systems and response plans could be considered a public policy issue, because public policies are designed to respond to social, economic or environmental challenges facing the society. Like other public policies, the development and implementation of adaptation strategies has widely been recommended to involve a diverse group of stakeholders (Ebi, Kovats & Menne 2006 ; IPCC 2007) through a participatory process. This concept is clearly articulated in the United Nations Framework Convention on Climate Change which calls for the involvement of stakeholders in the development and implementation of strategies to reduce risks associated with climate change (United Nations 1992).

The importance of engaging stakeholders in such adaptation processes is based on the premise that ensuring an inclusive process promotes ownership and buy-in, thereby leading to a successful outcome (Ebi, Kovats & Menne 2006). Consequently, participatory processes should be as inclusive as possible since this would build a platform for commitment, promote effective deliberations and enhance trust among the stakeholders leading to collective decision-making (Folke et al., 2005; Vogel et al., 2007). Inclusiveness ensures that major view points of all relevant stakeholder groups are taking into consideration before decision-making and this is more likely to be achieved when there's effective representation of relevant stakeholder groups. Additionally, it ensures a broad constituency of the process and good decision-making which increases the legitimacy and credibility of the process (Hemmati 2002).

Recently, the involvement of different stakeholders is increasingly being used in climate policy processes especially with the availability of tools and guidelines to engage stakeholders in adaptation policy design and implementation (Lim & Spanger-Siegfried 2004). These participatory processes are usually characterised by a heterogeneous group of stakeholders since they represent different institutions or groups, have different knowledge, background and understanding about the "concept" under deliberation (van Asselt Marjolein & Rijkens-Klomp 2002).

Between late January and early February of 2009 an exceptional heat wave hit most parts of south-eastern Australia (Australian Government: Bureau of Meteorology 2009) with Adelaide and Melbourne particularly affected. Adelaide recorded a 13-day heat wave with daily maximum temperatures reaching in one of these days 45.7°C (Nitschke et al., 2011), which was approximately 12-15^{o}C above normal (Australian Government: Bureau of Meteorology 2009). The early 2009 heat wave resulted in an estimated 500 heat-related deaths in both Adelaide and Melbourne with other social, economic and environmental consequences (Parliament of Victoria 2010; Reeves et al., 2010). There was an increase in ambulance call-outs and emergency department presentations which stretched health services in Adelaide (Nitschke et al., 2011; Williams et al., 2011). It is noteworthy that apart from the early 2009 heat wave, other recent record-breaking heat waves in Adelaide occurred in 2008 and 2010 (Australian Government:Bureau of Meteorology 2010; Nitschke et al., 2011).

Following the early 2009 heat wave and its consequences in Adelaide, relevant stakeholders were brought together to develop a heat wave early warning system and response plan[2] in order to reduce the health impacts of future heat waves. Stakeholders were brought together on the basis that heat waves cannot be prevented but rather the health impacts could be significantly reduced if such a plan was in place. As indicated, the development of the heat-health policy for Adelaide took place through a participatory process. Although similar plans have been developed around the world (Michelozzi et al., 2006; U.K. Department of Health 2005), there are limited studies that have explored participatory processes in the development of heat wave warning systems and response plans within the context of multi-stakeholder processes. As a result, little is known about the context in which these plans have been developed, how inclusive the planning processes have been and what challenges stakeholders face during the development of such adaptation strategies.

The aim of this paper was to conduct an analysis of the participatory planning process during the development of the heat-health policy in Adelaide that took place in mid 2009. This paper draws insight from the concept of multi-stakeholder processes in the development of public policies and situates it within the context of adaptation to climate change. It explores the inclusiveness of the policy development process, examines the main issues that emerged during deliberations and how these issues were successfully managed. The policy environment, institutional arrangements and framework during the development of the heat-health policy has been reported elsewhere (Akompab et al., 2013b).

8.2 Methodology

A qualitative exploratory approach was considered necessary for generating rich data that would shed light on the planning process, since little or no research had previously been conducted within this area. Specifically, a case study design was used with empirical data gathered from both primary and secondary sources (Doole 2002; Voss, Tsikriktsis & Frohlich 2002). The study was conducted with approval from the Human Research Ethics Committee of The University of Adelaide (No. H-061-2011).

[2] The heat wave early warning system and response plan developed in Adelaide in mid-2009 was known as the "Extreme Heat Arrangements", which for the purpose of this paper is known as the heat-health policy.

The detail methods of the study and the approach by which stakeholders were recruited has been previously described (Akompab et al., 2013b). Briefly, in collaboration with the lead agency that coordinated the participatory process, a list of selected stakeholders (i.e. from both state and non-state sectors) was approached by email. Potential participants were stakeholders who participated in the development of the heat-health policy. A purposive sampling technique was used to select stakeholders on the basis that they would provide rich data relevant for the study. Stakeholders were informed about the objectives of the study, their voluntary participation, how confidentiality would be maintained and that the results would be published with anonymity. Of the original 30 stakeholders approached by email, 16 agreed to participate in the study. Through a snow-balling sampling technique, three additional stakeholders were identified who agreed to participate, bringing the total number to nineteen.

In-depth, semi-structured interviews were conducted among the stakeholders between June 2011 and August 2011. Each stakeholder provided written consent before the start of the interview. Although 19 stakeholders expressed interest to participate, interviews were conducted among 18 of them due to the principle of data saturation. In qualitative research, data saturation is the point reached when no new ideas, concepts and views are expressed after a number of interviews have been conducted and this usually informs the researcher when to stop data collection (Bowen 2008). Of the 18 interviews, 17 were conducted face-to-face and one by telephone. Fifteen of the face-to-face interviews took place in the workplaces of the stakeholders, while the rest were held in a meeting room in the Discipline of Public Health, The University of Adelaide. The interviewed stakeholders represented the public sector (n=10), the private sector (n=1), non-governmental organisations (n=5) and researchers (n=2).

All interviews were conducted with the aid of an interview guide. The questions in the guide were designed after a review of the literature on the concept of multi-stakeholder processes and adapted in the context of the heat-health policy development process. Stakeholders were posed questions such as *(i) "Who were the stakeholders involved in the planning process"? (ii) "What do you think was the criteria used to select stakeholders involved in the process?" (iii) "What were some of the issues that steered much discussion during the participatory process?"* There were both follow-up and probing questions during the interviews. All interviews were audio-digitally recorded and short notes were also taken during the interviews. The interviews ranged on from 20 to 41 minutes. All interviews were transcribed verbatim, de-identified and checked for accuracy. Individual transcripts were later forwarded to the stakeholders for respondent validation (Mays & Pope 2000). Data from interviews was complemented by those gathered from secondary data including government reports, websites and email correspondence.

A framework analysis was used due to its suitability in analysing policy research data (Ritchie & Spencer 1994). After the audio-recordings were reviewed, transcripts were read and re-read and a list of themes was identified. Transcripts were then imported into Nvivo 9 qualitative data analysis software) to facilitate indexing by coding (Ritchie & Spencer 1994). New themes were added to the original coding frame as new ideas and concepts emerged. After mapping the data, results were then interpreted based on the main themes. Document analysis gathered from the secondary sources also complemented the data analysis process.

8.3 Results

Analysis of the responses of the stakeholders revealed three broad themes (some with sub-themes) and included: (1) inclusiveness and representation, (2) the main discussions during the process, and (3) how the main discussions were successfully managed to move the process forward. These broad themes are discussed below and are supported by relevant verbatim quotes[3] from the data corpus.

8.3.1 Inclusiveness of the participatory adaptation process

Most of the interviewees stated that the main actors who were part of the participatory process were from the government, private sector, non-governmental organizations, community associations and researchers/scientists. However, the majority of the actors who were involved in the process were from public institutions which are part of the emergency management arrangements already existing in South Australia. Hence, there were no systematic criteria that were initially laid down to determine which actors were to be included in the process, probably due to time constraints as cited by some stakeholders. Participation in the process was purely based on past experience in managing emergencies and willingness

[3] The quotations use the following conventions. Ellipsis points (. . .) indicate materials that were deleted in order to de-identify the quotes. The symbol [Pause] indicates a short pause in speech, while [X], [Y], or [Z] represents a de-identified stakeholder agency which was involved in the process.

to take part in the process. The fact that the different actors were diverse (representing the public, private, civil society and researchers/scientists) made a majority of the interviewees confident that the participatory process was quite inclusive with many expressing satisfaction with the level of engagement as illustrated in the following quote:

> *"It was developed with a range of stakeholders, a range of people that took a very active part of this. Not the least of which is the likes of the... and, umm, ... Umm, so, you know, I don't think whilst it rests..., I don't think any one person or agency actually has; can lay claim to the plan as such." (S-4)*

It was reported that these stakeholders were all involved at the early stages of the participatory process. Although most stakeholders indicated that the process was largely inclusive, some interviewees highlighted limits in the extent of inclusiveness given that this was an "experimental process"; in the sense that it was the first time that an adaptation strategy for heat waves was being developed in Adelaide. Some stakeholders noted that due to time constraints, there were some stakeholder groups who were not involved in the process. Most of these were community groups and were realized to be relevant groups only after the process already begun. For example, as demonstrated in the following response:

> *"Umm, the one that I felt was a real missing one was we didn't have anybody from Mental Health there although I did go out and talk with them separately. But I thought Mental Health was a big area that we didn't do very well. So I think we should have had a much stronger involvement with those other cultural agencies because they were the people who had connections to all of the people who, umm, [Pause] who may not have spoken English. And they were the ones who could have conveyed the messages to them." (S-12)*

One stakeholder felt that an important group that was not directly involved was the mass media (e.g., radio and TV) since the adaptation strategy had a communication component. This stakeholder stated that it was important for the mass media to be involved so that they could provide inputs on how messages should be tailored for public dissemination. Although most of the agencies involved in the process had a communication unit, this stakeholder believed that such units needed the support and inputs from the mass media, as illustrated in the following quote.

> *"Maybe media because at some point you have got to get the message to the community. There wasn't a specific media – I mean this sort of media. We have all got our own media but I wonder whether, you know, a [Y] media or a [Z] media is the best way of communicating that to the community or whether some of these other things are better." (S-2)*

Nonetheless, another stakeholder mentioned that although the mass media was not directly involved, the communication units of the institutions that were involved in the process consulted with them indirectly. It was realised that these stakeholder groups were not left out intentionally because some of them were only identified as relevant groups after the participatory process. The reasons given why these groups were not involved was twofold.

First, because there was no systematic stakeholder analysis carried out to identify the relevant groups prior to the process due to the emergency situation. Second, the endeavour was an "experimental process". Nonetheless, although the group of stakeholders who were part of the process cut across the broader stakeholder sectors (public sector, private sector, civil society, researchers/scientists), there was no consideration for a balanced representation of stakeholders from each of these sectors. Hence, there were some sectors which had greater representation than others. For example, more stakeholders were from the public sector than any other sector. Most of the stakeholders indicated that "a balance had to be struck" between making the process inclusive by ensuring that the right number of actors were involved and at the same time making the group size manageable such that decisions could be easily reached, as illustrated in the following quotes:

> *"And I think that is a good way of saying: let's keep the number sitting around the decision-making table, umm, as concise as possible for good decision-making. But at the same time don't exclude, umm, interested stakeholders from being able to contribute to that decision in some way. And I think that is an important thing." (S-10)*

> *"Umm, in the development [Pause] I believe that the stakeholder group was adequate for this task. If we had had a larger group it would have been more difficult to develop the policy. Umm, now that the policy is in place, of course, there are more stakeholders that can be included now that there is a policy. But, in the formulation of the policy, I believe the group was about right."(S-14)*

8.3.2 Key issues of discussion that emerged during the participatory process

Given the diversity of stakeholders who take part in such participatory processes, differences in views and ideas over what is under deliberation inevitably occur. This is because these individuals have different knowledge, background, understanding, and opinions about the subject matter. Multi-stakeholder processes are relatively new in the context of heat wave response planning. Hence, this study attempted to understand what sort of issues emerged as a result of differences in views during the process of formulating the adaptation strategy for heat waves.

All the interviewees acknowledged that there were certain issues that were the centre of much discussion during the process. However, these did not undermine or act as an impediment to the process. The main discussions that emerged during this particular process stemmed from the complexity in understanding ambient meteorological conditions and operationalising a heat alert system. These issues could be classified into three and included: the definition of what was to be considered a heat wave; the geographical applicability of the definition; and the temperature thresholds to issue a heat alert. These issues are discussed in turn below.

8.3.2.1 The definition of a heat wave

The definition of what could be considered a heat wave during the design of the heat-health policy was one of the issues that provoked much discussion during the process. At the time, heat waves had only been identified as a new social and public health threat in Adelaide, and as a result almost all the stakeholders had no previous experience in planning and managing the consequences associated with heat waves. Due to lack of prior experience, interviewees noted that reaching a consensus on a practical definition for a heat wave, and how to distinguish it from extreme heat, was quite a problem due to the diverging views held by the different stakeholders. This diversity of views prolonged discussions during the meetings, and sometimes outside meetings on a one-to-one basis when stakeholders met each other. This is illustrated in the following response:

> *Q. Can you please tell me about some of the main issues that brought about much discussion during the participatory process?*
>
> *A: "Hmm. the main debating points that I seem to remember are around umm, the definition of what an extreme heat event is, and just understanding umm, what the [Pause] whether there were three levels at the time; the alert, watch and warning meant."(S-7)*

Following prolonged discussions, stakeholders reached a common ground on the definition of a heat wave which guided them in formulating the heat-health policy. The definition reached as captured in one of the documents reviewed was:

> *A heat wave was defined as a period with 5 consecutive days where the dry bulb temperature is 35 degrees or greater/ or 3 consecutive days where the dry bulb temperature is 40 degrees or greater.(The South Australian Extreme Heat Arrangements 2009)*

8.3.2.2 The geographical applicability of the heat wave definition

Another issue that resulted in much discussion during the process was the geographical applicability of the heat wave definition that was reached. Stakeholders noted that the concept of the geographical applicability provoked discussions because temperatures that might be considered a heat wave in one part of the state may not be considered as a heat wave in another. Consequently, some stakeholders wanted the definition to be metropolitan specific; others argued that the definition should be applied state wide. These differences in position and diverging views surrounding this issue prolonged discussions as explained by this respondent:

"The definition and the application of it. Like was it a state-wide application or was there something else that was needed elsewhere. And I think the discussion about that was that it would be too hard to manage if you had different definitions for different locations. But if you apply that same scientific definition down to Mount Gambier[4] then it is an extreme heat wave for them because it is so cool down there. There was lots of discussion around that. Lots of discussion about whether that was a suitable definition or not and whether it applied to the whole state or whether it was a metropolitan-based – where the bulk of the population you would say is." (S-2)

8.3.2.3 The temperature thresholds to trigger a heat alert

Another issue that also steered much discussion was the appropriate temperature threshold to trigger a heat warning system. As indicated earlier most of the issues that brought about much discussion were as a result of the lack of evidence and limited knowledge about what constituted hazardous hot weather for Adelaide. Also, there was the lack of prior knowledge in operationalising a heat alert system to an emerging problem among the different stakeholders. While some stakeholders held the view that the initial temperature points set were high enough to trigger an alert, others wanted a much lower temperature value so that people would not be placed at risk before an alert could be issued. There was much discussion about this as illustrated in the following quotes:

Q. Can you tell me about some of the issues that prolonged discussions during the participatory process?

A: "Oh!!, there is definitely [Pause] there was discussion about the thresholds. Umm, like we said, we would like to first of all check [Pause] whether these thresholds are, uh, related, you know, are well related to health here. Because you don't want to have too early or too late the warning. Sort of too high level or at a too low level. Because if you have it at a too low level then you would have constantly heat health warnings which would be just useless." (S-1)

A: "The biggest, the most significant thing to come out of the stakeholder groups umm, was establishing the threshold, understanding the threshold and then understanding the expectation of their agencies when those thresholds were met." (S-4)

One of the stakeholders also indicated that sometimes discussions were protracted to the extent that some actors held their positions over small units of temperature values, as illustrated in the following quote:

"You will see that in the first one there are three warning levels in it and it actually had temperature levels. And it would say when it has got to a certain temperature level you need to do this, this or this. People got terribly hung up on the dot point of the temperature; whether it is 34.5 or 34.6; do we need to do this?" (S-5)

[4] Mount Gambier is the largest urban area in the state outside of Adelaide, located approximately 450 kilometres south of the state capital Adelaide.

8.3.3 Managing the key discussions and finding a common ground

Interviewees maintained that these major discussions did not impede the progress of decision-making but mainly supported the democratic nature by which the deliberations took place before a common ground was reached. The lead agency resolved these impasses by inviting scientists and researchers to the process to help clarify and shed light on these concepts to the broader stakeholder group. The scientists used evidence from past research on heat waves within Australia and more importantly from North America and Europe (given the past dramatic heat waves in these regions) to assist the stakeholders to arrive at an agreement on these concepts. It took the broader stakeholder group some time before they could understand these concepts as illustrated by the following response:

> *"I was working on the definition of the hazard. So from a meteorological perspective I had a very large job to convey heat wave definition and meaning to a group that had never experienced or had to understand a definition such as that before. So they were caught up with meteorological research.... And I would say that was technically difficult for the individuals that I was working with....it is important to understand that Australia, uh, at that time had no accepted national definition for heat wave. So they were being asked to, uh, understand fresh research. So it was technically difficult, particularly because ... they were not science officers."(S-14)*

Managing these main discussions enabled stakeholders to reach a consensus. After these issues were addressed the process moved forward as everyone was committed to ensuring that the heat-health policy was successfully developed. Indeed, the participatory process ended with a successful outcome.

8.4 Discussion

This paper explored a participatory process during the development of a heat wave early warning system and response plan, referred to as a heat-health policy. The focus was on the inclusiveness of the process and identification of the major issues which steered discussions among the stakeholders during the participatory process. The process took place in the aftermath a severe heat wave and was the first participatory process that stakeholders were engaged in developing such a system/policy. Hence, while interpreting these results, it is important to bear in mind the context in which the planning process took place.

The importance of inclusiveness in participatory processes has been extensively cited in the literature (Buchy & Hoverman 2000; Tompkins, Few & Brown 2008; van den Hove 2000). The legitimacy of a participatory process would be enhanced if those who are relevant, influential, and most likely to be affected by the decisions are well represented (Brown, Few & Tompkins 2005). However, interviews with stakeholders described here revealed that while attempts were made to make the process as inclusive as possible, there were shortcomings since there were some stakeholder groups who were not involved in the process. For instance, the mass media and some community groups were not directly involved.

There were a number of reasons that explained why there were gaps in making the process as inclusive as possible. First, the planning process took place with some urgency as stakeholders had to develop a policy that would save lives in the event of heat waves in the oncoming summer. Second, the issue of group size was also an issue, as the lead agency wanted a group that would be easily managed such that decisions could be easily reached. Third, the absence of a stakeholder analysis prior to the process may have explained why the process did not fully involve all the relevant groups. Fourth, this process was largely an "experimental process", since it was the first participatory process to develop a heat-health policy to reduce the impacts of heat wave in the Adelaide community.

It is also important to highlight at what stage the stakeholders who were part of the process were involved. We found that those stakeholders who were part of the process were involved at the beginning of the process and that explained why there was a lot of willingness by all the actors to successfully develop the heat-health policy. The reasons outlined above could also explain why there were some shortcomings in achieving balanced representation across the different stakeholder groups. For example, there were more stakeholders from the government than any other sector. This is probably because the process was initiated and led by the government and the fact that those who had experience in dealing with emergencies were mainly from public agencies. Although inclusiveness and representation are key elements of legitimacy, they are not a "panacea" for meaningful participation. For example, groups might be well represented in a process but some stakeholders may not be able to construct, discuss and share ideas during the process. This may be observed when those who represent certain sectors have limited knowledge and understanding about what is under discussion.

In certain policy processes, the "public" is recommended to provide input in the process (Buchy & Hoverman 2000) especially those who are affected by the policy. However, the findings of this study suggest that this might not have been feasible because of the complexity in understanding meteorological conditions related to heat waves. Nonetheless, public input would be relevant through an evaluation of the policy after its implementation where various population groups would be asked about their experiences around the policy and their feedback used to revise the policy.

Our finding that there were certain differences in view points during the process is consistent with the literature on participatory processes involving a diverse group of stakeholders. It was found that the source of the main discussions centred on the difficulty in understanding meteorological conditions pertaining to heat waves. Overall, it is worth noting that the scientific issues related to climate variability are quite complex and challenging (Ungar 2000). For example, a standard definition of a heat wave is still a challenge among the scientific community (Koppe et al., 2004; Robinson 2001). There is no universal acceptable definition for a heat wave; hence each region or country defines a heat wave based on their specific climatic conditions (Meehl & Tebaldi 2004).

Most heat wave response plans have a particular threshold to trigger a heat alert and this was another aspect that resulted in extended discussion during the process. It is noteworthy that the use of temperatures as triggers for heat alerts has been criticized by scientists, since some thresholds are arbitrary and do not consider geographical applicability across cities and countries (Harlan et al., 2006; Kalkstein, Sheridan & Kalkstein 2009; Sheridan & Kalkstein 2004).There was a lack of evidence about the health effects of extreme heat for the Adelaide population, and this contributed to the difficulty in making decisions about temperature triggers during this participatory process. As a result of the complexity in understanding meteorological science, providing policy makers with the best information is of paramount importance to enable them to formulate and successfully implement sustainable adaptation strategies (Lucarini 2002) to reduce population vulnerability.

It is important to note that although participatory processes are usually characterised by certain issues that may provoke discussion, this would depend on the particular context and scope of the process. For example, differences in view that may arise in a participatory process to develop an adaptation strategy for heat waves may not be the same as those during the development of an adaptation strategy for coastal sea level rise. The heat-health policy was developed around mid 2009 following the heat wave that occured between late January and early February 2009. In November 2009, there was another heat wave experienced in Adelaide which provided an opportunity for the heat-health policy to be tested. The state government collaborated with other agencies and community groups to provide an appropriate response to the heat wave. Since the development of the first heat-health policy, relevant stakeholders now have a better understanding of the meteorology associated with heat waves.

Our findings need to be interpreted with a few limitations in mind. The paper is limited in its generalisabilty since a case study methodology was used (Voss, Tsikriktsis & Frohlich 2002), and the findings are context dependent. The views of the stakeholders we interviewed are not considered to be representative and may have been affected by the time elapsed between the participatory process and when the data was collected. Despite these limitations, this study is the first to explore a multi-stakeholder process in developing an adaptation strategy in the context of human health and climate change. It increases our understanding of the need to draw knowledge and skills from a range of stakeholders in order to develop a plan that would benefit society. It further highlights the importance of excellent facilitation and management to find a common ground to move participatory processes forward.

8.5 Conclusions

Stakeholders bring unique knowledge, skills and competencies that would be relevant in predicting adverse weather conditions, designing and communicating risk messages to the population to reduce their vulnerability and even provide social services to those in need. Hence, ensuring that such participatory processes are inclusive with different players from all relevant sectors is crucially important because it ensures that appropriate and cost-effective solutions are developed to solve societal challenges. In participatory planning processes such as the one explored, it is quite common for differences in view points to emerge during deliberation. This is because stakeholders represent different interests, have different knowledge and understanding about issues related to meteorological conditions associated with heat waves. Consequently, it is important that such differences in viewpoints are quickly identified and managed amicably as this may build friendship, confidence and trust among the stakeholders. Issues like these could be successfully managed when there is careful and adequate planning prior to the participatory process. Overall, despite the urgency under which this heat-health policy was developed, the process was democratic where robust discussions took place. The heat-health policy provided a framework for which major revisions have been made over the past few years. Future empirical studies should examine the role of the different actors during implementation of heat-health policies and the balance of power that exists among state and non-state actors throughout the development and implementation of such policies.

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8.7 Conflicts of Interest

The authors have no conflicts of interest

8.8 References

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CHAPTER 9

CONCLUSIONS

9.1 Introduction

This thesis examined public perceptions, attitudes and adaptation to heat waves as well as the concept of multi-stakeholder engagements during the development of an adaptation strategy for heat waves. The research was conducted within the context of climate change and human health. Indeed, the research explored participants' views about heat waves, their understanding about the consequences of heat waves, their knowledge, risk perceptions and adaptive behaviours during a heat wave taking into account climate change. The study focused on heat waves because they are of public health significance, and given that they have been projected to increase as a result of climate change (Meehl & Tebaldi 2004). In particular, the research was conducted in Adelaide, Australia since the city has experienced record-breaking heat waves in recent years.

The findings of this research suggest that participants' experience of heat waves may have explained the high level of awareness and adaptive behaviours within the study population. Participants' responses indicated that heat waves evoke negative emotional and psychological reactions. The findings of this work show that there are some demographic factors that are significantly associated with risk perception and adaptive behaviours in relation to heat waves. A case study of policy development for heat waves indicates that the process can be effective using a participatory approach, involving a broad range of stakeholders within the context of good governance and institutional mechanisms. This chapter summarises the key findings of the previous chapters. Figure 9.1 presents a conceptual model that shows the relationship of the findings of this research project. The specific methodological limitations are not revisited in depth here since they have been addressed in each of the chapters. The strengths and weaknesses are presented followed by the theoretical and policy implications. The chapter ends by suggesting some areas for future research.

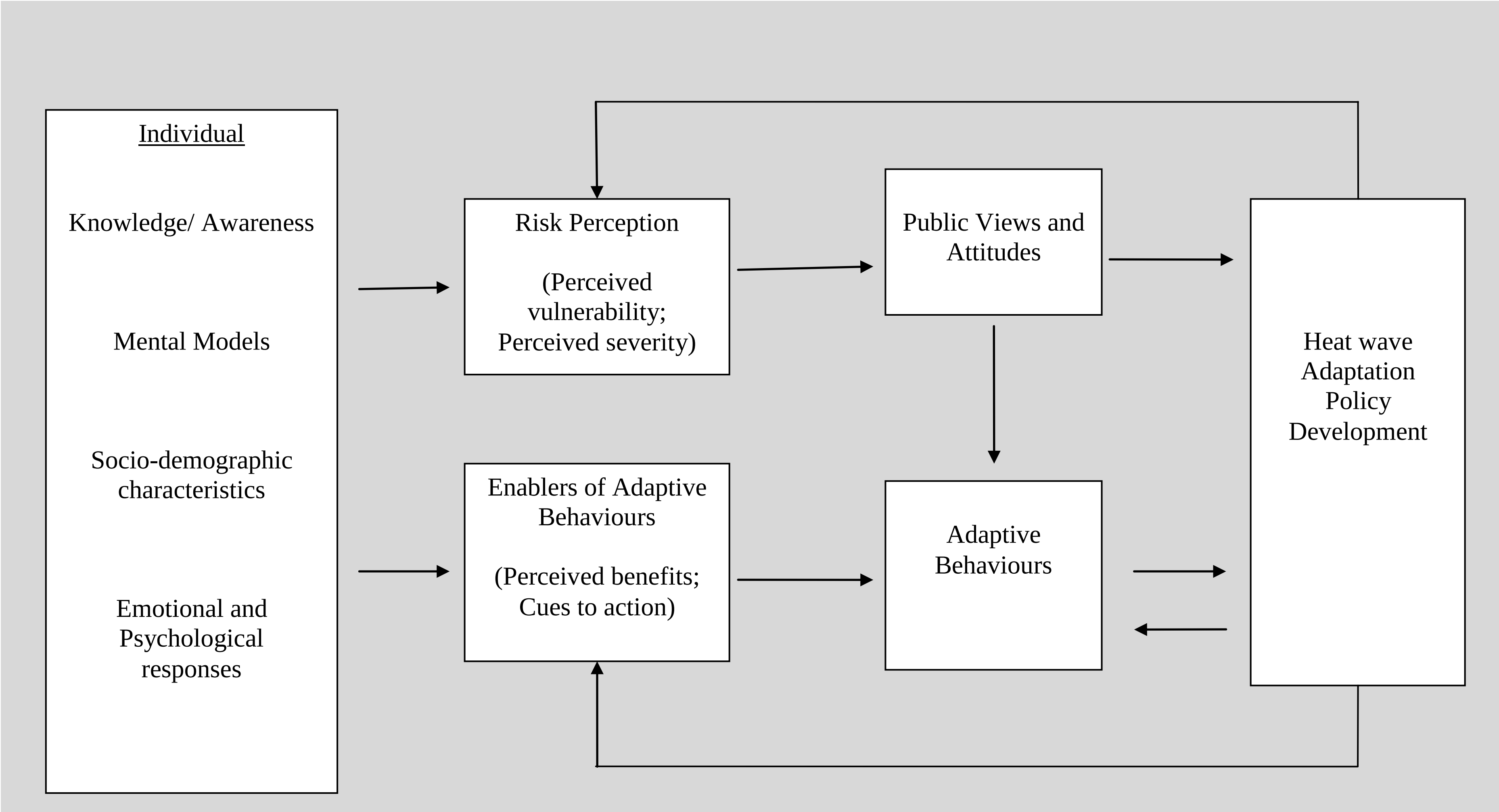

Figure 9.1 : A conceptual model of public perceptions, understandings, attitudes and adaptation to heat waves in a changing climate

9.2 Key findings of the study

The main empirical findings are chapter specific and were summarized within their respective chapters. The following section presents a synthesis of the key findings of the research project.

9.2.1 Participants' views on the link between heat waves and climate change are influenced by the uncertainty characterised by weather and the climate system

Most participants in Adelaide did not believe that heat waves experienced in the city prior to this study (e.g., the 2008, 2009, 2010 heat waves) were associated with climate change. While scientific evidence points to the fact that recent heat waves experienced were consistent with climate change projections, certain participants in study had different perspectives. This finding highlights that there was still denial and scepticism among certain individuals that frequent heat waves were as a result of climate change. Although there is scientific evidence, based on projections that heat waves would likely increase in frequency, intensity and duration in future (Meehl & Tebaldi 2004), most participants were ambivalent since they believed that climate-related projections are characterised with some degree of uncertainty. Nevertheless, participants opined that there has been a considerable change in weather pattern over the past years. It should be noted that people's views and beliefs about a particular phenomenon may change over time. Consequently, the experience of a severe heat wave at a later period may alter public opinion about rising global temperatures, heat waves and climate change.

9.2.2 Participants modify their behaviours during a heat wave

Participants in this research contend that heat waves pose a threat to their health and they mentioned a number of adaptive behaviours they usually undertake to stay safe during a heat wave such as drinking sufficient water to stay hydrated, reducing physical activity and listening to daily weather forecast to plan their outdoor activities. Although most of these preventive behaviours have proved to be successful in reducing heat-related morbidity and mortality, it is important for their effectiveness to be evaluated. More particularly, concise and targeted messages should be directed to vulnerable groups such as the elderly, the poor or the homeless to avoid misguided behaviours (Bouchama et al., 2007). Individuals could also be targeted by messages and information delivered through interpersonal networks (e.g., friends, relatives, educators, community leaders) and health care providers (e.g., the Telecross REDi which targets the elderly in Adelaide) in order to influence behaviour change (Dutta-Bergman 2004).

As reported in Chapter 6, 82.2% of participants had good adaptive behaviours during a heat wave. This finding may be as a result of participants' previous experience of heat waves and increased public awareness for heat wave warnings and health-preventive behaviours provided in recent years. It is noteworthy that since the heat wave response plan was developed in Adelaide, authorities have stepped-up public communication of any impending heat wave with advice provided on how to stay safe.

9.2.3 There exist knowledge gaps in the community about heat waves

The study applied the mental model approach to explore people's understanding about the consequences associated with heat waves. A prerequisite for any successful adaptation may depend on how individuals understand the consequences associated with the threat, although having knowledge and understanding about a particular threat may not necessarily translate into effective action. The study found that residents in Adelaide had a good understanding about the consequences of heat waves. However, there were a few gaps in the level of understanding among the participants. For example, participants were not able to mention that those who are obese and those on medications are vulnerability to heat waves (Koppe et al., 2004). The study also found that differences in knowledge and understanding about heat waves exist among individuals residing in the same community, even if they share similar socio-cultural and demographic characteristics. The mental models uncovered in the study may be explained by participants' inadequate knowledge about the consequences/risks associated with heat waves as well as due to their existing misconceptions about the heat waves. Identifying knowledge gaps and misconceptions in the community would enable authorities to develop concise messages to be communicated to the community to reduce any misinformation and strengthen their level of knowledge and understanding about heat waves and its consequences.

9.2.4 Heat waves are associated with negative emotional and psychological reactions

This research found that residents in Adelaide have a number of negative emotional and psychological responses during a heat wave. For example, fear, worry and anxiety were among the emotional reactions experienced by the participants. Emotional and psychological reactions may affect the mood of certain vulnerable populations, and some may become distressed, depressed which might affect their mental well-being. These findings suggest the need for social services (e.g., counselling and psychosocial support services) to be strengthened to provide support to those who might need them during a heat wave. Furthermore, residents in Adelaide are concerned about a number of issues whenever a heat wave occurs in the city. Participants in this study expressed concern about sleeping well, decreased agricultural productively, drying-off of their garden, the safety of their pets, and the cost of running an air-conditioner during a heat wave. Indeed, the cost of running an air-conditioner has been one of the barriers to staying cool during a heat wave (Sheridan 2007). This research found that the media is a prominent and integral source from which participants acquired information about heat waves. Hence, the way information is framed and communicated to the public during a severe heat wave (e.g., a heat wave that results in the death of individuals, bushfires etc.) might affect the emotional and psychological well-being of certain individuals. It is hoped that these findings may inform policy makers to strengthen services to support those in need during and after a heat wave.

9.2.5 There are variations in public attitudes towards heat waves in a changing climate

Although there was widespread awareness and the fact that participants were more concerned about the societal effects of heat waves, there were differences in attitudes among participants on certain aspects related to heat waves. For instance, 69.9% of the participants believed extremely or very likely that if heat waves were to increase in future, it would have severe consequences for society and the health of residents in Adelaide.

In Chapter 5, most participants' were more concerned about the societal impacts of heat waves than on themselves. This finding may explain the fact that most people don't consider the consequences of heat waves on them to be significant since they might take preventive actions to stay safe; however, they might believe that the consequences of heat waves to society are quite severe (e.g., bushfires, low agricultural productivity and economic losses as highlighted in Chapter 4). Additionally, women were more likely to be concern about the effects of heat waves. This finding is consistent with previous research which suggests that women tend to be more concern about environmental hazards than men (McCright 2010; Searle & Gow 2010).

Furthermore, attitudes also differed in relation to the immediacy of heat waves, as 49.3% of the participants indicated that Adelaide was already feeling the effects of heat waves; while 5.3% indicated that the effects would be felt beyond the next 25 years. This study further contributes to our understanding of Adelaide public's attitudes (e.g., what the public thinks about scientific projections that heat waves might likely increase in future) towards heat waves in a changing climate. Overall, due to the ongoing public discourse about heat waves and climate change it is likely that participants attitudes towards heat waves might have been influenced by their views on climate change.

9.2.6 People's perceived vulnerability and risk perception will depend on the severity of the heat wave

Most participants felt a high vulnerability to the heat wave scenario applied in the study. Moreover, about half of the participants (50.9%) were found to have a high risk perception to the heat wave scenario. These findings may be important because they shed light to emergency services on the extent to which individuals perceive a severe heat wave and provides these agencies an idea about the kind of emergency preparedness measures that need to be galvanised in the event of an extreme heat wave. We are reminded of the fact that projections show a rise in temperatures across most cities in Australia, which would likely result in an increase in the intensity and duration of heat waves (Suppiah et al., 2007). Although the heat wave in this study was hypothetical, given the 2013 heat waves experienced across Australia (Lloyd 2013; Lyell 2013; Villamarin 2013), it may be likely that such an extreme heat wave may be experienced in future. The study has made a contribution to examine how individuals evaluate the risk associated with a severe heat wave. The extent to which people perceive risks associated with climate-related events (e.g., heat waves) may influence policies that support adaptation. On the other hand, understanding public risk perception of heat waves could be important in developing risk communication strategies.

9.2.7 Socio-demographic factors are associated with heat wave-risk perception

Overall, this research was able to show that factors such as age, marital status, gross annual household income, fan ownership, and living arrangements were associated with risk perception to heat wave. More specifically, the study found that participants who were married, who earned a gross annual household income of ≥$60,000 and without a fan were less likely to have a high risk perception to heat waves. Those who were living with others were more likely to have a high risk perception to heat waves.

9.2.8 Usefulness of the health belief model and factors associated with adaptive behaviours during a heat wave

Among the constructs of the HBM, perceived benefit and "cues to action" were the main significant predictors of adaptive behaviours during a heat wave. These findings therefore underscore the usefulness of the HBM in examining adaptive behaviours during a heat wave. This study also identified some of the socio-economic/demographic characteristics that would predict adaptive behaviours during a heat wave; one of which was household income. In fact, individuals with a higher household income were more likely to have good adaptive behaviours during a heat wave. Household income in the context of heat waves may play an important part in air-conditioner ownership and use during a heat wave. Studies have shown that the financial cost of running an air-conditioner is a barrier among certain groups during a heat wave (Sheridan 2007). This finding supports the existing scholarship that individuals with a higher socio-economic status will less likely suffer from heat-related mortality and morbidity since they are more likely to take steps to keep themselves cool during a heat wave (Curriero et al., 2002). This study makes a contribution in identifying the factors that would predict the adoption of healthy behaviours during a heat wave. Identifying these factors is useful for health promotion specialists as it guides them in the design and implementation of programs to encourage appropriate behavioural adaptation during a heat wave.

9.2.9 Strong leadership, good governance and an enabling environment are foundations for the successful development of heat wave-adaptation strategies

The impacts of climate change are evident by events such as frequent heat waves which have negative consequences for human health and society at large. In the face of these impacts, policy makers, emergency management personnel, health authorities, service providers, meteorologists and other interested groups face the task of responding to the social, health, environmental and economic challenges that heat waves might pose to society. Of course, adaptation remains indispensible to respond to these climate-related impacts (e.g., heat waves). To effectively respond to the impacts of heat waves, there is a need for an adaptation strategy, plan or policy to be in place; the absence of which may undermine any successful heat wave response effort.

In the past, multi-stakeholder processes have proven to be successful in responding to societal challenges. This study applied this concept to explore the participatory process during the development of an adaptation strategy (heat wave policy) for heat waves in Adelaide. The findings show that there was good governance and institutional arrangements during the process of developing the policy. Good governance is fundamental in participatory processes as it enhances consensus-oriented decision making; it ensures that both formal and informal actors are involved in decision-making. To a larger extent, the views of all the stakeholders involved were taken into account during decision-making.

Although governance is a cornerstone for any participatory process, it could be sometimes difficult to ensure effective governance in its totality. For example, in this participatory process, not all the relevant actors were involved. Nevertheless, policy makers should strive to promote good governance in heat wave policy development processes. Adequate institutional arrangements played a major role in making the process successful. As a result, there is need for a lead institution to be identified that sets the goals, objectives and agenda of the process and coordinates the policy development process. There was a lot of interest and motivation to get things done during the process; that explains why there was strong leadership and political commitment demonstrated throughout the process. The existing laws governing emergency management, structures and systems greatly facilitated the process.

9.2.10 The inaugural nature of the adaptation strategy development process had a few challenges

Multi-stakeholder processes bring together individuals with different views, knowledge and skills; such processes are likely to face challenges. In processes related to adaptation, uncertainty about the event (e.g., heat wave), its complexity, lack of reliable data and adequate understanding are common place. Climate change by its self has proven to be challenging even to scientists. In the policy process explored in this study, the main challenges faced by stakeholders were related to the difficulty of some stakeholders to understand the meteorological science associated with heat waves at the time. It is therefore important for a core group of stakeholders involved in a heat wave policy development process to be knowledgeable about the science of heat waves. This core group which may comprise technical experts, meteorologists, through cooperation and knowledge exchange could transfer knowledge and understanding to others involved in the process. The study also highlights the need for mechanisms to be put in place to promptly address any differences in view points among stakeholders involved in a heat wave policy development process. Overall, multi-stakeholder processes if well planned and coordinated are quite effective in bringing together relevant groups in responding to the impacts of heat waves.

9.3 Strengths, limitations and challenges

This research project has addressed knowledge gaps in relation to the public understandings, emotional responses and adaptive behaviours to heat waves in the context of climate change. The findings make an important contribution to the knowledge base for the development of adaptive and risk communication strategies for heat waves. Furthermore, the study has examined the process of policy development for heat adaptation and identified the challenges inherent in this process. This research work has used several novel approaches to gather and analyse data representing the views and behaviours of the population of Adelaide. In particular, the use of the Health Belief Model to examine the relationships between risk perception and adaptive behaviours represents an innovative approach in this area. Using a heat wave scenario to elicit risk perception was another novel approach. A particular strength of the research project is that both qualitative and quantitative research design were utilised; which increase the overall validity of the findings. This mixed method approach has culminated in a comprehensive investigation of population perceptions, attitudes, adaptive behaviours; through to policy making process for a coordinated heat wave response.

The main limitations of this research study have generally been addressed in each of the chapters; thus only a few will be mentioned in this section. For the qualitative studies described in this thesis (Chapters 3, 4, 7 and 8), the limitations discussed relate to how well the studies identified the range of views on heat waves and the depth of understanding acquired. Generally, qualitative studies do not seek to make conclusions that are generalisable to populations; rather they seek to identify and explore the different views on a topic in great depth (Crouch & McKenzie 2006). In this work this was achieved by continual data collection to the point of data saturation (the point reached during interviews when no new ideas, meanings and themes are provided after a number of participants have been interviewed- this usually informs the researcher when to stop data collection), followed by thorough data analysis to reveal the underlying meanings. In Chapters 3 and 4, a convenience sample of NWAHS participants who expressed willingness to participate in the study were interviewed. It is possible that alternative views and meanings existing within the community were not revealed during this study. For example, it may be likely that those who were not interviewed would have had different views about the phenomenon. It is also possible that views about heat waves, particularly in the context of climate change, will change with time, and this may become apparent in any future studies.

For the quantitative survey study (Chapters 5 and 6), limitations were possible in relation to sampling and bias. For example, there was no defined probability sampling strategy (e.g., random sampling) used to select participants for the study. As a result, individuals in the North West Adelaide Health Study cohort did not have the same chance to participate in the study. In Chapter 6, participants' scores for knowledge about heat waves, perceptions and adaptive behaviours were dichotomised to facilitate analysis. For example, the researcher intended to use logistic regression for analysis with adaptive behaviours as a binary variable. It should be noted that categorisation results in loss of information and may have affected the results. Another possible limitation of this research project relates to the application of specific words. For example, the words "climate change" and "global warming"; "heat waves" and "extreme heat events" were sometimes used interchangeably respectively in certain studies in this research project. A challenge experienced during the project was related to the logistics of conducting some studies to coincide with a heat wave based on the acceptable definition in Adelaide, South Australia. During this period, daily maximum temperatures were high, but the number of days did not meet the criteria for a heat wave. As a result, a hypothetical heat wave scenario was used in one of the studies.

9.4 Theoretical implications

The findings of the present research have some theoretical implications for studies related to heat waves and climate change. The following sections summarises the main theoretical implications from this research.

9.4.1 Mental models are useful to obtain information about people's understanding about heat waves

In Chapter 4, the mental model was applied as a conceptual framework to explore participants' knowledge and understanding about the consequences associated with heat waves. The concept of mental model has widely been used in climate change studies (Kempton 1993; Lorenzoni, Pidgeon & O'Connor 2005). Mental models are sometimes based on incomplete facts, previous experiences and intuitive perceptions may shape actions and behaviour. Furthermore, they may define how people understand and solve societal problems (Morgan et al., 2002). Indeed, mental models are widely used to identify gaps in knowledge/understanding among individuals about a specific phenomenon. Assessing the public's understanding of the consequences of heat waves could be important in designing risk communication strategies. In this research, although participants had an understanding about the consequences of heat waves, there were some gaps in their level of understanding. The results further show that there were differences in the level of understanding about the consequences of heat waves among the participants. This finding demonstrates that mental models are not uniform among individuals living in a given community, even if they share similar socio-cultural and demographic characteristics (Besnard, Greathead & Baxter 2004). It further highlights the difference between expert and non-expert knowledge and understanding about scientific concepts. It is uncertain if participants' mental models would have been different if the study was conducted outside of the hot/summer season. Identifying those incorrect beliefs facilitates the development of risk communication messages to address any incorrect knowledge or misconception/misrepresentation about heat waves (Morgan et al., 2002).

9.4.2 The health belief model is a useful framework to study risk perception and behaviour modification during heat waves

The study presented in Chapter 6, was designed on the premise that an individual's motivation to adapt to climate change risks (e.g., heat waves) may be influenced by his/her relative risk perception (Grothmann & Patt 2005). Risk perception in this context expresses how an individual perceives the chances of being vulnerable to a threat and how he/she beliefs about the perceived severity of the threat. There has been limited contribution of the field of health promotion in understanding perceptions and behaviour change related to environmental health hazards such as heat waves. Consequently, this research applied the HBM as the theoretical framework for two reasons. First, to estimate risk perception (using the constructs of perceived vulnerability and perceived severity) of heat wave using a heat wave scenario. Secondly, to determine the extent to which people's adaptive behaviours would be shaped by their perceptions of heat waves.

The findings have demonstrated that the HBM could be used to determine risk perception to heat waves and examine the factors that might shape adaptive behaviours during a heat wave. Perceived benefit and cues to action are important predictors that would influence motivation for behaviour change during a heat wave. More than half of the participants had a high risk perception to the heat wave. Despite the uncertainty about future heat waves, this study was able to demonstrate that risk perception and to a larger extent adaptive behaviour could be predicted using scenarios for heat waves.

9.4.3 Participatory processes facilitate the development of adaptation strategies for heat waves

In Chapter 7 and 8, the concept of multi-stakeholder processes was explored during the development of an adaptation strategy for heat waves in Adelaide. Indeed, responding to current or future threats posed by climate-related risks such as heat wave necessitates the collective action of stakeholders. These individuals have a vested interest to ensure that they protect those they represent from societal and health challenges. Although the concept had widely been explored in different sectors, it had not been applied in the context of health adaptation to climate change. The results of the study support the existing scholarship that there is a benefit when public policies and strategies are developed within a participatory manner, with the involvement of a diverse group of stakeholders. For heat wave planning, these stakeholders may include groups such as government departments and agencies, local councils, researchers and academics, emergency services and health professionals, community organisations and service providers (e.g., groups representing people with disability, and culturally and linguistic diversity communities), private sector businesses, the media and utility providers (Victoria Government 2009).

Nevertheless, the study also highlights the fact that factors such as political commitment, strong leadership, effective coordination, accountability, transparency, trust and relationship building, knowledge of the meteorological science of heat waves, timely resolution of diverging ideas and opinions are amongst the crucial factors that would determine the success of any participatory process to develop an adaptation strategy for heat waves. This research has no doubt contributed to our understanding about how the concept of multi-stakeholder processes was conceptualised during the development of an adaptation strategy for heat waves in Adelaide.

9.5 Policy/ practical implications and recommendations

9.5.1 Strengthen community education about heat waves

There are existing gaps in knowledge and understanding about heat waves in the community. In order for the public to respond effectively during periods of heat waves, it is important that they have a good knowledge about heat waves and what actions they need to take to stay safe. At the community level, authorities should collaborate with local groups to promote health education about heat waves. Health education could be achieved through designing and disseminating tailored and concise messages through the mass media. Mass media messages have the advantage of reaching a majority of the population including some vulnerable population, although these messages may not reach other vulnerable groups such as the homeless. In addition to mass media, educational materials about heat waves should be developed and distributed to the public in the form of flyers, brochures, posters and pamphlets.

In addition, visual/pictorial representation about heat waves could be used during community education campaigns. This could be important for groups with low literacy skills (e.g., CALD communities) who are likely to understand information presented in the form of diagrams and pictures rather than in texts. There are studies which have shown that individuals exposed to pictures and diagrams are more likely to have a better understanding of health messages

(Houts et al., 2006). If the use of pictures/diagrams has shown to be successful in other health education programs, this could be tested in the case of heat waves.

9.5.2 Apply the HBM in heat waves behaviour change programs

This research project has shown that the health belief model could be a useful tool in predicting adaptive behaviours during periods of heat waves in Adelaide. Therefore, authorities, health promotion experts should apply the health belief model in the design and implementation of interventions to promote behavioural modification during a heat wave. Generally, the purpose of any health education programme is to educate the public, providing them information that will improve their health and reduce any health risk. It is important that those behaviours that place individuals at risk are identified such that they are targeted with health messages. For example, if individuals are noted to undertake strenuous physical activities or drinking excessive alcohol during a heat wave, such behaviours that put them at risk may be targeted.

Health messages could be developed based on each of the constructs of the HBM and disseminated to the public through various channels. A typical message for the construct of perceived vulnerability could be thus: "A heat wave has been declared in our community. Temperatures are soaring. Heat waves are a threat to human health. Everyone is at risk during this period; young or old". For perceived severity, health messages could be framed as: "Exposure to heat wave may lead to sun-burn, skin cancer. Heat waves could lead to heat-related illnesses, deaths and other consequences". In the same light, health messages in relation to perceived benefit could be framed as: "If everyone spends more time in an air-conditioned environment, drink lots of water, reduce physical activity, it would reduce the chances of suffering from heat related illnesses and deaths". Messages targeting perceived barriers should enable individuals understand that the benefits of taking preventive action overweighs the cost. For example, if cost of electricity is identified as a barrier among the elderly, messages could be framed as: "Do not be so concerned about the cost of running your air-conditioner; your health is more important than the cost of electricity. Government has taken steps to provide electricity rebates to seniors". Health messages for "cues to action" should be aimed at providing information, awareness and triggers to encourage individuals to undertake precautionary measures to stay safe during a heat wave.

9.5.3 Promote social welfare programs for seniors with lower socio-economic status

This research confirmed previous reports that certain individuals were concerned about the cost of running an air-conditioner during a heat wave. The high energy bills may particularly affect low-income households and other vulnerable groups such as the elderly which might put them at risk. Existing policy options need to be strengthened while new ones explored for state governments to assist such groups of people to manage their electricity cost during heat waves. For example, state governments should strengthen social programs designed to assist eligible seniors and pensioners during periods of extreme heat in Adelaide. Programs such as concessions and the electricity rebates should be strengthened (Government of South Australia 2012; Queensland Government 2012) in order to benefit those groups within the population who cannot afford to run an air-conditioner due to cost.

9.5.4 Increase access and utilisation of cooling centres

An alternative policy response in relation to the cost of running an air conditioner could be to establish more cooling centres for the population. Some of the centres may be established in neighbourhood communities as this would make access to these centres easy by some elderly individuals. For cooling centres which are in the city, authorities could put in place facilities for transporting individuals to and from those cooling centres. Aside from transport facilities, there are other factors that authorities should consider in relation to cooling centres. Issues such as security, duty of care for the elderly, first aid, activities/entertainment, availability of drinking water facilities in these centres should be taken into account.

Furthermore, utilisation rates should also be considered while establishing these centres. For example, it has been suggested that cooling centres are not well used by those who are at increased risk of heat-related morbidity and morbidity, but rather by low risk individuals (Kovats & Ebi 2006). In such a situation, the reasons for poor utilisation should be investigated in order for appropriate actions to be undertaken. Overall, more evaluation studies are needed to assess the effectiveness of cooling centres in reducing heat-related morbidity and mortality (Bassil & Cole 2010). Finally, authorities can determine whether private companies could be supported to provide cooling facilities in places such as shopping malls and cinemas.

9.5.5 Strengthen counselling and mental health services

This research study found that heat waves affect the psychological and emotional wellbeing of certain vulnerable groups which may likely impact their mental health. The effects of heat waves on mental health has previously been investigated (Hansen et al., 2008b) and vulnerable groups are affected through both direct and indirect pathways (Berry, Bowen & Kjellstrom 2010). As a result, policy makers, social and health workers would have to strengthen services to provide emotional, counselling and psychosocial support to individuals in the community who might be affected (and need them) during a heat wave. If possible these services should be integrated with the existing primary health care system (Berry, Bowen & Kjellstrom 2010).

9.5.6 Implications for heat waves-risk communication

Effective risk communication to the public requires an understanding of the way people conceptualise the risk associated with the threat. This research has described how heat wave risk is currently perceived within the Adelaide public, and the factors that may influence risk perception. Differences in risk perception related to socio-demographic factors and heat wave intensity demonstrate that risk perception is a complex process, and that policy makers may need to use multiple approaches to engage with all sectors of the community. If the level of risk perception of heat waves among the public is high, policy makers would find it easier to effectively engage with the public because of their acceptance of the risk. Consequently, this may facilitate public engagement in the design and delivery of risk communication messages. Overall, it is important that emergency management workers and other service providers take into account these factors when they design and implement risk communication strategies for heat waves.

This research found that the media is a valuable source for heat wave information which could play a significant role in risk communication. The media has to communicate messages to the public about the nature of heat wave and what people need to do to stay safe. Messages need to be clear, concise, consistent, reliable, targeted and framed in an appropriate manner to avoid panic and confusion among the public. Such messages would enable the public to make sound judgements and informed decisions to stay safe during a heat wave.

9.6 Future research direction

This research project has answered defined questions related to population health and heat waves in the context of climate change. However, there will be a continuing need for additional research to be conducted within this area. Future studies could be conducted in the following areas:

9.6.1 Risk perception and adaptive behaviours during heat waves

Cognitive factors play an important role in shaping adaptive behaviours (Grothmann & Patt 2005). There are many socio-cognitive theories that have been used to study health behaviours. As indicated in Chapter 6, the HBM was applied in this research because some of its constructs relate to perception (e.g., perceived vulnerability and perceived severity). Hence, the researcher decided to test the suitability of its constructs in the study. Further research could be conducted using other cognitive theories (e.g., the Protection Motivation Theory, Protection Action Decision Model) to study risk perception and how they might influence adaptive behaviours during heat waves. There is currently limited empirical research on risk perception and risk communication related to heat waves. More research is therefore needed to test new tools and methodologies to quantify risk perception to heat waves. In addition, a naturalistic observational study could be conducted to determine the adaptive behaviours of a sample of participants during periods of heat waves. Such a study would assist in triangulating the findings obtained from a questionnaire study which are mainly self-reported.

9.6.2 The role of "affect" in risk perception to heat waves

The public's perception of climate-related risks may be influenced by how people understand the uncertainty of climate change (Weber 2010). Individuals interpret future events differently from how they interpret current events, because future events are construed in more abstract terms while current events are interpreted in a more concrete manner (Trope & Liberman 2003). As a result, understanding the public perception of climate-related risks and impacts through the use of affective imagery may be useful in identifying, describing and explaining those images that may have an impact on the public; and which may influence their motivation to adapt to the impacts of climate change (Leiserowitz 2005; Lorenzoni & Hulm 2009; Lorenzoni et al., 2000). Future research could be conducted to examine the role of affective imagery in shaping risk perception to heat waves with the aim of exploring how this might potentially influence adaptive behaviours.

9.6.3 Social media, heat waves and risk communication

The media plays an important role in educating the public about climate-risks and is useful in disseminating information to enable the public to prevent harm from hazards (Boykoff 2010). Recently, emerging communication technologies such as Facebook and Twitter are being used as a form of public communication. Future studies could examine the role social media could play and how feasible these emerging technologies could be as a channel for risk communication during heat waves in urban areas. Such studies should also examine the inequalities associated with access to, knowledge and use of these communication technologies that may exist among individuals and communities.

9.6.4 Culture, social capital and network in facilitating adaptation to heat waves

Studies have shown that social networks are important in adapting to heat waves (Klinenberg 2002) although differing results have been obtained elsewhere (Wolf et al., 2010). Future studies in Adelaide could be conducted to examine the role of culture and social networks in facilitating adaptation to heat waves. Such studies should also examine the types of interventions needed to enhance community resilience to heat waves in Adelaide.

9.6.5 The psychology of heat waves

This research project has illustrated that heat waves affect the emotional and psychological wellbeing of certain individuals in the community. Further quantitative studies could be conducted to examine the effects of heat wave on mood, anxiety and depression. Such studies could use standardised instruments which have previously been used in the field of psychology but adapted to study heat waves.

9.7 Closing remarks

There is increasing recognition that climate-related risks such as heat waves pose a threat to human health and that adaptation planning will be important to minimise the health impacts. The studies described in this thesis have increased our understanding of people's views, their attitudes, risk perception of a heat wave scenario, and heat-adaptive behaviours. Furthermore, the study sheds light on the effectiveness of multi-stakeholder processes in the development of adaptation strategies for heat waves.

Although there is a vast amount of scientific literature suggesting that heat waves are related to climate change, some people's views about heat waves were more strongly tied to their experiential knowledge than to climate change projections. This finding may highlight the fact that the public has been polarised by media and political discourse about climate change. This research has identified some of the emotional and psychological reactions associated with heat waves; as well as the social, environmental and lifestyle concerns of the public. Furthermore, the study found that gaps exist in the level of understanding about the consequences associated with heat waves within the community. These findings will inform new approaches and strategies to enhance people's understanding about the risks associated with heat waves and to engage them in adopting protective behaviours.

The extent to which people perceive heat waves as threatening will guide the development of risk communication strategies. Using the health belief model, this research has identified a number of socio-demographic factors that can predict risk perception and adaptive behaviours in relation to heat waves. It further makes an argument for psychological/cognitive characteristics to be taken into account in designing and implementing behaviour change programs for heat waves.

At the policy development level, relevant stakeholders face the task of putting in place strategies, policies and actions to protect vulnerable groups from future impacts of heat waves. This is based on the recognition that concrete and timely strategies and actions would significantly reduce human vulnerability to heat waves. This research has shown that participatory processes that include a wide variety of stakeholders are effective in the development of heat wave-adaptation strategies. During the development of these strategies, decision-making is key since the extent to which relevant stakeholders feel that their views are taken into account may determine the success of the adaptation process. Consequently, this work has contributed to our understanding that strong leadership, governance; effective legislative and institutional frameworks are among the factors required to ensure the successful development of adaptation strategies for heat waves. If these heat wave adaptation strategies are in place and appropriately implemented, this would contribute to reduce human vulnerability to current or future threats posed by heat waves in a changing climate.

9.8 References

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APPENDICES

Appendix A: RELEVANT ADDITIONAL MATERIALS

1. Introduction

Since most journals usually have word limitation, there are certain methodological details which could not incorporated in the manuscripts. Therefore, this appendix provides further information about the research studies that were conducted which will be relevant for any future reader of this thesis. As previously explained, three studies were conducted (two qualitative studies and one quantitative studies). It should be recalled that participants who took part in study 1 and study 2 were recruited from the North West Adelaide Health Study Cohort while those in study 3 were stakeholders who were involved in the development of the adaptation strategy for heat waves. This chapter has been organised into three sections. The first section provides detail methods for the qualitative study (study 1), the second section outlines details of the questionnaire study (study 2) and the third section provides details about the case study (study 3) conducted to explore multi-stakeholder processes during the development of heat-warning system and response plan.

2. QUALITATIVE STUDY

(STUDY 1)

2.1 Development and pre-testing of the interview guide

The interview guide (Appendix D) was developed after a review of the literature on climate change, global warming and heat waves. The interview questions were open-ended and explored participants' views about heat waves in relation to climate change, the understanding about consequences associated with heat waves, their concerns and worries during a heat wave and the actions they usually undertake to stay safe during a heat wave.

The interview questions were then forwarded to five experts with experience in conducting qualitative research in the fields of sociology, psychology, public health, anthropology. These experts were asked to review the questions and propose suggestions to improve the questions. The experts reviewed the questions and provided feedback and suggested that some questions should be re-worded. The questions were revised based on the suggestions of these experts. The revised interview guide was forwarded again to three of the initial experts for final expert validation. The interview questions were pre-tested among two participants via telephone. The purpose was to test the questions and check whether there were any issues regarding wording, understanding and the time it might take for each interview. Pre-testing was aimed to identify what needed to be corrected before the actual interviews. Pre-testing was conducted as if it was the actual study, with both follow-up and probing questions posed. These interviews were audio-digitally recorded and short notes were also taken. Some of the interview questions were then reworded on the basis of the pre-testing.

2.2 Data collection approach

A convenience sample was selected from the NWAHS cohort members who agreed to take part in the telephone interview study. Selected individuals were contacted by a staff member of the NWAHS in mid December 2011 to remind them about the study and to obtain permission for their telephone numbers to be passed on the PhD candidate who would conduct the interviews. A week later, a package containing an approach letter (Appendix E) and the information sheet **(**Appendix F) was mailed to the participants. The information sheet provided details about the study, how data collected would be used and their rights as a participant. Participants were assured that any information they provided would be kept confidential and their privacy maintained.

A few days later, the PhD candidate contacted the participants via telephone, introduced himself and arranged for a suitable date and time to conduct the interviews. Each individual was again contacted the day before the interview date to remind them about the interview and to check if they would still be available for the interview. All participants who were contacted indicated that they were looking forward for the interview the following day. In qualitative research, equipment failure may undermine the quality of data that is collected through interviews (Easton, McComish & Greenberg 2000). As a result, all the equipments (e.g., the audio-recorder, batteries) were checked prior to each interview to ensure that they were working properly. There was also a “standby” recorder and batteries available prior to each interview.

Although participants had been sent an information sheet, they were provided information about the interview at the start of each interview. Participants were informed about the structure of the interview, the estimated interview duration, that the interviews will be recorded and were assured their confidentiality. Oral informed consent was obtained from each participant prior to the start of each interview. Each interview began with an opening question, which was later followed by the main questions. The interviews were open-ended and semi-structured in order to gather the views and perspectives of the participants. As interviews were semi-structured, questions were not necessarily posed in the same order as they appeared on the interview guide, as the sequence changed based on how the interview progressed (Cooper et al., 2005). Probes were used during the interviews to elicit more information from the participants (Patton 2002, p.373; Rivero-Mendez, Dawson-Rose & Solis-Baez 2010). In addition to probes, follow-up questions were used to explore new areas which had not been previously thought of, as these mainly arose during the interview (Gray 2004, p.217).

The interviews were conducted during summer following days of hot weather in Adelaide (as explained in the manuscripts), since it was important for the hot weather to be salient to them at the time. Interviews were conducted among 14 participants until saturation was reached. Prior to the end of each interview, participants were asked *"What other things would you like to add in relation to what we have just discussed?"* All the interviews were audio-digitally recorded although short notes were also taken. The interview duration ranged from 15 to 40 minutes. At the end of each interview, basic socio-demographic data were collected from the participants. All participants were thanked for taking part in the interview. A gift voucher of $20 was later forwarded to all the participants as a token of appreciation for their contribution to the study.

2.3 Additional materials on theoretical framework applied in Chapter 4 (Mental Models)

The mental model theory originated from the field of psychology and has widely been applied across many academic fields. A "mental model" is an individual's thought processes, understanding and interpretation of a particular phenomenon in the real world. They are the cognitive representations that are held by individuals about their surrounding environment (Moseley, Desjean-Perrotta & Utleyb 2010). Mental models are shaped by peoples' prior knowledge, existing ideas and past experiences and individuals use them to reason, interpret and explain the world (Lambert & Walker 1995). They influence how individuals conceptualise and interpret new concepts and they are constructed in people's minds as a result of their perception, imagination, knowledge and world views (Johnson-Laird 2013). It has been suggested that mental models may be unstable, inaccurate, inconsistent and incomplete and they may change over time as individuals acquire new knowledge through social interaction (McClary & Talanquer 2011).

Mental models have also been applied in the field of natural hazards. Mental models for a particular hazard seek to identify both the correct and incorrect beliefs that are held by individuals (Breakwell 2013). By identifying those incorrect beliefs, it facilitates the development of risk communication messages to address any incorrect knowledge or misconception/misrepresentation about the hazard (Morgan et al., 2002). Many studies have examined lay and expert mental models of climate change. For example, previous research found participants' misconceptions and inconsistencies on how people understood the physical mechanisms relating to climate change. In fact, most participants indicated that climate change is caused by increased ultraviolet light entering the atmosphere due to ozone depletion (Bostrum et al., 1994). Similar misrepresentations have also been reported in other climate change research (Etkin & Elise 2007; Kempton 1993; Lorenzoni, Pidgeon & O'Connor 2005). It has also been applied to study how experts and non-experts conceptualise wildfires (Zaksek & Arvai 2004).

With regard to heat waves, researchers applied a modified mental model approach to examine knowledge gaps between experts and the lay public in relation to climate-induced heat wave health risk. They found that although there were significant variations, public knowledge and perception of climate change and its associated hazards were somewhat similar to expert knowledge (Chowdhury, Haque & Driedger 2011). Overall, the concept of mental models posits that people have some existing knowledge about a hazard and they could be supported to better understand the hazard and its risks so as to make informed decisions. This could only be possible after identifying the incorrect knowledge and understanding about the hazard. Thus information designed to enable people have a better understanding about a phenomenon should be presented to them in a simple form that is in line with their belief systems (Morgan et al., 2002).

2.4 Data management and transcription

The interview notes were developed at the end of each interview and stored in a locked-file cabinet. The audio-recordings of the interviews were downloaded and later transcribed verbatim (Morrison-Breedy, Cote-Arsenault & Feinstein 2001) and stored in the password protected computer in the Discipline of Public Health, The University of Adelaide. The transcripts were later read, cross-checking with the interview notes. Later, each transcript was read again line-by-line while simultaneously listening to their respective audio recordings to examine their accuracy and integrity (Witcher 2010). The transcripts carried the usual conventions in terms of: the person speaking denoted by Q-Question (from interviewer), A-Answer (from the respondent), the time elapse between utterances, gaps and non-linguistic utterances like “um huh”(Polit & Beck 2008, p.509). However, non-linguistic utterances where removed from the quotes in the manuscripts for the sake of readability. The transcripts, interview notes were read and re-read in order to establish familiarity with the data prior to the actual data analysis.

Data were qualitatively analysed using widely used methods. For example, in Chapter 4, data were analysed using deductive thematic analysis. Deductive analysis (Braun & Clarke 2006) was used to examine how the findings would relate to the concept of mental model-the theoretical framework applied in the study. Indeed, data analysis started during interviews as important ideas and concepts from the initial data collected were noted as interviews progressed. After transcribing all interviews, transcripts were read while simultaneously listening to the audio-digital tapes in order to validate the accuracy of the transcription. This also enabled the PhD candidate to familiarise himself and have a deeper understanding of the data; patterns and meanings identified were noted.

The transcripts were then imported into NVivo 9 to facilitate coding. An initial set of codes were used to guide analysis. Each transcript was read to identify important texts that had meaning and coded accordingly. Nevertheless, new codes were created as new ideas and concepts emerged from the data. Analytical memos were developed during the process and incorporated in the analysis. Later, the codes were reviewed and closely related codes were merged to form categories. All the texts in the categories were systematically reviewed to ensure that they were properly coded. Minor refinements were made to ensure that the texts were coded to their appropriate categories.

The categories were later reviewed with similar categories refined and grouped into themes and sub-themes accordingly. Each theme and sub-theme was further reviewed by the one of the candidate's supervisors to check for accuracy and any discrepancy was resolved by refining the coding process. Discussion took place with the authors and everyone agreed that the themes and quotes were appropriate which were later interpreted.

3. QUESTIONNAIRE STUDY ON ATTITUDES, RISK PERCEPTION AND ADAPTIVE BEHAVIOURS (STUDY 2)

3.1 Sampling method

The sampling unit was considered as a single individual within the North West Adelaide Health Study (NWAHS) cohort and the sample size was defined as the minimum number of individuals (sampling units) required to build statistical conclusion and inferences. There were a number of factors that were taken into account in determining the sample size of the study and this included the cross-sectional design, the feasibility, the cost and available resources(Schneider et al., 2007). The minimum sample size to draw statistical inferences from the study population was calculated from the following formula (Daniel 2005,p.189).

$$n=\frac{Z^2 \text{ x } (p) \text{x } (1-p)}{d^2}$$

where n =minimum sample size,

Z = Z statistic for a 95% confidence interval (alpha=1.96)

p = estimated proportion of the study population having a good adaptive behaviour.

d = precision/margin of error that was tolerated; fixed at 5%

Since there had been limited studies that had estimated the proportion of study participants with good adaptive behaviours during heat waves, an assumption was made for the value of *p(proportion);* such that 50% (*p=0.50*) of individuals in the study population would have good adaptive behaviours. The level of precision was set at 5% in order to calculate the sample size. The minimum sample size was derived after the following calculations:

$$n=\frac{(1.96)^2 \text{ x } 0.5(1-0.5)}{(0.05)^2}$$

$$n= 256$$

3.2 Development of the questionnaire

The questionnaire was developed through a number of stages as outlined below.

3.2.1 Literature review

A literature review was conducted to search for a valid instrument that had previously examined knowledge, attitudes, perception and adaptive behaviours during heat wave in the context of climate change. The following key words were used “heat wave perception questionnaire, adaptive behavior questionnaire, knowledge about heat waves questionnaire, with the search conducted in the following databases; Google Scholar, Pubmed, Scopus, Medline, Web of Science. The search results found three instruments that had examined knowledge and heat awareness and behavior modification during extreme heat (Kosatsky et al., 2009; Shendell et al., 2010; White-Newsome et al., 2011). There was one study that had used the Health Belief Model (HBM) to assess health belief related to heat waves (Richard, Kosatsky & Renouf 2011). However, this study was not conducted within the context of a heat wave scenario. Although the objectives of the current study were different, the aforementioned studies however guided the development of the questionnaire for this study.

3.2.2 Structure and content of the questionnaire

The structure and content of the questionnaire was informed by the objectives, the theoretical framework and analytical approach of the study. The theoretical framework for the study was the Health Belief Model (HBM), which has widely been used to study health behaviour change. Based on the objectives of the study, the questionnaire was drafted to consist of five main sections. Three of the five sections had to be on summated scales: (i.e. the section on knowledge, perceptions and adaptive behaviours). The statements with scales were developed following the guidelines on the development of scales for questionnaires (Spector 1992). Rating scales have been previously used in quantifying constructs which are not directly measured (e.g., those that have used the HBM). These scales provide a straight forward way of asking participants questions that are easy and versatile to analyse and which can be compared over time (Brace 2008, pp.66-67).

Knowledge about heat waves: An initial pool of 15 statements was developed to assess knowledge about heat waves in the context of climate change (as described below, eight statements were used in the final study). The knowledge statements were designed to determine participants' knowledge about heat-related illnesses, vulnerability to heat waves, and the consequences associated with heat waves. The response choices for the knowledge statements were "True", "False" or "Don't Know". All the positively worded statements with "True" responses were developed to given a score of "1" while the "False" and "Don't know" responses were given a score of "0". On the other hand, for the negatively worded statements, all the "False" responses were designed to give a score of "1" and the "True" and "Don't Know" responses were to be given a score of "0".

Perception of a heat wave scenario: The health belief model (HBM) was the theoretical framework used to develop the statements on perception. However, additional statements from other instruments that had used the HBM served as a framework for the development of specific statements (Kloeblen & Batish 1999). A five point Likert scale guided the development of the statements on perception since it has been reported to be understood by respondents (Brace 2008, p.66). The statements on the perception scales were developed taking into account a heat wave scenario (i.e. a heat wave characterised by 45°C for seven consecutive days). The response choices were strongly disagree, disagree, uncertain, agree and strongly agree; scored from "1" to "5" respectively. Five constructs from the HBM were used in the study i.e. perceived vulnerability, perceived severity, perceived benefit, perceived barrier, and cues to action. Three of the statements on perceived barrier were negatively worded.

Adaptive behaviours during heat waves*:* The scale on adaptive behaviours was developed after reviewing the preventive measures usually recommended by health agencies for individuals to protect themselves during a heat wave (Centre for Disease Control 2011; Department of Health: Government of South Australia 2011). Furthermore, during the preceding summer of the study (2010/2011), an observation study was carried out where the publics' adaptive behaviours during the hot weather were observed. For example, some people were observed using umbrellas, others walked under shady areas. This observational study, together with the health advice that authorities usually provide guided the development of the adaptive behaviours scale. There were initially 15 statements to assess adaptive behaviours which were later revised and reduced to ten. The responses for each statement were**:** "Always", "Sometimes", and "Never".

Attitudes towards heat waves: The questions and response options were informed by previous surveys on public attitudes towards climate change (Akerlof et al., 2010; Leiserowitz, Smith & Marlon 2010; Leviston et al., 2011; Leviston & Walker 2010; Leviston & Walker 2011; Reser et al., 2011). There were 15 questions adapted to examine attitudes towards heat waves in the context of climate change. These questions were revised and ten questions were finally considered for the study.

Finally, the questionnaire also collected information about participants' socio-demographics related to age, gender, marital status, level of education, employment status, gross household income, fan and air-conditioner ownership. It is also important to note that the draft questionnaire was also informed by the previously conducted qualitative study (i.e. study 1). The responses provided by participants contributed to the refinement and rewording of some of the questions and informed some response choices in the questionnaire.

3.2.3 Content validity of the questionnaire

The draft questionnaire was assessed for only content validity due to time constraints. After the development of the draft questionnaire, it was validated through a review by 1) PhD colleagues, 2) my PhD supervisors, and 3) an expert panel.

Review by PhD colleagues/peers: The draft questionnaire was forwarded to three peer PhD candidates for review and critique. After reviewing the draft questionnaire, two of them suggested rewording of some of the questions on knowledge since they argued that more simple words could be used to increase understanding by the lay public. There were a few typing and sequencing errors identified. Overall, the feedback and suggestions provided by them was used to revise the draft questionnaire.

Review by PhD supervisors: After revising the draft questionnaire based on feedback from my PhD peers, it was forwarded to my PhD supervisors (n=4) for review, comments and suggestions for improvement. After receiving feedback from my supervisors, modifications were made on the draft questionnaire. For example, it was suggested that the 15 statements to assess knowledge and adaptive behaviors should be reduced to eight and ten statements respectively. There was also rewording of the instructions of some sections of the draft questionnaire as well as some questions and statements. For example, the statement in

Section 3: *"It may exacerbate my existing illness";* it was suggested that the word "*exacerbate*" should be replaced by a simple word like "*worsen",* to ease understanding by the participants. One of the statements on the adaptive behaviours section was identified as double-barrelled i.e. *"Drink a few bottles of alcohol or cup of tea to stay alert".* This statement was later revised and reworded as *"Drink a few cups of coffee to stay alert".* Overall, the feedback provided by my supervisors was used to revise the draft questionnaire.

Expert panel review: The draft questionnaire was later forwarded to ten experts via email to assess the face and content validity of the questionnaire. The experts included researchers in the area of public health (n=3), emergency management workers who had previously responded to heat waves in Adelaide (n=3), psychologists (n=2), a sociologist (n=1), a statistician (n=1). The experts were asked to determine the relevance of the questions, to make suggestions for improvements and to suggest ways to minimize potential error. In this way, the experts were assessing the draft questionnaire for face and content validity (Taymoori & Berry 2009), through a Delphi technique; a means of gathering data through information exchanges from a group of experts who do not necessarily meet face-to-face (Campbell et al., 2002). Each expert independently submitted their feedback via email and based on the feedback provided, the draft questionnaire was revised. Upon revision, the draft questionnaire was again forwarded to five of the initial experts for another round of feedback. These experts were satisfied with the questionnaire and indicated that it was now ready to be piloted.

3.2.4 Pilot testing

The draft questionnaire was pilot tested among 20 volunteers in Adelaide, who were thought to share similar characteristics with the intended study population. Pilot testing usually enables potential errors to be identified before a questionnaire is actually used to collect data (Polit & Beck 2008). The pilot testing was carried out to determine if the questions were easy to understand, if respondents would interpret the questions in a similar manner and whether the response choices were appropriate for the questions. Volunteers were informed about the intent of the pilot testing and assured confidentiality. They were provided with the draft questionnaire and a feedback sheet (Appendix G) to provide comments after completing the questionnaire. Volunteers, were asked to comment on questions which were difficult to understand, those they didn't feel comfortable to answer (the intent was to identify questions which might result in missing data so that they could be modified), whether the instructions were easy to follow and to indicate the estimated time they used to complete the questionnaire. The feedback provided by the volunteers indicated that the questions were easy to understand and unambiguous and the average duration to complete the questionnaire ranged from 15 to 20 minutes. Only minor modifications were made as a result of the pilot-testing.

3.3 Additional materials on theoretical framework applied in Chapter 4 (The Health Belief Model)

The Health Belief Model (HBM) was used as the conceptual framework to examine risk perception and adaptive behaviours. The model has widely been used to explain and predict human behaviour focusing on the beliefs of individuals. It was initially developed by researchers in the United States to explain the use of preventive services (Kohler, Grimley & Reynolds 1999). The model hypothesises that human behavior depends mainly on the value that an individual places on a particular goal and on the individual's estimate of the likelihood that a given action will achieve a desired outcome i.e., the idea that adopting specific health behaviors would either reduce the chances of disease (Bartholomew, Parcel & Kok 2006).

The original model developed had four main constructs i.e., perceived susceptibility, perceived severity, perceived benefit and perceived barriers (Glanz, Rimer & Viswanath 2008). Perceived susceptibility is an individual's belief that he/she is likely to develop a specific disease or health condition. Perceived severity refers to an individual's belief that if he/she develops the disease/health condition, it would lead to serious negative consequences (Abraham & Sheeran 2005). Consequently, if an individual perceives that he/she is susceptible to a particular disease/health condition, the individual is more likely to modify his/her behaviours to minimize the risk. Some authors suggest that perceived severity may sometimes be considered in terms of morbidity and mortality associated with the particular disease/ health condition (Clarke et al., 2000).

On the other hand, perceived benefit is an individual's opinion that the options available to modify his/her behavior would decrease the risk of having the disease/ health condition. Indeed, people tend to modify their behaviour when they believe that the new behaviour will decrease their chances of developing the disease (Hayden 2009). Perceived barriers are generally obstacles to undertaking preventive behaviours that might help to prevent disease. Clearly, the presence of perceived barriers reduces a person's motivation to modify his/her behavior to prevent the disease or health condition. Some researchers have suggested that perceived barriers may represent environmental factors such as lack of support from families and friends, low resources or lack of time, lack of motivation, cost, inconvenience, embarrassment and loss of pleasure (Allison, Dwyer & Makin 1999; Clarke et al., 2000).

Since its development, the HBM has been modified to improve its predictability, incorporating additional constructs including cues to action, health motivation, intention and self-efficacy (Bartholomew, Parcel & Kok 2006; Lajunen & Räsänen 2004). Cues to action helps trigger/motivate an individual to undertake preventive behaviours and they are either internal or external. Internal cues may include symptoms of illness, while external cues may include media campaigns about the health promotion or interpersonal interactions such as learning from a friend (Poss 2001). Self-efficacy is a person's belief of how capable he/she is able to undertake preventive behaviours (Lin, Simoni & Zemon 2005).

According to the above understanding and in the context of heat waves, perceived susceptibility will refer to how individuals believe that they will suffer from a health condition if exposed to heat waves. Perceived severity refers to an individual's belief that suffering from any health condition due to exposure to heat waves would lead to serious consequences. Perceived benefit refers to an individual's belief that the recommended preventive measures (e.g., using an air conditioner) would protect him/her from suffering from a heat-related health condition. Perceived barriers refer to any barrier whether external (e.g., cost of electric bills) or internal that might prevent an individual from using a recommended preventive measure. Cues to action refer to the triggers that would motive an individual to undertake preventive behaviours during a heat wave (e.g., reminders from the mass media, family, friends and doctor).

3.4 Data collection and management

The approach by which participants were recruited, the study setting and timing of data collection has been described in the published papers. This section outlines how data was collected and managed. A package containing the self-administered questionnaire (Appendix H), an approach letter (Appendix I), the study information sheet (Appendix J) and a reply-paid envelope was mailed through Australia Post to the 490 individuals selected to take part in the study. The information sheet provided details about the study, including the option of voluntary participation, how collected data would be used, participants' rights in the study and confirmation of confidentiality. The approach letter was signed by a chief investigator of the NWAHS and carried the logo of the NWAHS and The University of Adelaide. Participants were requested to complete the questionnaire and return it using a supplied reply-paid envelope. As indicated in the manuscripts, completing the questionnaire was construed as providing consent to take part in the study. No follow-up or reminder calls were made to the participants.Ethics approval was obtained from The University of Adelaide Human Research Ethics Committee (No. H-061-2011) and The Queen Elizabeth Hospital Human Research Committee (No. 2011136), as the latter considers the ethics of all research regarding the cohort.

All returned questionnaires were checked for accuracy, consistency and completeness. Of the 490 questionnaires mailed, 272 were returned giving a response rate of 55.5%. However, due to missing data, five of the questionnaires were eliminated leaving 267 valid questionnaires. A Microsoft Access data base was developed and saved in a password protected computer. Data from the 267 questionnaires were entered into the Access data base. In order to reduce data entry errors, the Access data entry programme was designed to provide checking of data, with inconsistency and range checks to verify the accuracy and completeness of the data. Data entry validation was conducted by randomly verifying 10% of the entered data with its corresponding questionnaire. All the questionnaires were then locked into a filing cabinet to protect confidentiality. The data was later "imported" into STATA version 12 (Stata Corp College Station, TX, USA) where a final round of data validity (range checks, consistency checks, and appropriate codes for missing data) was performed before analyses. The internal consistency of the items used to measure knowledge about heat waves and the constructs of the HBM were computed to estimate the reliability coefficient i.e., Chronbach's alpha. Arguably, Chronbach's alpha is an important index that determines the extent to which responses to the individual items in a scale are consistent/correlate with one another (DeVellis 2003). A high reliability coefficient indicates a high reliability of the measure.

4. CASE STUDY ON PARTICIPATORY ADAPTATION PROCESS (STUDY 3)

4.1 Introduction to case study design

A case study design is a research technique that is used to explore a phenomenon within a particular context through the use of multiple data sources. The use of multiple data sources allows the phenomenon to be explored from different "angles" which enables an in-depth understanding of the phenomenon (Baxter & Jack 2008). A case study has been described as an empirical inquiry of an everyday phenomenon within its real-life context, in a situation where the boundaries between the phenomenon are not clearly "demarcated" (Yin 1984 ,p.23).There are five elements that have been suggested to be taken into account when designing a case study; the study's research questions, its proposition, unit of analysis, the logic of the data to its proposition and the criteria for interpreting the findings of the study (Yin 2003, p.23).

There are many types of case studies; although the type of case study utilised may be determined by the particular form of inquiry that is being investigated (Stake 1995). Stake (1995) identifies both instrumental case studies and inquiry case studies. The former is used to provide insights about an issue while the latter is used to obtain an in-depth understanding of the case (Stake 1995). Case studies are exploratory in nature and can either be single or multiple. Single case studies explore a specific case, while multiple case studies collect evidence from many cases. It has been suggested that single case studies are best suited when the case is being used to test an underlying theory, when the case is a unique one or when it is investigating a phenomenon which has not been addressed through other scientific methods (Yin 1994). Multiple case studies could be analysed within and across different settings (Baxter & Jack 2008). A multiple case study carried out across different settings enables a researcher to explore the similarities and differences that exist between the cases, although this form of design is cumbersome and takes a long time (Baxter & Jack 2008). Nonetheless, single or multiple case studies can be conducted at a specific point in time or at different intervals over a time period (Schell 1992). The present study was designed as a single case study although its intent was not to test any particular theory.

Case studies can also be classified as intrinsic, instrumental or collective (Stake 1995). Stake (1995) posits that intrinsic case studies are mainly used to study a unique case; instrumental case studies are used to gain an in-depth understanding of a particular phenomenon while he describes collective case studies as being similar to multiple cases. Case studies can also be descriptive, exploratory or explanatory (Stake 1995). The qualitative study among the stakeholders used an exploratory approach.

4.2 The unit of analysis in case study design

It has been suggested that the unit of analysis in any case study research should be defined in the early stages when designing the study, preferably most likely during the process of reviewing the literature (Darke, Shanks & Broadbent 1998; Tellis 1997). Once the unit of analysis has been determined, it becomes easy to determine the "case" of the study. It should be noted that the "unit of analysis" and the "case" are two closely related concepts in any case study (Darke, Shanks & Broadbent 1998), with the *"boundary"* between them important to be identified at the early stages of designing the study (Mills, Durepos & Wiebe 2010). The boundary between the "unit of analysis" and the "case" is similar to defining the inclusion and exclusion criteria widely used in quantitative research and enables the study to have a specific context for which the analysis is conducted (Baxter & Jack 2008). The boundaries of a "case" study can be defined by location and time (Creswell 2009), definition and context (Miles & Huberman 1994) or by time and activity (Stake 1995). In the context of the study conducted in this thesis, the case study was defined by location and time since the participatory process explored took place in mid 2009 in Adelaide, South Australia.

The "unit of analysis" in case studies may be an individual, a group or an organisation and this usually guides the amount of data that is required to be collected to answer a study's research questions (Yin 1994, p.21-24). On the other hand, the "unit of analysis" is the major phenomenon that is being analysed in the study; answering the *"what"* or *"who"* questions of the study (Mills, Durepos & Wiebe 2010). In the study conducted, the "unit of analysis" was defined as the "group of stakeholders" who were involved in the participatory process during the development of the adaptation strategy for heat waves.

The “unit of analysis” has also been used to determine whether a case study is holistic or embedded. A case study is described as holistic when only one “unit of analysis” is used to explore a phenomenon and embedded when more than one “unit of analysis” is explored. Nonetheless, multiple case studies may either have one or more “unit of analysis” (Mills, Durepos & Wiebe 2010). On the basis of this, the study exploring the development of the adaptation strategy was therefore a holistic case study since it had the group of stakeholders as the single “unit of analysis”. The choice of selecting a case study design depends on many factors including the type of the research question, the researcher’s level of control over the actual behavioural events and the degree of focus on contemporary events (Yin 1984).

4.3 The concept of triangulation in case study design

The term “triangulation” has widely been used in the social and behavioural sciences discipline. It refers to the use of many approaches or techniques to collect data for a particular study which may help enhance the validity of the study (Lyn 2009, p.35). This concept is quite useful in case study research since data used to support the evidence is usually gathered through multiple sources (Yin 1984). There are four different types of triangulation in case study research: data triangulation, researcher triangulation, theoretical triangulation and methodological triangulation (Denzin 1984). In the study explored in this thesis, data triangulation was used since more than one source of data was used in the study.

There are generally six main sources to generate data for any case study research: documentation, archival records, interviews, direct observation, participant observation, physical artefacts (Yin 1984). Although these sources are considered relevant for gathering data for case study research, it is widely acknowledged that it can be difficult to collect data from all six sources. Consequently, it has been proposed that if data is collected from at least two sources, it is enough to shed light on the phenomenon which is being explored (Yin 1984). In this regard, the two main sources of data used in this study were interviews with stakeholders and documentation review.

4.4 Recruitment of stakeholders

Initial contact was made with the lead agency that coordinated the participatory process in order to gain support and obtain advice on how best to approach relevant stakeholders who were involved in the participatory process. The lead agency provided the PhD candidate with a list of stakeholders who took part in the process. A non-probability purposive sampling (Babbie 2001; Maxwell 2005) technique was used to select a representative sample of 30 stakeholders across the different stakeholder groups (i.e. both state and non-state actors). The selection process was done on the basis that those selected would provide rich information for the study (Babbie 2001, p.194). Next, the lead agency contacted those stakeholders selected via email (Appendix K) and informed them about the study, attached to which was the study information sheet (Appendix L). A week later the PhD candidate followed-up with a second email (Appendix M) requesting their participation in the study; the study information sheet was also attached to the email.

Stakeholders were informed that their interview transcripts would be de-identified and confidentiality maintained. Stakeholders were requested to contact the PhD candidate via email or telephone to express their interest in participating in the study and to suggest a suitable date and time when the interview could be conducted. They were equally asked to suggest their preferred method of interview (in-person or via telephone). Among the 30 stakeholders approached, 16 expressed interest in participating. Using snow-ball sampling (during the interviews) five more stakeholders were approached and three agreed to participate, bringing the number of stakeholders who expressed interest to participate to nineteen. Those who could not participate apologised for lack of time, scheduling issues or because they had relocated to a different city after the participatory adaptation process.

4.5 Data collection

Interviews were conducted between July and August 2011 through a series of semi-structured interviews among the stakeholders who were involved in the participatory process. Before each interview stakeholders were thanked for agreeing to take part in the study, they were informed about the objective of the study, informed about the presence and rationale of audio-digital recorder. Stakeholders were assured of confidentiality and privacy of any information that they would provide and were informed that their interview transcripts would be de-identified before analysis. They were then given an opportunity to ask any questions or seek clarity about the study. Each stakeholder was provided with two informed consent forms (Appendix N) to sign, one copy was kept by the stakeholder and the other copy was kept by the PhD candidate. They were also provided with another copy of the participant's information sheet and an Independent complaints procedure form (Appendix O) to keep for their records.

Interviews were conducted by the PhD candidate with the aid of an interview guide (Appendix P) which had an opening question and the subsequent main questions. The interviews were in-depth (Marshall & Rossman 2006; Tellis 1997), exploratory and open-ended. The flexibility and open-ended nature of the interview allowed stakeholders to respond to the questions in a "free and relaxed manner". All interviews were audio-digitally recorded and short notes were also taken, while maintaining eye contact with the stakeholders. Maintaining eye contact while taking the short notes was important as the PhD candidate used both interpersonal and communication skills to maintain the flow of the interview while gathering the evidence about the participatory process.

Follow-up questions in the form of probes were used during the interviews when the stakeholder gave a short response or whenever any stakeholder mentioned an idea which needed further clarity and understanding. In addition to probes, body language was used to encourage stakeholders to speak. For example, the PhD candidate (interviewer) used non-verbal cues such as nodding the head from time to time as the stakeholders responded to the questions. Nodding the head was purely impromptu as a sign of "satisfaction" to the responses which the stakeholder provided. Sometimes, non-linguistic utterances like *"uh huh", "Yeah",* were used to express satisfaction thus encouraging stakeholders to speak more. After all of the main questions of the interview guide were covered, stakeholders were asked *"What else would you like to add in relation to what we have just discussed?"* The interview duration ranged from 20-41 minutes and a summary of demographic characteristics were collected at the end of each interview. A "thank you letter" (Appendix Q) was sent via email to the stakeholders who participated in the study.

4.6 Transcription of the interview audio-files

The next phase involved transcribing the audio-recordings. This was one of the most important steps in the process because the quality of the research findings was to be determined by how accurate the audio-recordings were transcribed. Transcription simple involves the translation of the views and perspectives of the participants in a manner that accurately reflects the information provided by the stakeholder during the interview (Gibson & Brown 2009). It is therefore a way of ensuring not only the quality but as well as the rigor of the data that is to be analysed (Poland 1995). The audio-records (initially coded) were transcribed verbatim (Halcomb & Davidson 2006).

The transcripts carried the usual conventions in terms of:-the person speaking denoted by Q-Question (from interviewer), A-Answer (from the respondent), the time elapse between utterances, gaps and non-linguistic utterances like “um huh”(Polit & Beck 2008, p.509). The reviewed transcripts were then forwarded to the stakeholders by email for them to validate the accuracy of the discussions and make any amendments where necessary (respondent validation).Stakeholders were given a one-week timeline to review and provide feedback. All the stakeholders were happy with their respective transcript and granted their approval for the data to be analysed.

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Appendix B: Ethical Approval Letter (The University of Adelaide)

THE UNIVERSITY of ADELAIDE

RESEARCH BRANCH
RESEARCH ETHICS AND COMPLIANCE UNIT

BEVERLEY DOBBS
EXECUTIVE OFFICER (LOW RISK)
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THE UNIVERSITY OF ADELAIDE
SA 5005
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email: Beverley.dobbs@adelaide.edu.au
CRICOS Provider Number 00123M

13 April 2011

Associate Professor P Bi
Discipline of Public Health, University of Adelaide

Dear Associate Professor Bi

PROJECT NO: H-061-2011
Extreme Heat and Population Health; Adaptation and Coping Strategies in a temperate Australian city.

I write to advise you that on behalf of the Human Research Ethics Committee I have approved the above project. Please refer to the enclosed endorsement sheet for further details and conditions that may be applicable to this approval.

The expiry date for this project is: 30 APRIL 2014

Where possible, participants taking part in the study should be given a copy of the Information Sheet and the signed Consent Form to retain.

Please note that any changes to the project which might affect its continued ethical acceptability will invalidate the project's approval. In such cases an amended protocol must be submitted to the Committee for further approval. It is a condition of approval that you immediately report anything which might warrant review of ethical approval including (a) serious or unexpected adverse effects on participants (b) proposed changes in the protocol; and (c) unforeseen events that might affect continued ethical acceptability of the project. It is also a condition of approval that you inform the Committee, giving reasons, if the project is discontinued before the expected date of completion.

A reporting form is available from the Committee's website. This may be used to renew ethical approval or report on project status including completion.

Yours sincerely

PROFESSOR GARRETT CULLITY
Convenor
Human Research Ethics Committee

Appendix C: Ethical Approval Letter (The Queen Elizabeth Hospital)

Government of South Australia
SA Health

HUMAN RESEARCH ETHICS COMMITTEE (TQEH/LMH/MH)

The Queen Elizabeth Hospital
Lyell McEwin Hospital
Modbury Hospital

Ph: +61 08 8222 6841
Fax: +61 08 8222 6007
Email: qeh.ethics@health.sa.gov.au

DX 465101
The Queen Elizabeth Hospital
28 Woodville Road
Woodville South SA 5011

26 October 2011

A/Prof Peng Bi
Attention: Derick Akompab
Discipline of Public Health
Mail Drop 605 207
The University of Adelaide SA 5005

Dear A/Prof Bi

Application Number **2011136**

The Human Research Ethics Committee Chairman has expedited the approval of your protocol under Section 5.1.19 and Section 5.3.2 of the National Statement on Ethical Conduct in Human Research entitled:

"Extreme Heat Events and Population Health: Adaptation and Coping Strategies in a Temperate Australian City."

In accordance with the National Statement on Ethical Conduct in Human Research, the following documents have been reviewed and approved:

- Letter of Support from NWAHS for three part study, dated 28 September 2011.
- Participant Invitation Letter (Questionnaire), dated November 2011.
- Participant Information Sheet (Questionnaire), version unknown, undated.
- Patient Questionnaire, version unknown, undated
- Participant Invitation Letter (Focus Group), dated November 2011.
- Focus Group Discussion – Moderators Guide, version unknown, undated.
- Participant Information Sheet and Consent Form (Focus Group Discussion), version unknown, undated.
- Participant Invitation Letter (Interview), November 2011.
- Patient Information Sheet and Consent Form (Interview), version unknown, undated.
- Interview Schedule, version unknown, undated.
- Approval Letter from The University of Adelaide Human Research Ethics Committee, dated 13 April 2011.
- Ethics Application dated 8 March 2011.

Approval Status: **FINAL**

Site(s): **The Queen Elizabeth Hospital**
The Lyell McEwin Hospital
Modbury Hospital

Period of Approval: **26 October 2011 – 26 October 2012**

***Please note the terms under which Ethical approval is granted:**

1. Researchers are required to immediately report to the Human Research Ethics Committee anything which might warrant review of ethical approval of the protocol, including:
   a) serious or unexpected adverse effects on participants;

b) proposed changes in the protocol; and
c) unforseen events that might affect continued ethical acceptability of the project

2. Protocols are approved for up to twelve months only and a report is required at the end of the study or 12 month period. Extensions will not be granted without a report to the Committee.
3. Confidentiality of the research subjects shall be maintained at all times as required by law
4. All research subjects shall be provided with a Patient Information Sheet and Consent Form, unless otherwise approved by the Committee
5. The Patient Information Sheet and Consent Form shall be printed on the relevant site letterhead stating the contact details for the researchers
6. The Patient Information Sheet must state that the Executive Officer can be contacted for information regarding conduct of the study, policies and procedures, or if the participant wishes to make a confidential complaint
7. A report and a copy of any published material should be forwarded to the Committee at the completion of the project.

Yours sincerely

A/Professor Timothy Mathew
Chairman, Human Research Ethics Committee (TQEH/LMH/MH)

Appendix D: Interview Guide

Public's views, understanding, concern and emotional responses to heat waves

INTERVIEW GUIDE

Introduction/Setting the Stage

- Your Name/
- Thank Participant for accepting to take part
- Explain Objectives of Study
- Explain Structure and **Duration**
- Explain presence of digital recorder(s)
- Explain Confidentiality
- **Do you have any questions in relation to what I just explain?**
- Are you willing to take part in this interview?

Opening Question

- **Can you please tell me what you know about heat waves?**

Main Questions

1. What do you think has been responsible for heat waves that have been observed in Adelaide in recent years?
2. "How do you then respond to scientific opinion that recent heat waves in Adelaide are consistent with climate change projections?"
3. "What do you think about scientific projections that heat waves would increase with intensity and severity in Adelaide in the future?"
4. Can you tell me about some of the social and health consequences associated with heat waves?
5. What are you concerned or worried about when there is a heat wave in Adelaide?
6. What groups of people do you think are vulnerable to heat waves in Adelaide?
7. What are the things that you normally do to stay safe when there is a heat wave?
8. What are some of the barriers that may hinder you from adequately protecting yourself from the effects of extreme heat?

Concluding Remarks

- What other things would you like to add in relation to what we have just discussed?

END

Thank participant for taking part in the interview.

Appendix E: Participant Approach Letter

North West Adelaide Health Study

17 November 2011
Dear Sir/Madam,

Thank you for your continued participation in the North West Adelaide Health Study, which contributes valuable health information to the South Australian community. We are seeking your assistance to participate in a project that is exploring the development of better strategies to help people cope with hot weather/heat waves, in collaboration with researchers from the Department of Public Health of The University of Adelaide. Heat waveshave been identified as major public health issue in our community. Please see the attached information sheet for more details.

We will be calling you over the next few weeks regarding your participation in a 25-30 minute telephone interview. Once again, there will be no cost to participants and your involvement is voluntary. If you are able to help us with this project, a gift voucher of $20 will be provided in appreciation of your contribution to the study.

This study has been approved by the Human Research Ethics Committee (TQEH/LMH/MH). If you have any questions about the study, please call one of the Study Team on (tel) 8313 1212 or 8313 1215, or email us at pros.nwahs@adelaide.edu.au. If you wish to speak with someone not involved in the study, please telephone the Executive Officer of the Human Research Ethics Committee on (tel) 8222 6841.

We very much appreciate the time and effort that you continue to give to us. We look forward to speaking with you soon.

Yours sincerely

Associate Professor Anne Taylor
Principal Investigator (Epid), North West Adelaide Health Study

Head, Population Research & Outcome Studies,
Discipline of Medicine, The University of Adelaide

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Appendix F: Participant Information Sheet

Public's views, understanding, concern and emotional responses to heat waves

PARTICIPANT INFORMATION SHEET

Invitation to Participate

We invite you to participate in a research study which we believe is of potential importance. However, before you decide whether or not you wish to participate, we need to be sure that you understand why we are doing it and what it would involve if you agree.

To help you understand why this study is being conducted and what it would involve should you agree to participate, we are providing you with the following information. Please read it carefully – the researchers conducting the research will be happy to discuss it with you and answer any questions that you may have. You are also free to discuss it with outsiders if you wish (i.e. family, friends and/ or your local doctor). You do not have to make an immediate decision.

Participation is Voluntary

Participation in any research project is voluntary. If you do not wish to take part you are not obliged to. If you decide to take part and later change your mind, you are free to withdraw from the study at any stage without providing any reason. Your decision to take part, not to take part or to withdraw will not affect your routine treatment, your relationship with those treating you, or your relationship with The Queen Elizabeth Hospital or researchers from the North West Adelaide Health Study.

Background of the Study

Heat waveshave been identified as a major public health issue in our community. Researchers from the Department of Public Health of The University of Adelaide, in association with the North West Adelaide Health Study, are undertaking a new research project in order to inform the development of better strategies to help people cope with hot weather/heat waves.

Who is sponsoring it?

The study is being sponsored by the University of Adelaide.

What does participation involve?

The purpose of this study is to explore your understanding, views and beliefs about heat wavesand how they affect people's health. It will involve a telephone interview that will take **approximately 25-30 minutes.** With your permission, the interview will be recorded for transcription purposes. A gift voucher of $20 will be provided in appreciation of your contribution to the study.

Will confidentiality be maintained?

Your confidentially will be maintained at all times. Initial contact will be made with you by a member of the NWAH Study team and if you agree to take part, your name, telephone number and the best time to contact you will be provided to the researcher so that the interview can occur. Your recorded interviews will be securedly stored in a password-protected computer in the Discipline of Public Health, University of Adelaide. Only the researchers will have access to the information you provide. Your interview transcripts will be **de-identified** and **there will be no way to identify you in any documents produced.**

How will the information be used?

The information that you provide will be collated in a report. The results will also be compiled and submitted to The University of Adelaide as a PhD thesis. Results of the study may also be published in scientific journals and presented at conferences.

What will I get out of this study?

Although you may have no direct benefit from participating in the study, your views, thoughts and perspectives will assist government and other service providers to develop effective programs and strategies that will help reduce any impacts of heat wavesin our society.

What if I have a question about the study?

If you **would** like more information about the study or have any questions, you can contact any of the following:

- **Janet Grant**, NWAH Study Coordinator, Discipline of Medicine, The University of Adelaide; Tel: (08) 8313 1212 Email: janet.grant@adelaide.edu.au
- Derick Akompab, PhD Candidate, Discipline of Public Health, The University of Adelaide; Tel: (08) 8303 6875 Email: derick.akompab@adelaide.edu.au
- Assoc Prof Peng Bi, Acting Head- Discipline of Public Health, The University of Adelaide; Tel: (08) 8303 3583 Email: peng.bi@adelaide.edu.au
- Dr Susan Williams, Research Associate, Discipline of Public Health, The University of Adelaide; Tel: (08) 8313 1043 Email: susan.williams@adelaide.edu.au
- Prof Martha Augoustinos, Discipline of Psychology, The University of Adelaide Tel: (08) 8303 4627 Email: martha.augoustinos@adelaide.edu.au
- Prof Iain Walker, Social & Behavioural Sciences Research Group, CSIRO Sustainable Ecosystems Tel: (08) 9333 6291 Email: iain.a.walker@csiro.au
- Dr. Arthur Saniotis, Discipline of Public Health, University of Adelaide, Tel (08) 8313 6882, Email: saniotis.arthur@adelaide.edu.au

The Human Research Ethics Committee (TQEH, LMH, MH) has approved this study. Should you wish to speak to a person not directly involved in the study in relation to:

- matters concerning policies
- information about the conduct of the study
- your rights as a participant or
- should you wish to make a confidential complaint
  you should contact The Executive Officer of this Committee on (08) 8222 6841

Appendix G: Volunteer Feedback Form

Q1. How long (approximately) did it take you to complete the questionnaire?

Q2. Were the instructions on the questionnaire clear to enable someone understand the directions of the questions? (Please tick one)
☐ Yes
☐ No “If No, please give a brief explanation in the space below”

Q3. Which questions were difficult for you to understand?

Q4. Which questions did you feel uncomfortable to answer?

Q5. What do you suggest could be done to improve the questionnaire?

Appendix H: Questionnaire

North West Adelaide Health Study

THE UNIVERSITY of ADELAIDE

Health Beliefs, Adaptive Behaviours and Coping Strategies to Extreme Heat (Events) among a cohort of residents in Adelaide, Australia

	FOR OFFICE USE ONLY
Dear Participant, We rang you in October 2011 asking for your help with a sub-study about extreme heat/heat waves. Could you please help us by completing this questionnaire? It is made up of five sections and will take you approximately 20 minutes to complete. Please note that all your responses will be treated confidentially. **THANK YOU**	ID ______________________

SECTION ONE: KNOWLEDGE ABOUT HEAT WAVES

This section relates to people's understanding of heat waves. Please indicate if you believe the following statements are true or false.
(Please tick ☑ ONLY ONE BOX per statement).

Statement(s)	True	False	Don't Know
1. High atmospheric pressure with less rainfall is responsible for extreme heat events in Adelaide	❐3	❐2	❐1
2. Heat-related illnesses result from extreme heat exposure	❐3	❐2	❐1
3. Diabetes is an example of a heat-related illness	❐3	❐2	❐1
4. Excess sweating during extreme heat days may be a sign of heat stress	❐3	❐2	❐1
5. Individuals with heart conditions have a greater chance of becoming ill during extreme heat events	❐3	❐2	❐1
6. The elderly and young children are the only ones who are vulnerable to extreme heat events	❐3	❐2	❐1
7. Heat-related illnesses are not known to cause death	❐3	❐2	❐1
8. Extreme heat events may lead to bush fire	❐3	❐2	❐1

SECTION TWO: AWARENESS, CONCERN AND UNCERTAINTY ABOUT HEAT WAVES

This section relates to people's level of awareness, views and concern about extreme heat (events). Please tick ☑ **ONLY** relevant boxes for each of the following questions.

Q.1 Where do you normally get information about heat waves *?(Please tick all that apply)*

❒ $_1$ Radio ❒ $_4$ My doctor
❒ $_2$ Television ❒ $_5$ Friends, relatives or neighbour
❒ $_3$ Newspaper ❒ $_6$ Internet
❒ $_7$ Other sources of information about heat waves________________________

Q.2 How closely do you follow news about heat waves from these sources? *(Please tick **one** only)*

❒ $_1$ Very closely
❒ $_2$ Somewhat closely
❒ $_3$ A little closely
❒ $_4$ Not at all

Q3. Personally, <u>how well informed do you</u> ***do you think you are about heat waves and its consequences?*** *(Please tick **one** only)*

❒ $_1$Very well informed
❒ $_2$ Fairly well informed
❒ $_3$ Not very well informed
❒ $_4$ Not at all informed

Q4. Considering any potential effects of heat waves which there might be on <u>you personally</u>, how concerned, if at all, are you about heat waves? *(Please tick one only)*

❒ $_1$ Extremely concerned
❒ $_2$ Very concerned
❒ $_3$ Fairly concerned
❒ $_4$ Not at all concerned ⟶ If "Not at all concerned", please go to **Question 6**

Q5. If you are concerned about the potential effects of heat waves, <u>what are you concerned about?</u> (*Please tick all that apply)*

❒ $_1$ My personal comfort ❒ $_5$ My health
❒ $_2$ My pets ❒ $_6$ Outdoor leisure activities
❒ $_3$ My sleep ❒ $_7$ Garden
❒ $_4$ My relatives ❒ $_8$ Others (*please specify*)________________

Q6. How do you feel during a heat wave? *(Please tick all that apply)*

❒1 Mentally tired	❒2 Disoriented	❒3 Happy	❒4 Distressed
❒5 Unwell	❒6 Confused	❒7 Uncomfortable	❒8 Feel the same as usual

Q7. Considering any potential effects of extreme heat which there might be on society in general, how concerned, if at all, are you about heat waves? *(Please tick **one** only)*

❒1 Extremely concerned
❒2 Very concerned
❒3 Fairly concerned
❒4 Not at all concerned

Q8. How likely, do you think heat waves in Adelaide will increase in the future as some experts have projected? *(Please tick **one** only)*

❒1 Extremely likely
❒2 Very likely
❒3 Somewhat likely
❒4 Less likely
❒5 Not at all

Q9. If heat waves in Adelaide were to increase in the future, how likely do you think this will have consequences in Adelaide? *(Please tick **one** only)*
❒1 Extremely likely
❒2 Very likely
❒3 Somewhat likely
❒4 Less likely
❒5 Not at all

Q10. When, if at all, do you think Adelaide will start feeling the social and health effects of heat waves? *(Please tick **one** only)*

❒1 Adelaide is already feeling the effects
❒2 In the next 5 years
❒3 In the next 15 years
❒4 Beyond the next 25 years
❒5 Never

SECTION THREE: PERCEPTIONS OF A HEAT WAVE SCENARIO AS APPLIED IN THE HEALTH BELIEF MODEL

In this section, we are interested in how people perceive heat waves. Please imagine that a **severe heat wave** strikes Adelaide **with temperatures of at least 45^{o}C for seven consecutive days.** How strongly do you agree or disagree with each of the following statements about **what would happen during such a heat wave period**. ***(Please tick ☑ ONLY ONE BOX** per statement)*

Statement(s)	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
I think I may suffer from dehydration during such a heat wave	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
I think my body temperature may rise abnormally during such a heat wave	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
I think I may suffer from body weakness during such a heat wave	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
I think I may suffer from sun burn if I get exposed during such a heat wave	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
If my body temperature gets elevated during such a heat wave it may cause me to see a doctor	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
If I get dehydrated during such a heat waves, it may lead me to being hospitalised	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
Dehydration under such a heat wave may provoke long term damage to my health	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
If I develop sun burn during such a heat wave, it may lead to skin cancer	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
Hospitalisation as a result of dehydration during such heat wave may cause me to be absent from work	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
Eating hot meals during such a heat wave will enable me to cope with the heat	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
Staying in an air conditioned environment will reduce the chance of me suffering from dehydration	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
Using sunscreen will prevent me from developing sunburn during such a heat wave	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
Wearing dark clothing outside during this period will reduce my chances of sweating	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
Listening to daily weather forecasts would enable me to plan my outdoor activities	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
Staying indoors during such a heat wave would be quite boring	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
Taking a cool shower from time to time at home during this period would waste water and increase my water bills	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
For security reasons, I would not open my doors at night to allow air to enter during such a heat wave	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
Due to my health, I will drink less water during such a heat wave	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$
Because of the cost of electricity, I would be reluctant to turn on the air conditioner during such a heat wave	❐$_5$	❐$_4$	❐$_3$	❐$_2$	❐$_1$

Cues to Action

In this part of the questionnaire, we are interested in what would motivate people to protect themselves from the health effects of a heat wave with temperatures of **45 degrees for 7 consecutive days.** How much do you agree or disagree with the following statements **regarding your decision to take** precautionary measures (**keeping yourself safe**) during such a heat wave period.

*(Please tick ☑ **ONLY ONE box** per statement)*

I WILL KEEP MY SELF SAFE FROM THE EFFECTS OF THE HEAT WAVE IF….

Statement(s)	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
A family member or friend tells me about the dangers of the heat wave	❒$_5$	❒$_4$	❒$_3$	❒$_2$	❒$_1$
I watch TV and see how an ambulance transports someone to the hospital due to dehydration from the heat wave	❒$_5$	❒$_4$	❒$_3$	❒$_2$	❒$_1$
I read a local news paper and get news about the health effects of the heat wave	❒$_5$	❒$_4$	❒$_3$	❒$_2$	❒$_1$
My doctor reminds me about the dangers of the heat wave	❒$_5$	❒$_4$	❒$_3$	❒$_2$	❒$_1$
As a result of my personal experience of heat waves in Adelaide, I would keep safe during such a heat wave	❒$_5$	❒$_4$	❒$_3$	❒$_2$	❒$_1$

SECTION FOUR: ADAPTIVE BEHAVIOURS DURING A HEAT WAVE

In this section, we want to understand how you modify your behaviour during periods of extreme heat/heat waves in Adelaide. Please indicate how often you do the following things during a period of extreme heat/heat waves.
*(Please kindly tick ☑ **ONLY ONE box** per statement)*

	Always	Sometimes	Never
Drink plenty of water to stay hydrated	❒3	❒2	❒1
Go for a swim to cool down	❒3	❒2	❒1
Wear-dark coloured clothes when going outside	❒3	❒2	❒1
Listen to daily weather forecast	❒3	❒2	❒1
Drink a few cups of coffee to stay alert	❒3	❒2	❒1
Wear a hat when going outside	❒3	❒2	❒1
Do some outdoor gardening during the day	❒3	❒2	❒1
Seek protection of shady areas when outdoor	❒3	❒2	❒1
Go to a shopping centre to cool down	❒3	❒2	❒1
Use an umbrella when walking outside	❒3	❒2	❒1

SECTION FIVE: SOCIO-DEMOGRAPHIC CHARACTERISTICS

In this section, we would like you to provide some basic information about yourself. Please remember that all responses will be treated as **confidential.**

Q1. What is your current marital status?
*(Please tick **one** only)*

❒1 Never married
❒2 Married/Defacto
❒3 Separated/ Divorced
❒4 Widowed

Q2. Which of the following best describes your highest educational level achieved? *(Please tick **one** only)*
❒1 Finished primary school
❒2 Did some secondary school (Year 8-Year 11)
❒3 Completed high school (Year 12)
❒4 Did some additional training (Apprenticeship, TAFE courses etc.)
❒5 Undergraduate University
❒6 Postgraduate University

Q3. Which of the following describes your current employment status?
*(Please tick **one** only)*
❒1 Employed full time
❒2 Employed part time or casual
❒3 Self employed
❒4 Unemployed
❒5 Retired/pension recipient
❒6 Home duties
❒7 Other *(please specify*)______________________

Q4. Which one of the following categories best describes your household's gross annual income? (*before tax) (Please tick one only)*

❒1 Less than $20,000
❒2 $20,000-39,999
❒3 $40,000-59,999
❒4 $60,000-79,999
❒5 More than $ 80,000

Q5. Which of the following best describes your living arrangements? *(Please tick **one** only)*

❒1 Live alone
❒2 Live with my partner/family
❒3 Live with relative (s)
❒4 Live with others

Q6. Do you have a fan at home? *(Please tick **one** only)*
❒1 Yes
❒2 No

Q7. Do you have an air conditioner at home?

❒1 Yes- If "Yes" ***which type***? →

❒2 Central unit
❒3 Wall unit
☐4 Window unit

❒5 No

END

Please check that you have completed all questions on the 8 pages.

On behalf of researchers of the North West Adelaide Health Study and the University of Adelaide, we sincerely thank you for taking the time to complete this questionnaire. Please, return it in the reply-paid envelope or if damaged, address any envelope to:

Derick Akompab
Discipline of Public Health
Faculty of Health Sciences
The University of Adelaide
Reply Paid 498
ADELAIDE SA 5005

Appendix I: Survey Approach Letter

17 November 2011

Dear Mr/Mrs/Ms______

Thank you for your continued participation in the North West Adelaide Health Study, which contributes valuable health information to the South Australian community. We are seeking your assistance to participate in a project that is exploring the development of better strategies to help people cope with hot weather/heat waves, in collaboration with researchers from the Department of Public Health of The University of Adelaide. Heat waves have been identified as major public health issue in our community.

We are inviting you to take part in this study, by completing a questionnaire that would take you approximately 15 minutes. Once again, there will be no cost to participants and your involvement is voluntary. Please read the attached information sheet for more details. If you agree to take part in the study, please send us the completed questionnaire (attached) using the reply-paid envelope.

This study has been approved by the Human Research Ethics Committee (TQEH/LMH/MH). If you have any questions about the study, please call one of the Study Team on (tel) 8313 1212 or 8313 1215, or email us at pros.nwahs@adelaide.edu.au. If you wish to speak with someone not involved in the study, please telephone the Executive Officer of the Human Research Ethics Committee on (tel) 8222 6841.

We very much appreciate the time and effort that you continue to give to us. We look forward to speaking with you soon.

Yours sincerely

Associate Professor Anne Taylor
Principal Investigator (Epid), North West Adelaide Health Study

Head, Population Research & Outcome Studies,
Discipline of Medicine, The University of Adelaide

Encl

Appendix J: Participant Information Sheet (Questionnaire Study)

North West Adelaide Health Study

THE UNIVERSITY of ADELAIDE

"Health Beliefs, Adaptive Behaviour and Coping Strategies to Extreme Heat (Events) among a cohort of residents in Adelaide, Australia"- (Survey)

Invitation to Participate

We invite you to participate in a research study which we believe is of potential importance. However, before you decide whether or not you wish to participate, we need to be sure that you understand why we are doing it and what it would involve if you agree.

To help you understand why this study is being conducted and what it would involve should you agree to participate, we are providing you with the following information. Please read it carefully – the researchers conducting the research will be happy to discuss it with you and answer any questions that you may have. You are also free to discuss it with outsiders if you wish (i.e. family, friends and/ or your local doctor).

Participation is Voluntary

Participation in any research project is voluntary. If you do not wish to take part you are not obliged to. If you decide to take part and later change your mind, you are free to withdraw from the study at any stage without providing any reason. Your decision to take part, not to take part or to withdraw will not affect your routine treatment, your relationship with those treating you, or your relationship with The Queen Elizabeth Hospital or researchers from the North West Adelaide Health Study.

Background of the Study

Heat waveshave been identified as a major public health issue in our community. Researchers from the Department of Public Health of The University of Adelaide, in association with the **North West Adelaide Health Study,** are undertaking a new research project in order to inform the development of better strategies to help people cope with hot weather/heat waves.

What does participation involve?

The purpose of this study is to examine you level of understanding, awareness, concern, beliefs and adaptive behaviour during periods of extreme heat or heat waves. **By returning the completed questionnaire you are consenting to be part of the study.** The questionnaire will take you about **15 minutes** to complete although your progress will depend on how quickly you move through the questions. While completing the questionnaire you are free to decline to answer any question that you don't understand or any that you don't feel comfortable to answer. **After completing the questionnaire please enclose it and send to us using the reply-paid envelope.**

Will confidentiality be maintained?

Your confidentially will be maintained at all times. The questionnaire will be de-identified before data is entered into a computer programme for analysis. Your name will not be recorded when the data is analysed. The questionnaire will be stored in a locked filling cabinet in the Discipline of Public Health, University of Adelaide, while the data entered into the computer program for analysis will be password protected. Only members of the research team will have access to the data.

How will the information be used?

The information that you provide will be collated in a report. The results will also be compiled and submitted to The University of Adelaide as a PhD thesis. Results of the study may also be published in scientific journals and presented at conferences. There will be no way **to identify you in any documents produced.**

What will I get out of this study?

Although you may have no direct benefit from participating in the study, your responses provided in the questionnaire will assist government and other service providers to develop effective programs and strategies that will help reduce any impacts of heat waves in our society.

What if I have a question about the study?

If you **would** like more information about the study or have any questions, you can contact any of the following:

Janet Grant, NWAH Study Coordinator, Discipline of Medicine, The University of Adelaide, Tel: (08) 8313 1212 Email: janet.grant@adelaide.edu.au

- Derick Akompab, PhD Candidate, Discipline of Public Health, The University of Adelaide
  Tel: (08) 8303 6875 Email: derick.akompab@adelaide.edu.au
- Assoc Prof Peng Bi, Acting Head- Discipline of Public Health, The University of Adelaide
  Tel: (08) 8303 3583 Email: peng.bi@adelaide.edu.au
- Dr Susan Williams, Research Associate, Discipline of Public Health, The University of Adelaide Tel: (08) 8313 1043 Email: susan.williams@adelaide.edu.au
- Prof Martha Augoustinos, Discipline of Psychology, The University of Adelaide
  Tel: (08) 8303 4627 Email: martha.augoustinos@adelaide.edu.au
- Prof Iain Walker, Social & Behavioural Sciences Research Group, CSIRO Sustainable Ecosystems Tel: (08) 9333 6291 Email: iain.a.walker@csiro.au
- Dr. Arthur Saniotis, Discipline of Public Health, The University of Adelaide, Tel (08) 8313 6882, Email: saniotis.arthur@adelaide.edu.au

The Human Research Ethics Committee (TQEH, LMH, MH) has approved this study. Should you wish to speak to a person not directly involved in the study in relation to:

- matters concerning policies
- information about the conduct of the study
- your rights as a participant or
- should you wish to make a confidential complaint
  you should contact The Executive Officer of this Committee on (08) 8222 6841

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Appendix K: Introductory email sent to stakeholders

From: Stevenson, Robert (SES) [Stevenson.Robert@ses.sa.gov.au]
To: (**Note: *Email addresses of recipients removed for privacy reasons***)
Cc:
Subject: Study into Extreme Heat Arrangements Plan

Good morning everyone,
Earlier this week I had a meeting with Derick Akompab, a PhD student at Adelaide Uni.
As part of his PhD studies, Derick is looking at the SA Extreme Heat arrangements - part of the Extreme Weather Hazard Plan - and particularly the processes by which these arrangements were formulated and implemented.
The attached Stakeholder Approach Letter and Participant Information Sheet provide details of this study.
As explained in these documents, Derick would like to interview you to gain your perspectives on this process - as you were a participant in the process.

I would ask that if possible, you participate in this valuable research.

Kindest regards,

Bob

Bob Stevenson
State Emergency Management Planning Officer
SES Disaster Management Services
phone: 8463 6707
mob: 0400 641 242
fax: 8410 3115
email: stevenson.bob@ses.sa.gov.au

All of us moving forward to one goal:
Supporting our communities to protect what is important to them.
"The information in this e-mail may be confidential and/or legally privileged. It is intended solely for the addressee. Access to this e-mail by anyone else is unauthorised. If you are not the intended recipient, any disclosure, copying, distribution or any action taken or omitted to be taken in reliance on it, is prohibited and may be unlawful."

Appendix L: Information sheet for stakeholders

'Engaging stakeholders in an adaptation process: A case study of Heat-health policy[5] development in Adelaide, Australia'

The Discipline of Public Health, University of Adelaide is conducting a research project under the direction of Associate Prof Peng Bi, Dr Susan Williams, Prof. Martha Augoustinos, Prof. Iain Walker and Derick Akompab as part of a PhD project.

This study has been carefully reviewed and has received Ethics Approval from the University of Adelaide Human Ethics Committee. This research is completely different from any other previous study(s) that you might have taken part, and so we will greatly appreciate your time in participating in the study. This study seeks to explore the concept of multi-stakeholder processes and how it was conceptualised during the development of the Extreme Heat Arrangement Plan in 2009.

What will your participation involve?

You have been selected because you are representing a key stakeholder group involved in the design of the Extreme Heat Arrangements in Adelaide. Although we value your participation in this study, it is worth noting that your decision to be part of this study is entirely voluntary. You can contribute in this study by participating in an interview to discuss your views, thoughts about the participatory process.

We anticipate that interviews will take **approximately 30-45 minutes** of your time. Interviews can take place either in person (in your work place or another convenient location) or if you prefer by telephone. With your permission the interview will be recorded and transcribed. You will be given the opportunity to review the transcripts and validate the interview data before it is analysed.

Will confidentiality be maintained?

Yes, of course. Your confidentiality will be maintained at all times by the researchers. Any information you provide will be securely stored in a computer in which only the research team will have access to it. Your interview transcript will be **de-identified** to remove any information that may identify you or your organisation. If we wish to publish any direct quotes or comments from your interview, you will be given the opportunity to review this prior to publication, and to withhold consent if you feel they may identify you.

---

[5] **Heat-health policy** in this study refers to the Extreme Heat Arrangements developed as part of the Extreme Weather Hazard Plan for South Australia after the 2009 heat waves.

How will the information collected be used?
We will seek your permission to digitally record the interviews, to facilitate the collection of information for data transcription and analysis. After transcribing the interview, you will be sent a copy of the transcript to provide you an opportunity to confirm the accuracy of our conversation and to add, modify or clarify any points. The information that you provide will be merged together with those of other participants and analysed.

All results will be reported at the group level; no single participant analysis will be conducted or reported. The results will be compiled in a report to be submitted to the University of Adelaide as a PhD thesis. Results of the study may also be published in scientific journals and presented at conferences. As indicated, there will be no way to identify you in the thesis, reports and scientific papers as your name, job title or your institution will **NOT** be divulged.

How useful will be the results?
The results of this study will generate lessons learnt and contribute towards strengthening processes that involve different group of stakeholders in the development of future strategies, policies and plans to respond to extreme heat in Adelaide.

Contacts for further Information

If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact any of the following member(s) of the research team.

- **Derick Akompab,** PhD Candidate, Discipline of Public Health, The University of Adelaide.Tel:**(08) 8303 6875** Email: **derick.akompab@adelaide.edu.au**

- **A/Prof Peng Bi**, (Principal Supervisor) Head-Discipline of Public Health, The University of Adelaide. Tel: **(08) 8303 3583** Email: **peng.bi@adelaide.edu.au**

- **Prof. Martha Augoustinos**, Discipline of Psychology, The University of Adelaide. Tel: (**08) 8303 4627** Email: **martha.augoustinos@adelaide.edu.au**

- **Dr Susan Williams**, Research Associate, Discipline of Public Health, The University of Adelaide. Tel: **(08) 8313 1043** Email: **susan.williams@adelaide.edu.au**

- **Prof. Iain Walker,** Social and Behavioural Sciences Research Group, CSIRO Sustainable Ecosystems **Tel: (08) 9333 6291** Emai**l: iain.a.walker@csiro.au**

- **Dr. Arthur Saniotis**, Discipline of Public Health, The University of Adelaide, **Tel (08) 8313 6882**, Email: saniotis.arthur@adelaide.edu.au

Appendix M: Follow-up email to stakeholders

Dear Dr/Mr/Ms________
This is a follow-up to the introductory email sent to you on 8 July 2011 by Mr Bob Stevenson of the South Australia State Emergency Services. I am a PhD candidate in the Discipline of Public Health, The University of Adelaide, under the supervision of Associate Prof Peng Bi. I am conducting research on the Extreme Heat Arrangements more particularly the processes by which these arrangements were formulated in the aftermath of the 2009 heat waves in Adelaide.

Given your role in the development of the plan, your views could make a valuable contribution to this research. I would therefore like to invite you to participate in an interview to gain your views and perspectives about the process. The interview will consist of 10 questions and take between 30-45 minutes. Please find attached the participant information sheet for more details.

If you are willing to participate in an interview, please contact me on **08 8303 6875 or 04 0438 0809 or via email at derick.akompab@adelaide.edu.au** to arrange a time and date for the interview. The interview can take place at a time and place that is most convenient to you, either in person or if you prefer by telephone.

I look forward to your reply and thank you for considering this invitation.

Kind Regards,

Derick Akompab
PhD Candidate
Discipline of Public Health
The University of Adelaide, Australia

Appendix N: Copy of Informed Consent Form

THE UNIVERSITY OF ADELAIDE, HUMAN RESEARCH ETHICS COMMITTEE

1. I, ...*(please print your name)* hereby grant consent to take part in the research study titled:

   Engaging stakeholders in an adaptation process: A case study of Heat-health policy development in Adelaide, Australia

2. I acknowledge that I have read the attached participant information sheet.

3. I have had the project, so far as it affects me, fully explained to my satisfaction by the research worker. My consent is given freely.

4. I agree to this interview/discussion to be audio/video recorded.

WITNESS

I have described to... *(name of participant)*
the nature of the research to be carried out. In my opinion she/he understood the explanation.

Status in the Project:..

Name:..

....

(Signature) *(Date)*

Appendix O: Independent Complaint's Procedure Form

THE UNIVERSITY OF ADELAIDE
HUMAN RESEARCH ETHICS COMMITTEE

Document for people who are participants in a research project

CONTACTS FOR INFORMATION ON PROJECT AND INDEPENDENT COMPLAINTS PROCEDURE

The Human Research Ethics Committee is obliged to monitor approved research projects. In conjunction with other forms of monitoring it is necessary to provide an independent and confidential reporting mechanism to assure quality assurance of the institutional ethics committee system. This is done by providing research participants with an additional avenue for raising concerns regarding the conduct of any research in which they are involved.

The following study has been reviewed and approved by the University of Adelaide Human Research Ethics Committee:

Project Title:

Engaging stakeholders in an adaptation process: A case study of Heat-health policy development in Adelaide, Australia

1. If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the project co-ordinator:

   Name: Associate Professor Peng Bi
   Tel: **(08) 8303 3583**
   Email: peng.bi@adelaide.edu.au

2. If you wish to discuss with an independent person matters related to
   - making a complaint, or
   - raising concerns on the conduct of the project, or
   - the University policy on research involving human participants, or
   - your rights as a participant

contact the Human Research Ethics Committee's Secretary on phone (08) 8303 6028

Appendix P: Interview guide for stakeholders

Engaging stakeholders in an adaptation process: A case study of Heat-health policy development in Adelaide, Australia.

Introduction/Setting the Stage

- Your Name/Identity Card
- Thank Participant
- Explain Objectives of Study
- Explain Structure and Duration
- Explain presence of digital recorder(s)
- Explain Confidentiality
- Do you have any questions in relation to what I just explain?
- Are you willing to take part in this interview?
- *Sign Consent Form*

----

1. What was the catalyst that led to the development of the heat-health policy? Who do you think initiated the process?
2. Who were the stakeholders involved during the process of developing the heat-health policy? What criteria were used to select stakeholders who were involved?
3. How was consultation and engagement among the different stakeholders carried out during the process?
4. Can you tell me how decision-making took place during the participatory process?
5. How was communication and coordination carried out among the stakeholders during the heat-health policy development process?
6. What mechanisms were put in place to ensure the integrity and quality of the participatory process?
7. What were some of the challenges that stakeholders encountered during the process and how were they resolved?
8. What do you think were some of the lessons learnt during the heat-health policy development?
9. What do you think were some of the lessons learnt during the heat-health policy development process?
10. What do you think could be done to improve a similar participatory process in future?

Appendix Q: Thank you letter to stakeholders

Dear Dr/Mr/Ms______

On behalf of the research team, I would like to thank you very sincerely for your participation in the research study entitled: *Engaging stakeholders in an Adaptation Process: A case study of Heat-health policy development in Adelaide, Australia.*

I deeply appreciated the time you set aside to share your views, thoughts and perspectives during the interview. The insights you provided during the interview will contribute towards the understanding of how the participatory process during the development of the Extreme Heat Arrangements took place.

Please be assured that the data you provided will be kept confidential. Once your interview recordings are transcribed, I will provide you with the opportunity to review the transcript. Thereafter, data will then be analysed together with those of other stakeholders who took part in the study.

If you are interested in receiving a summary of the research findings once the data is analysed, please do not hesitate to let me know.

Thank you once again for supporting this research.

Kind Regards

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