AAG
Australian Association of Gerontology

AAG Rapid Evidence Assessment

Research on heatwaves and older people in Australia

July 2023

Acknowledgements

Acknowledgement of Country

Australian Association of Gerontology (AAG) acknowledges Traditional Owners of Country throughout Australia and recognises the continuing connection to lands, waters and communities. We pay our respect to Aboriginal and Torres Strait Islander cultures, and to Elders past and present, and to all Aboriginal and Torres Strait Islander peoples including members of the Stolen Generations. For further information about AAG's Aboriginal and Torres Strait Islander Ageing Advisory Group, see the AAG website.

Sponsor

This work was funded by the Australian Government through the Dementia and Aged Care Services Fund.

Australian Government
Department of Health and Aged Care

Contributors

This paper was developed by Tonye Segbedzi (former AAG Policy and Research Officer), Dr Cecilia Gomez-Inclan (AAG Policy and Research Officer), Dr Sandra South (former AAG Policy and Research Manager) and Dr Amber Mills (AAG Policy and Research Manager).

Preferred citation

Australian Association of Gerontology (2023) AAG Rapid Evidence Assessment: Research on Heatwaves and Older People in Australia.

Contents

Executive summary

References are excluded from this summary.

Background

The aim of this rapid evidence assessment is to analyse the quality of research we know about heatwaves and older people in Australia and to develop recommendations for policy and practice.

Methodology

In July 2019, the International Journal of Disaster Risk Reduction published a paper titled 'Older adults in disaster and emergency management: What are the priority research areas in Australia' (1). The paper included a scoping review of global literature published between 2000 and 2018 on older adults and natural hazards. This AAG rapid evidence assessment considered 14 Australian publications identified in the scoping review that explored the topic of heatwaves. This list was enriched with three more papers, two original research and one review piece. These reports were found in references of the previous 14 papers, and they were published in the same period (2000 to 2018). We then manually analysed the full text of the 17 total publications and synthesised relevant information, including an assessment of the quality of the evidence.

Results

- Year of publication: Four studies were published after early 2015.
- Type of study: The most common type of studies were explorations of relationships, followed by descriptive studies.
- Publication region: The most common regions covered were South Australia, Queensland and Victoria.
- Quality of evidence: Overall, the quality of the research evidence was low to very low due to the risk of bias. However, the evidence provides valuable insights into the impact of heatwaves on older people and possible policy and practice responses to heatwaves.
- Topics explored: The majority of the studies focussed on the impact of heatwaves on the health of older people and most also provided recommendations about policy or practice improvements.

Key learnings

Measurement issues

There are inconsistencies in the definition of a heatwave. There are also inconsistencies in the way cause of death is reported. Another complication is the possibility of 'short-term mortality displacement' (i.e., that heatwaves merely hasten imminent deaths). These measurement issues make it difficult to accurately determine the impact of heatwaves.

General impact

From 1844 to 2010, the 350 heatwaves recorded in Australia have been responsible for an estimated 5332 deaths. Between 1988 and 2009, Brisbane had 70 heatwave days, Melbourne had 56 and Sydney had 37. Price Waterhouse Coopers modelled the number of deaths from excess heat at 120-130 deaths per year in 2030, but when climate change projections are factored into the model, heat-related deaths are up to five times greater are predicted. During the period 1907–2010, the greatest numbers of heat-associated deaths have occurred in Victoria (742 deaths), with New South Wales (579 deaths) and South Australia (406 deaths)

also notable. Most heatwave deaths have occurred in January, followed by February and December. Heatwave-related mortality mostly occurred on the same day as the heatwave or the next day.

Mortality

Of the 5332 heatwave fatalities that occurred in Australia between 1844-2010, 510 were people aged over 64 years. During the period 1988-2011 in the five largest cities of Australia, heatwaves were associated with an average national death increase of 28% for people aged 75+. There are variations in the mortality rates for older people during heatwaves for South Australia, Queensland and Victoria. Heatwaves appear to have greater impact on females, especially those aged over 75.

Morbidity

A study of the 2008 and 2009 heatwaves in Adelaide showed significant increases in morbidity for older people with cardiac, neurological, renal and mental health conditions as observed in a previous study in the same city. Another Adelaide study concluded that the risk of direct heat-related hospitalisations could be 10 times higher during heatwaves for people with heart disease, and >20 times higher for people with dementia. During the 2009 heatwave in Melbourne, there was a 61% increase in metropolitan ambulance callouts for direct heat-related conditions in those aged 75 years+ and a 46% increase in direct heat-related emergency department presentations in those aged 75+.

Preparedness

In 2010, many organisations that supported older people did not have heatwave response plans. Long term risk reduction must also consider urban planning and building design. The conversion of existing dwellings for heatwave conditions represents a significant challenge. Having an air conditioner was a statistically significant protective factor during the 2009 heatwave in Adelaide. However, some older people cannot afford air conditioners, and some are reluctant to use them due to the cost of electricity. A pilot study showed that air conditioning just the bedroom during a heatwave does not consume more energy. Stakeholders raised some potential problems with the strategy of creating a register of older people who are at high-risk of heat-related illness.

Education

Several publications discussed the need for education of general practitioners, staff of organisations that support older people, older people and their families/carers both before and during heatwaves. However, they also mentioned the need for extra resources to do this. One publication considered a range of ways to provide heat-health messages for older people. Another found that older people were more likely to see heatwave messages if they were relayed via television, radio, newspaper. A problem was identified in communicating with older people during heatwaves if there is a power outage.

Other responses

An Adelaide study found that by regularly checking high-risk groups during heatwaves, vulnerable groups are more likely to achieve better health outcomes. Stakeholders saw the idea of cooling centres being set up in country hospitals and residential care facilities as a good strategy, but they identified some barriers. A Melbourne study found a significant increase of older patients in emergency departments on heatwave days who had a diagnosis of dehydration. However, stakeholders noted that many older people are reluctant to increase their fluid intake for reasons including incontinence issues, use of diuretic medications or medical advice to restrict fluid.

Vulnerable groups

Several publications identified groups of older people who have additional risk factors that make them particularly vulnerable during heatwaves. These included people experiencing homelessness; people with dementia; people with relevant medical conditions including heart disease, renal conditions, diabetes, neurological and mental health conditions; culturally and linguistically diverse people; people living in an urban environment; and people on low incomes.

Aged care

None of the publications identified in this review covered aged care. However, one publication reported that living in residential aged care reduced the risk of heat-related morbidity during the 2009 heatwave in Adelaide. The Australian Department of Health has issued resources for aged care providers on 'Caring for older people in warmer weather.' The Victorian and Tasmanian Governments have also published detailed resources to assist residential aged care service to become heatwave ready.

Policy and practice recommendations

Based on the learnings from this rapid evidence assessment, AAG makes the following policy and practice recommendations about older people and heatwaves to the Australian Government and State and Territory Governments below. The analysis of the reports can be found in Appendix 2, where they are ordered by date of publication. The reference to this appendix in the following set of recommendations is as '(Publication #)'. The citation of these papers is provided as a (number).

1. Planning

1.1 **Develop a national climate change and health strategy** for Australia (Publication 4 and 17) (2), (3) and(4).

1.2 Support aged care providers and other relevant organisations that support older people to **develop organisational heatwave response plans** (Publication 3)(5) and (Publication 7)(6).

2. Education

Support aged care providers and other relevant organisations that support older people to **educate staff and volunteers, older people and their families/Carers** about responding to heatwaves (Publication 3)(5) and (Publication 7)(6).

3. Register of vulnerable people

Consider establishing a **register of older vulnerable people** that can be used to contact them before and during heatwaves (Publication 2 and 3) (7) (5).

4. Additional contact

Support aged care providers and other relevant organisations that support older people to facilitate **additional contact with older people during heatwaves** (Publication 3)(5) and Publication 16)(8)).

5. Cooling centres

Consider establishing **cooling centres for older people at hospitals or residential aged care facilities**. Implementation issues need to be carefully considered (Publication 3(5) and Publication 6 (9)).

6. Homeless outreach

Provide **outreach programs for older people experiencing homelessness** to assist them during heatwaves**.** Provide more public drinking fountains (Publication 3)(5).

7. Air conditioners

Facilitate access to air conditioning in at least one room for older people. Implementation issues need to be considered, including:

- Installing air conditioning in public and community housing
- Financial support for people on low income (e.g., for installation, repairs, servicing and power costs)
- User-friendly air conditioner design, and supporting older people with how to use the controls (Publication 3)(5), (Publication 6)(9), (Publication 8)(10) and (Publication 16)(8).

8. High-risk medical conditions

Develop **specific prevention strategies for older people with medical conditions that place them at higher risk during heatwaves** (including dementia, heart disease, neurological conditions, renal

conditions, mental health issues and diabetes (Publication 1)(11), (Publication 5)(12), (Publication 9)(13) and (Publication 16)(8).

9. Hydration

Develop **nuanced health messaging about hydration for older people** to take account of people with congestive heart failure, taking diuretic medications, with concerns about continence and other relevant issues (Publication 6)(9).

10. Power outages

Develop **back-up strategies for older people if power supplies are interrupted during heatwaves,** for example if air conditioners or telephones cannot be used (Publication 6)(9).

11. Built environment

Improve urban planning and building design to address thermal comfort of older people during heatwaves (Publication 8)(10) and (Publication 10)(14).

12. Further research

Conduct further research about older people and heatwaves in Australia, including:

- Research on retrofitting existing houses to improve thermal comfort (Publication 8)(10)
- Research to address measurement issues (e.g. definition of heatwave and mortality displacement) (Publication 9)(13), (Publication 12)(15) and (Publication 17)(3)
- Location-specific research about impacts and responses (Publication 11)(16) and (Publication 17)(3)
- Research about vulnerable groups (e.g. people with specific medical conditions or socio-demographic characteristics) (Publication 11)(16) and (Publication 14)(17)
- Research about aged care (18)
- Evaluation of policy and practice interventions.

Heatwaves have killed more Australians than bushfires, cyclones, earthquakes, floods and severe storms combined and are the main threat to Australians' mortality from climate change

Actuaries Institute of Australia (19)

Background

Introduction

'Extreme heat is a well-documented threat to health, and the loss of lives associated with heatwaves exceeds that for any other natural hazard in Australia. It is well known from international and Australian reports that older persons are amongst the most vulnerable during heatwaves, particularly those aged 75 years and over. With predictions of more frequent and intense bouts of hot weather as a consequence of climate change, it is important to focus on evidence-based strategies to minimise preventable heat-associated health events among the vulnerable aging population' (9).

Definition of heatwave

There is no internationally accepted definition of a heatwave. The Australian Bureau of Meteorology defines heatwave as follows:

> 'A heatwave occurs when the maximum and the minimum temperatures are unusually hot over a three-day period at a location. This is considered in relation to the local climate and past weather at the location' (20).

Based on this approach, the same weather conditions may be considered a 'heatwave' in some parts of Australia but not others.

Aim

AAG rapid evidence assessments systematically review the breadth and quality of research evidence on a given topic based on set methodology with limited resources (e.g. staff or time constraints) (21). The aim of this rapid evidence assessment was to analyse what we know about heatwaves and older people in Australia and to develop recommendations for policy and practice improvements.

AAG projects

This paper forms the final part of a larger project **Ageing Planet: Climate Change in an Ageing World**, which is a collaboration between the International Longevity Centre (ILC) United Kingdom and AAG (as executive office for ILC Australia). Among other things, a key objective of the project is 'to ensure that global policy on climate change recognises the importance of ageing.' Activities for the project so far include:

- Radio National Big Ideas program (November 2020) 'Covid, climate change and older Australians'
- AAG workshop (November 2020) 'Climate change and older people: Victims, villains or vanquishers?'
- ILC -UK webinar (November 2020) 'Climate Change in an Ageing World'
- Advocacy event at Parliament House Canberra (March 2021), led by the Climate and Health Alliance.

In addition, AAG has published a policy paper on a related topic 'Promoting older people's resilience and post-traumatic growth following disasters, trauma and adversity' (22).

Government policy

In Australia, State and Territory governments have primary responsibility for emergencies within their borders (23). All have general plans for managing emergencies, and many have plans specifically for managing heatwaves (Table 1). In general, these plans:

- Link to (or form part of) state emergency management plans
- State what weather conditions trigger activation of the heatwave plan
- Specify a lead agency, and assign roles and responsibility for various tasks
- Describe lines of communication
- Outline plans for preparedness, response and recovery
- Note vulnerable groups, including older people.

It is important to note that most State and Territory heatwave plans have only been developed over the past decade, so some of the research publications discussed in this rapid evidence assessment predate relevant plans (Publication 3)(5) and (Publication 15)(24).

Table 1. State and Territory heatwave plans

State or Territory	Plan	Year
Australian Capital Territory	Extreme Heat Plan (25)	2019
New South Wales	State Heatwave Subplan (26)	2018
Northern Territory	Territory Emergency Plan (27)	2021
Queensland	Heat Management Sub-Plan (28)	2019
South Australia	Extreme Heat Strategy (29)	2016
Tasmania	Emergency Management Arrangements (30)	2019
Victoria	State Extreme Heat Sub-Plan(31)	2017
Western Australia	State Hazard Plan: Heatwave (32)	2020

Methodology

Scoping review

In July 2019, the International Journal of Disaster Risk Reduction published a paper by Australian researchers Fountain et al. titled 'Older adults in disaster and emergency management: What are the priority research areas in Australia' (1). The paper included a scoping review of global and Australian literature published between 2000 and 2018 on older adults and natural hazards. Detailed information about the scoping review methodology is provided in the paper. In summary:

- A scoping review was conducted in October 2018 using two databases: Scopus and Web of Science.
- The following criteria were applied to database searches by searching article title, abstract and keywords. Each search was within 2000–2018, and included the keywords 'older adults,' 'elderly,' and 'ageing.' Nine searches were conducted per database, using the following hazard terms: 'bushfire,' 'wildfire,' 'forest fire,' 'cyclone,' 'hurricane,' 'earthquake,' 'flood,' 'heatwave,' 'tsunami,' 'natural hazard,' and 'natural disaster.'

- The inclusion criteria were older adult related articles, scholarly peer-reviewed literature, and people-related articles (i.e. non-people related articles were excluded, e.g., 'ageing infrastructure,' or 'ageing structures').
- Duplicates across the two databases were removed.
- References were manually crosschecked using the following search terms: 'Title contains (keyword) OR abstract contains (keyword) AND title contains (hazard) OR abstract contains (hazard).' Some articles discussed multiple hazards.
- The articles in each hazard group were separated by countries that were included in the research.
- The total number of articles after refining and removing duplicates was 719. Out of the 719 publications, 42 were focused on Australian hazards. In Australia, heatwaves were the most prevalent topic, with 16 publications identified.

Out of the 16 reports used in the Fountain et. al. 2019 (1), it was decided to remove two. One was removed from the list since it was repeated in the reference list of the review (1), this is publication 15 (24). The second one was removed due to its focus on ultraviolet radiation rather than heatwaves (33). The final list of 14 publications was then enriched with three additional papers, two original research and one review piece, found in references of these 16 papers published in the same period (2,7,11). A total of 17 papers were then reviewed in the rapid evidence assessment.

Rapid evidence assessment

This rapid evidence assessment considered 17 Australian research publications on heatwaves. We then manually analysed the full text of the publications and synthesised relevant information. Due to resources constraints, we did not attempt to locate literature outside the databases searched as part of the scoping review, or to undertake further identification of publications based on the reference lists of included publications. We did not exclude publications based on research methodology or study design as we aimed to assess the limited research evidence that was available.

A single reviewer manually analysed the full text of the 17 Australian publications to obtain the following information:

- Publication details: Year; authors; title of article; name of publication; region of publication
- Type of studies reported in publication (i.e. study design/methodology) and sample size
- Overview of key points as provided by the author(s) in the abstract
- Quality of the evidence
- Topics explored.

The assessment of the quality of the evidence was based on the framework presented in AAG's Overview of AAG Research Evidence Review Approaches (see Appendix 1 for a summary of criteria) (21). We then sought to provide a narrative synthesis of key learnings from the topics explored in the publications and to develop recommendations for policy and practice improvements. A numbered list of the 17 publications and summarised information extracted from them (including the quality of evidence assessment) is provided at Appendix 2. For ease of reference, we give both the publication number in this list and the citation throughout this report.

Results

Year of publication

Table 2 shows the number of Australian research publications on older people and heatwaves by year. This rapid evidence assessment includes research published during the period 2000 to 2018. Only 4 studies were published after the beginning of 2015.

Table 2. Publication year

Year	Number of publications N=17
2007	1
2008	1
2010	1
2011	4
2012	2
2013	0
2014	4
2015	2
2016	1
2017	0
2018	1

Type of study

Table 3 shows the type of study reported on in the Australian research publications on older people and heatwaves. The taxonomy of study types from the EPPI-Centre Keywording Strategy for Classifying Education Research was adopted (34). The most common type of studies were:

- Explorations of relationships, where the aim is to examine statistical associations between different variables in order to develop hypotheses
- Descriptive studies, where the aim is to produce a description of a state of affairs or a particular phenomenon and/or to document its characteristics (e.g. a single point in time survey).

Table 3. Type of study

Type of study	Number of publications N=17
Exploration of relationships	10
Description	3
Case-controlled study	2
Other (non-systematic) literature review	2

Region of publication

Table 4 shows the location of Australian research publications on older people and heatwaves. Location was grouped by State or Territory. The most common regions covered were South Australia, Queensland and Victoria. Some publications covered more than one region, so N is > 17.

Table 4. Publication region

Region	Number of publications N>17
Australian Capital Territory	0
New South Wales	2
Northern Territory	0
Queensland	5
South Australia	8
Tasmania	0
Victoria	4
Western Australia	1
Australia – whole country	2
Not stated	1

Quality of evidence

Appendix 2 presents a summary of quality of the evidence assessment for each included publication. Overall, the quality of the research evidence based on the evidence assessments was low to very low due to the high risk of bias resulting from the research methods used and other study limitations (such as low sample sizes and self-selection of participants to the studies). Nonetheless, the assessment of the evidence showed that the included studies, in particular the descriptions and explorations of relationships, provided valuable insight into the impact of heatwaves on older people and possible policy and practice responses to heatwaves.

Topics explored

Table 5 shows the topics explored in the Australian research publications on older people and heatwaves. The labels applied to topics were developed and refined during extraction of information from the included publications. The majority of the research focussed on quantifying the impact of heatwaves on the health of older people (mortality and morbidity). Most publications also provided recommendations about policy or practice improvements. It is important to note that none of the publications covered residential aged care. Many publications explored more than one topic, so N is >17.

Table 5. Topic explored

Topic studied	Number of publications N>17
Impact of heatwaves	14
Preparation and prevention	7
Education and communication	4
Responses during heatwaves	7
Diversity groups	3
Policy or practice improvements	8

Discussion of key learnings

Measurement issues

As noted earlier, there is **no universally accepted definition of a heatwave**. Inconsistencies in definitions have made it difficult to determine absolute numbers of heat-related deaths (Publication 10)(14). Even a small change in the heatwave definition has an appreciable effect on the estimated health impact (Publication 9)(13). **Under-reporting of heatwave impact may also be an issue**. There are inconsistencies in the way cause of death is reported. Publication 10 stated that 'with the underreporting of heat-associated deaths, it is likely that extreme heat has killed many more people than has been reported' (Publication 10)(14). Another complication is the **possibility of 'short-term mortality displacement.'** That is, some older or chronically ill individuals would have died anyway within a short period and their imminent death is simply hastened by the heatwave. Publication 17 found that in addition to the widely observed abnormal increases in deaths during heatwave period, obvious drops in mortality after heatwave could also be seen. The authors concluded that 'most likely, the overall impact of heatwave could have been overestimated in many previous studies that only assessed acute heatwave exposure' (Publication 17)(3).

General impact

Number of heatwaves

Publication 10 found that **350 heatwaves have been recorded in Australia from 1844 to 2010 and they have been responsible for an estimated 5332 deaths**. During that period, there have been **11 significant heatwaves that each caused 20 or more deaths** and collectively caused 34.5% (1837) of the total deaths. The most recent two significant heatwaves were Queensland in 2000 (22 deaths) and Southern Australia in 2009 (432 deaths) (Publication 10)(14).

Publication 13 considered data for the period 1988-2009 for the three biggest Australian cities and found that (at the 95th centile of historical mean temperature for two or more consecutive days) **Brisbane had 70 heatwave days, Melbourne had 56 and Sydney had 37 during 1988-2009** (Publication 13)(35) while South Australia had 31 under their definition (Publication 1 and 2)(7,11).

Future projections

The Intergovernmental Panel on Climate Change 5th Assessment Report (2013) confirmed that extreme heat events are very likely to happen with a higher frequency and longer duration (Publication 16)(8). In 2007, the Commonwealth Scientific Industrial Research Organisation (CSIRO) developed climate change projections for Australia that **indicated an increase in number of days over 35°C in the next 50 years, ranging from moderate to substantial** (Table 6) (Publication 8) (10).

Table 6. Projected number of days over 35°C (10)

Population centre	Current	2070 low emissions scenario	2070 high emissions scenario
Adelaide	17	26	36
Brisbane	1	3	7.6
Canberra	5	10	18
Darwin	11	89	227
Melbourne	9	14	20
Perth	28	41	54
Sydney	3.5	5.3	8

In 2011, it was reported that dramatic changes are expected In Darwin (Northern Territory), with the Commonwealth Scientific and Industrial Research Organisation predicting the annual average of days with temperatures >35°C to increase from the current 11 days to between 141 and 308 days in 2070.

In contrast, in Hobart (Tasmania) there will be little change with the current average of 1.4 days >35°C per year increasing up to 3.4 days by 2070 (Publication 4)(2).

Price Waterhouse Coopers modelled the number of deaths across the major Australian capital cities arising from excess heat at approximately 80 per year in 2011, rising to between 120-130 in 2030 and between 170-200 in 2050. When climate change projections are factored into the model**, heat-related deaths of up to five times greater are predicted** (Publication 8)(10).

Where do heatwave deaths occur?

Publication 10 found that during the period 1907–2010, **the greatest numbers of heat-associated deaths have occurred in Victoria (742 deaths), with New South Wales (579 deaths) and South Australia (406 deaths) also notable**. There were fewer deaths in Queensland (180 deaths), Western Australia (107 deaths) and Northern Territory (26 deaths). Only one heat-associated death was revealed for the Australian Capital Territory and none have been recorded for Tasmania (Publication 10)(14).

When do heatwave deaths occur?

The majority of heatwave deaths have occurred in **January, followed by February and December**, coincident with the southern hemisphere's summer (Publication 10)(14).

It appears that the health effects from heatwaves are acute and continue only for a few days. Publication 13 found that heatwave-related mortality mostly occurred on the same day as the heatwave or the next day in the three cities studied (Publication 13)(35). Publication 11 stated their preliminary analysis of Brisbane data showed no statistically significant increases in health effects beyond time lags 0 to 3 days (Publication 11)(16). However, publication 17 stated that 'we also surprisingly found that across cities, heatwave impact on mortality significantly differed in the length of lags.' The authors said this difference could reflect geographical variations in adaptation responses and susceptibility factors (Publication 17)(3).

Mortality

National

In summary, older people are significantly more vulnerable to the risk of heat-associated death than the general population (except for infants), and this vulnerability increases with age (Publication 10)(14). **510 of the 5332 heatwave fatalities that occurred in Australia between 1844-2010 were seniors aged over 64 years.** 332 of those senior fatalities occurred in the period 1956-2010 (Publication 10)(14).

Publication 17 examined 368,767 deaths of people aged 75+ during the period 1988-2011 in the five largest cities of Australia. It found **heatwave was associated with an average national death increase of 28%** (Table 7)**.** Although the estimated deaths varied by heatwave intensity and duration, the pattern was not consistent across cities (Publication 17)(3).

Table 7. Heatwave effect on mortality of people aged 75+ by city (3)

City	**Heatwave effect** (95% confidence interval)
Adelaide	9%
Brisbane	49%
Melbourne	31%
Perth	21%
Sydney	36%
National	**28%**

South Australia

Publication 5 considered data from two extreme heatwaves in Adelaide in 2008 and 2009. It found that there was a **modest increase in mortality in 2008 - 3% for ages 65-74 and 4% for age 75+.** There was a **borderline significant increase in mortality in 2009 - 15% for ages 65-74 and no change for age 75+.** The authors noted with surprise that these results were much lower than for the 2009 Victorian heatwave and concluded that 'similar large differences in mortality between cities have been observed overseas and the importance of location-specific parameters and investigations is strongly supported' (Publication 5)(12). This publication follows Publication 1(11).

Queensland

Publication 12 examined mortality data from Brisbane from 1996-2004 and found that people aged over 75 were most vulnerable to heatwaves. For example, at the 95th centile of historical mean temperature for two or more consecutive days, **the risk of mortality increased by 8% for those aged 64-75 and increased by 21% for those aged over 75** (Publication 12)(15). This increased to 24% and 39% respectively at the 99th centile.

Publication 9 considered data from three heatwaves in Brisbane in 2000, 2001 and 2004. It found that even after adjusting for the confounders of humidity and pollution, there was a **statistically significant increase mortality in the 75+ age group for deaths from non-external causes (51% increase), cardiovascular causes (83% increase) and diabetes (almost 10-fold increase) and for the 65-74 age group for deaths from cardiovascular causes (almost 3 fold)** (Publication 9)(13).

Victoria

In the 2009 Victorian heatwave, there were **374 excess deaths over those occurring in the same period for the previous 5 years, with 66% of those in the 75+ age group** (Publication 14)(17). See further Victorian data in the section below on women.

Women

Publication 13 examined mortality data for the period 1988-2009 for the three biggest cities and found that **heatwaves appeared to have greater impact on females, especially females aged over 75, regardless of which definition of heatwave was used** (Table 8) (Publication 13)(35).

Table 8.: Heatwave effect on relative risk of mortality for people aged 75+ by city and sex (35)

Heatwave days*	Brisbane	Melbourne	Sydney
Males			
99%	**1.33**	**1.38**	NA
95%	1.05	1.04	0.99
90%	1.03	1.03	**1.03**
Females			
99%	**1.61**	**1.63**	NA
95%	**1.15**	**1.12**	**1.06**
90%	**1.07**	**1.05**	**1.06**

**Centile of mean temperature for two or more consecutive days; Bold typeface indicates statistical significance*

Morbidity

Publication 14 notes that while there are multiple studies evaluating the mortality associated with heat waves, there has been limited research on related morbidity (Publication 14)(17).

Publication 1, 2 and 5 examined data from the 2008 and 2009 heatwaves in Adelaide. It found **significant increases in morbidity in specific health categories for older people** during both heatwaves. For example, in the 2008 Adelaide heatwave:

- Ambulance callouts:
  - Total ambulance callouts increased by 13% for ages 65-74 and 4% for age 75+
  - **Cardiac callouts** increased by 18% for ages 65-74 and 2% for age 75+
  - **Neurological callouts** increased by 39% for ages 65-74 and 11% for age 75+
- Hospital admissions
  - Total hospital admissions increased by 6% for ages 65-74 and 11% for age 75+
  - **Renal admissions** increased by 7% for ages 65-74 and 23% for age 75+
  - **Direct heat** admissions almost doubled for ages 65-74 and three-fold for age 75+
- Emergency department admissions
  - Total emergency department admissions increased by 9% for ages 65-74 and 3% for age 75+
  - **Mental health** admissions increased by 24% for ages 65-74 and 15% for age 75+
  - **Renal admissions** increased by 30% for ages 65-74 and 14% for age 75+
  - **Direct heat** admissions increased by 59% for ages 65-74 and almost three-fold for age 75+ (Publication 5)(12).

Publication 16 considered hospital admissions during the 2009 Adelaide heatwave (among patients aged 18+ with a median age of 73 years). It found that after controlling for other variables, **the risk of direct heat-related hospitalisations could be 10 times higher during heatwaves for people with heart disease, and >20 times higher for people with dementia**, compared with those who do not have these conditions (Publication 16)(8).

Publication 11, which analysed data from 2000-2008 in Brisbane, found the mean number of **emergency department presentations on heatwave days was 11% higher among people aged 65-74 and 13% higher among people aged 75+** than on non-heatwave days (Publication 11)(16).

Publication 14 noted that during the 2009 heatwave in Melbourne there was a **61% increase in metropolitan ambulance callouts for direct heat-related conditions in those 75 years+ and a 46% increase in direct heat-**

related emergency department presentations in those aged 75 years and older. The authors examination of medical records from a Melbourne hospital during 2005-2010 showed that on days with a high ambient temperature, there was a **significant increase in the number of patients older than 64 years of age presenting to the emergency department complaining of weakness and having a discharge diagnosis of dehydration. They also found that the emergency department length of stay was somewhat longer** (by 24 minutes) among this age group (Publication 14)(17).

Preparedness

Planning

Publication 17 concludes that **developing heatwave plans at both the national and regional level is necessary because there has been regional heterogeneity in the pattern of health impacts** (Publication 17)(3). A key recommendation from the2020 Lancet Countdown on Health and Climate Change policy Brief for Australia was to 'develop a national, cross-sectoral climate change and health strategy' (4).

As discussed earlier, all States and Territories now have emergency or heatwave management plans. In some States and Territories, these plans have cascaded down into plans for health departments (e.g. Heat Health Plan for Victoria (36)) and local councils (e.g. Heatwave Planning Guide: Development of heatwave plans in local councils in Victoria (37)). However, **in 2010 many organisations that support older people did not have heatwave response plans**, although the situation may have improved since then (Publication 3)(5).

Publication 10 noted that 'most [heatwave] planning currently relies on reducing risks through information and education to influence and change public behaviour, and emergency response when an event unfolds. However, while public education and emergency management is important, **long term risk reduction must also consider urban planning, building design, community development and social equity** (Publication 10)(14).

Housing design

Publication 3 reported that some stakeholders did pre-summer assessments of home environments for habitability during hot weather and referred clients to other support services if improvements were needed (Publication 3)(5).

Publication 8 noted that due to the large amount of existing housing stock and the relatively low proportion of new houses that are constructed each year, the conversion of existing dwellings for heatwave conditions represents a significant challenge. The authors conducted a pilot study under heatwave conditions on a small 2-bedroom home in Adelaide that is typical of public housing. With no modifications, they found the living/kitchen area was hotter than the 'comfort temperature' (30°C) for more than 65% of occupied hours and the bedroom was more than the comfort temperature (26°C) for nearly 90% of the time. A ceiling fan in the bedroom only reduced the time above the comfort temperature to 65%.

In summary, they found that **none of the retrofit measures they tested had a significant impact [these included increased attic ventilation, ceiling insulation, double glazing, window blinds and window film)** and concluded that **for this type of housing, it is impossible to achieve thermal comfort during a heatwave without air conditioning** (Publication 8)(10).

Air conditioning

Publication 16 reported that **having an air conditioner in the bedroom was a statistically significant protective factor in reducing hospital admissions** during the 2009 heatwave in Adelaide (Publication 16)(8).

Publication 15 found that (among a sample of 997 people aged 65+), there was **significantly higher ownership of household air conditioning in South Australia (95.2%) compared to Victoria (86.2%),** and more South Australian respondents had their air conditioners serviced regularly (31.2% vs 20.9%) (Publication 15)(24). However, the stakeholders in publication 3 reported that some of their older clients could not afford an air conditioner or to replace an older non-repairable style air conditioner (Publication 6)(9). The lack of air conditioners in public housing was a specific concern (Publication 3)(5) and (Publication 8)(10).

In addition to the cost of installing/replacing and servicing an air conditioner, several publications reported that **older people are often reluctant to use the air conditioner due to the cost of electricity**, for example (Publication 3)(5) and (Publication 6)(9). Publication 8 noted that electricity prices increased by up to 60% over the five years to 2010 and further price rises are inevitable (Publication 8)(10). The stakeholders in publication 6 also noted **several other barriers to the usage of air conditioning,** including:

- Understanding and using the control panels on modern air conditioners can present challenges for older people
- Fear of house fires due to faulty air conditioners
- Concern that overuse of air conditioners could jeopardise power supplies during heatwaves (Publication 6)(9).

Greater use of air conditioning during heatwaves causes peak electricity loads, so power outages are more common (Publication 8)(10). When power fails, air conditioners cannot be used, so a back-up plan is required (Publication 3)(5). See discussion below on public cooling centres.

To minimise both installation and ongoing operational costs for occupants, publication 8 explored the concept of creating a 'cool refuge' by installing air conditioning in just one room or zone of the house (rather than the whole house). The pilot study showed that **making the main bedroom a cool refuge achieves the aim of consuming no more daily energy during heatwaves than would be used during non-heatwave conditions** (i.e. 52.2 MJ/day). It also provided the benefit of lowering of peak load on the electricity grid during heatwaves. The study demonstrated residents could maintain thermal comfort without extra ongoing costs if they are able to restrict their area of occupation to just part of the house during heatwave periods (Publication 8)(10). An example of how this strategy could be implemented is the Climate Safe Rooms Program in Geelong Victoria – see here (38).

Register of vulnerable people

Publication 3 considered the strategy of **creating a register of older people who are at high-risk of heat-related illness,** although this was not current practice at that time. These vulnerable people could be contacted before or during a heatwave by relevant organisations or via a network of volunteers to act as 'buddies.' Stakeholders noted that a number of organisations held client records that could theoretically be utilised to create a database (e.g. district nursing services, General Practitioners and Commonwealth funded home care services). However, stakeholders also raised **some potential problems with this strategy**, including: confidentiality rules, the need for appropriate screening tools to identify high-risk people and the need for evidence to demonstrate that such an intervention would be effective (Publication 3)(5). The stakeholders in publication 3 pointed out that the most vulnerable in the community may be unlisted on databases due to isolation and not having someone to register them for services (Publication 6)(9).

In 2012, Victoria created a register of vulnerable people to address bushfire evacuations and it was expanded to cover all hazards in 2015. 64 local councils participated in the scheme. An evaluation conducted in 2020 identified **concerns about the accuracy of the information in the register and about community organisations' understanding of their role in implementing the scheme**. It was noted that (in relation to

older people) these issues might be exacerbated by the change from block funded aged care services to funding individuals to engage a range of services based on choice (39).

Education

Who

Several publications discussed the need for education of older people and relevant workers, both before and during heatwaves. Publication 5 noted that over 85% of Australians visit General Practitioners (GPs) each year, so GPs have an ideal opportunity to implement harm minimisation strategies. The authors concluded that the best health protection measures for older people to reduce hospitalisation was through **education and training of medical personnel, older patients and their Carers** (Publication 7)(6).

Publication 3 considered the need for **pre-summer education for staff of organisations that support older people** (including district nursing services, home care services and delivered meals services) about risk factors and protective strategies for clients during heatwaves. These support organisations also all thought they could play a role in **educating older clients before summer**. However, they also mentioned the need for extra resources to do this (Publication 3)(5).

How

Publication 3 considered **a range of ways to provide heat-health messages for older people, both before and during heatwaves,** including:

- Developing webpages of information
- Distributing pamphlets
- Recorded messages and providing advice on telephone services
- Media announcements
- Contacting people on a register of vulnerable people (discussed above)
- Providing advice during appointments with GPs and practice nurses
- Providing advice during home visits by district nurses, home care providers and meal delivery services (Publication 3)(5).

Publication 15 reported that more than 75% of the older people they surveyed recalled there being health warnings about heatwaves, but less could recall the actual messages (Victoria 57.9% compared to 64.4% in South Australia). **The majority said they were more likely to see heatwave warning messages if they were relayed via television, radio, newspaper or information in their letter box.** When asked the best means of communicating these messages, Victorians favoured radio, whereas in SA television was the preferred media. **More people in Victoria (22.6%) than in SA (15.2%) chose text messages via mobile phone as the preferred method** (Publication 15)(24).

Power outages

Publication 6 noted the **problem of communicating directly with older people during a heatwave if they do not have a traditional landline and there is a power outage** (because cordless telephones are dependent on electricity) (Publication 6)(9). A similar problem would arise for most telephone and internet services provided via the NBN broadband network (40). However, it is possible that more older people may have mobile phones now.

Recent developments

As discussed earlier, all States and Territories now have emergency or heatwave management plans. Many of these include provisions for education and communication during heatwaves. For example, the South

Australian Extreme Heat Strategy refers to booklets and fact sheets about extreme heat, increased advertising in both print media and radio during heatwaves, email messaging across-government agencies, and liaison between the Health Media Unit and Emergency Services to co-ordinate information (29).

Other responses

See earlier sections of this paper for discussion about use of air conditioners and education/communication during heatwaves. Other responses during heatwaves are discussed below.

Need to respond quickly

Several publications drew inference about the short time lag between the onset of a heatwave and the impact on mortality and morbidity. For example, publication 5 noted that mortality was instantly elevated on the hottest day of the 2009 heatwave, with only two-day latency until daily mortality peaked and concluded that **there is a very small window of opportunity for preventive action during the heatwave** (Publication 5)(12). Publication 3 suggested that because the window of opportunity is narrow, **strategies should include proactive as well as reactive components** (Publication 3)(5).

Cooling centres

Publication 6 reported that **opinions about promoting publicly available heat-relief or 'cooling centres' such as shopping malls were mixed amongst stakeholders**. The logistics of older people traveling in the heat to cooling centres and requiring nourishment (and possibly extra care) whilst in the centre, was viewed by some as being problematic (Publication 6)(9). Publication 3 noted that older people would still need medication and care while at the cooling centre (Publication 3)(5).

Publication 6 considered **cooling centres being set up in country hospitals and residential care facilities. While stakeholders saw this as an effective primary health care strategy, which overcame some of the logistical problems with shopping centres, they identified some barriers**, including people not wanting to leave animals home alone, limited access to transport, financial constraints, mobility issues, and reluctance to leave the comfort of their home (Publication 6)(9).

Social contact

The stakeholders in publication 6 reported that **older people who had support from family or neighbours fared better during periods of extreme heat, than those without** (Publication 6)(9).

Publication 16 found that **having an emergency button and having more social activities were both statistically significant protective factors in reducing hospital admissions** during the 2009 heatwave in Adelaide. The authors stated that 'one striking finding from our study is the beneficial factor of having more social support in reducing the morbidity during heatwaves. Usage of emergency buttons (which is usually linked with community health professionals) means vulnerable people could receive timely health support when they are in need. These results suggest that **by regularly checking high-risk groups during heat, vulnerable groups are more likely to achieve better health outcomes during heatwaves** (Publication 16)(8).

Publication 3 noted that some **home care providers and meal delivery staff observed their clients for deterioration during heatwaves** and had a protocol to report to supervisors if they care concerned about a client. Stakeholders reported that **district nurses and other relevant home care providers visited vulnerable clients more frequently on hot days** to provide advice and assistance (including arranging hospitalisation if required). They also **suggested using a community-based 'buddy system' for checking on vulnerable people**, similar to schemes that had been used for bushfires (Publication 3)(5).

Hydration

Several publications discussed the importance of hydration during heatwaves. Publication 7 noted that **limiting fluid intake either unconsciously, or for medical reasons, amplifies the impact of heat stress in older people**. Dehydration can be caused directly by excess caffeine intake and diuretic medication (Publication 7)(6). Publication 5 reported that renal disease-related increases were of particular concern during the 2009 heatwave and that **heat-related dehydration appears to promote acute renal failure** (Publication 5)(12). Publication 14 found a **significant increase of older patients in emergency departments on heatwave days who had a discharge diagnosis of dehydration** (Publication 14)(17). Publication 16 reported that 'using refreshment' was a statistically significant protective factor against hospital admission during the 2009 Adelaide heatwave (Publication 16)(8).

The stakeholders in publication 6 stated that older people are often not well hydrated, and with a diminished thirst sensation, some simply forget to drink. Even if thirsty, many prefer hot tea to water. Further, they noted that **many are reluctant to increase their fluid intake for reasons including incontinence issues, use of diuretic medications or advice about fluid restrictions** (people with congestive heart failure). **Fear of falling during the night** and not being found was also identified as being a barrier to fluid intake (Publication 6)(9).

Publication 6 noted that **when providing advice to keep hydrated during hot spells, authorities should be mindful of people with specific medical conditions and those taking medications that can interfere** with thermoregulation. They said more research needs to be undertaken in this area to inform guidelines regarding the management of certain conditions during extreme weather (Publication 6)(9).

Other adaptive behaviours

Publication 15 considered other adaptive behaviours by older people during heatwaves. In response to the question, '**When it is very hot how often do you reduce the number of activities that require physical effort?' 60.7% of people in SA reported doing so 'most of the time', compared to 52.3% in Victoria**. Those who did not reduce physical activities were asked why. Whereas the activities of some were already restricted by poor health or age, at least 30% in each state recognised that 'things still have to be done.' In **SA, 82.8% said they stay indoors 'most of the time' during heatwaves compared to 75.4% in Victoria**. The vast majority of respondents claimed they **wore cool and light clothing** (Publication 15)(24).

Vulnerable groups

Several publications noted that there are some groups of older people who have additional risk factors that make them particularly vulnerable during heatwaves. See earlier sections of this paper for discussion about women, people with limited social contact and people without air conditioning. Other vulnerable groups are discussed below.

Homelessness

Publication 3 noted that homelessness is associated with several factors that increase vulnerability to heat-related illness including lack of access to shade, drinking water and air-conditioned shelter, limited access to sources of information, social isolation and economic deprivation. Stakeholders reported that the paucity of outreach programs specifically targeting older people experiencing homelessness was a significant gap in capacity to minimise harm. They also suggested the need for more free, publicly accessible drinking fountains (Publication 3)(5).

Dementia

Publication 16 found that compared with controls, **patients admitted to hospital during a heatwave were more than 20 times more likely to have dementia** (adjusted overall risk =26.43) The authors noted there is not much evidence about health outcomes during heatwaves among patients with dementia and that their study may be the first to report a dramatically increased risk of morbidity, with potentially significant implications for the development of guidelines for patient care (Publication 16)(8). Stakeholders in publication 6 noted that cognitive impairment can affect clarity of thought and adaptive behaviours. Dementia patients, particularly those pre-diagnosis, were said to be amongst the most vulnerable, and over-dressing was seen as a problem for these individuals during hot weather (Publication 6)(9).

Other medical conditions

As discussed earlier, **there are specific medical conditions that increase risk of death or hospitalisation during heatwaves, including heart disease, renal conditions, diabetes, neurological and mental health conditions.**

In publication 6, stakeholders discussed **medications that can predispose users to heat stress.** These include medications that may interfere with renal function or sodium balance; cardiovascular drugs that may impact on thermoregulatory mechanisms, and psychoactive medications which may cause confusion, sedation, or dull the senses. Publication 7 noted that:

- Dehydration can be caused directly by diuretic medication
- Beta blockers cause reduced vasodilation and decrease sweat production
- Vasodilators aggravate heat illness by exacerbating hypotension
- Sedatives, antidepressants and antipsychotics can cause lethargy, altered cognition and memory impairment, leading to decreased mobility, reduced sweating and less desire to drink fluid
- Poor mobility is one of the most important contributors to heat related health risk as people are less likely to be able to 'move' to keep cool in the heat (Publication 7)(6).

Cultural and linguistic diversity

Stakeholders in publication 6 noted that many of the older generation were born overseas, immigrating to Australia from Europe in the 1950s and 1960s. They pointed out that that linguistic barriers can emerge for some ageing immigrants if first language reversion occurs. This can increase isolation and may be a significant issue during heatwaves because it affects the uptake of heat-health information (Publication 6)(9).

Urban environment

Publication 8 reported that **heatwaves and the urban heat island effect are both contributors to heat-related illness** especially where there is little vegetation and dense urban form (Publication 8)(10).

Publication 14 stated that metropolitan Melbourne regularly exhibits a distinct urban heat island effect that appears to produce an area of high risk for emergency department morbidity and residential mortality (Publication 14)(17). Since 1844, Australia's population has increased from approximately 260,000 to 22.3 million in 2010. This growth has come with greater urbanisation and high-density housing, exacerbating the issue through a heat island effect (Publication 10)(14). Australia's population is projected to reach between 37.4 and 49.2 million people by 2066 (41).

Low income

Publication 11 noted that research on heat-related morbidity and its association with socioeconomic disadvantage is limited but existing literature identifies the poor as among the most vulnerable groups. Their study of heatwaves in Brisbane during 2000-2008 found that in the more disadvantaged areas, heat-related emergency department presentations increased 19-28% for people aged 65-74, and 4-7% for people aged 75+ on heatwave days. However, even in less disadvantaged areas there was still an increase of 8% for people aged 65-74 and those aged 75+ on heatwave days. They said that while many factors may explain these findings, they were unable to assess this with their data (Publication 11)(16).

Aged care

Research

None of the publications identified in the scoping review results substantively covered aged care (1). Although some publications included participants who may have been providing or receiving home care, issues unique to home care were not specifically addressed (for example, publication 3(5), publication 6(9) and publication 15(24). Residential aged care was briefly mentioned in the following two publications. Publication 7 noted that studies following the **2003 European heatwave found significant increases in mortality in residents of nursing homes and institutions**. Although these studies focused on the effects of air conditioning in nursing home residents, the results showed that many variables, such as patient mobility and carer knowledge, must be considered, not just temperature (Publication 7)(6). However, publication 15 reported that an Australian study (Zang, Nitschke and Bi, 2012) **found living in residential aged care reduced the risk of heat-related morbidity during the 2009 heatwave in Adelaide** (Publication 15)(24).

However, the scoping review did refer to one study that covered residential aged care (but it was not included in their results due to the specific search terms they used). This study described heatwave preparations by Victorian public residential aged care services in the summer of 2010-2011. In summary, the main preparations undertaken were:

- Heatwave plans
- Installation, repair and maintenance of air conditioning units
- Testing power generators
- Staff education
- Heat-health messaging for residents and families
- Ensuring supply of appropriate drinks and fluid-rich foods (18).

Resources

In 2017, the former Australian Department of Health (DOH) issued two resources for aged care providers (one for residential aged care and one for home care) on 'Caring for older people in warmer weather.' These are available here. The resources state that 'to assist the comfort of care recipients and for you to meet your responsibilities under the Aged Care Act 1997, the department has created a checklist which may be useful in considering the activities you may need to undertake during a heatwave.' (42).

The Aged Care Quality and Safety Commission webpage on 'Preparing for heatwave conditions' includes links to some resources, including resources from the Bureau of Meteorology and advice from the Australian Medical Association. It is available here (43).

In 2013, the Victorian Department of Health and Human Services published a detailed 'Residential aged care services – heatwave ready resource.' It is available here (44).

In 2016, the Tasmanian Department of Health published 'Heatwave ready Tasmania: resources for residential aged care facilities in Tasmania.' It is available here (45).

Limitations of this rapid evidence assessment

This rapid evidence assessment only covers 17 publications on heatwaves. The authors noted that the search criterion used for the literature review was somewhat limited, for example the term 'aged care' was not included in their criterion. Additionally, as only two databases were accessed, not all academic publications related to older adults and heatwaves were included in the dataset. The review also did not include grey literature (1).

Only three reviewers extracted information from each publication, and one undertook the assessments of the quality of the evidence, due to resource constraints. Thus, there is some potential for errors or bias in the extraction of information.

AAG did not attempt to locate unpublished research, to locate grey literature outside the databases searched as part of the scoping review, or to undertake further identification of publications based on the reference lists of included publications outside of the scoped period. This may mean that important research has been missed, or that there may be a publication bias present that we were unable to identify.

This rapid evidence assessment found that, overall, the quality of the research evidence based on the evidence assessments was low to very low due to the high risk of bias. Nonetheless, the assessment of the evidence showed that the included studies, in particular the descriptions and explorations of relationships, provided valuable insight into the impact of heatwaves on older people and possible policy and practice responses to heatwaves. There was consensus in the literature on the key recommendations summarised in this rapid evidence assessment. However, we acknowledge that this consensus may represent a shared bias between the authors of the included publications, older people included in the research and the authors of this rapid evidence assessment. Furthermore, there may be a bias in the lived experiences captured in the included studies as the recruitment was often limited to a set number of support services and/or to those who are willing to participate.

References

1. Fountain L, Tofa M, Haynes K, Taylor MR, Ferguson SJ. Older adults in disaster and emergency management: What are the priority research areas in Australia? International Journal of Disaster Risk Reduction. 2019;39(101248).

2. Peng Bi, Williams S, Loughnan M, Lloyd G, Hansen A, Kjellstrom T, et al. The Effects of Extreme Heat on Human Mortality and Morbidity in Australia: Implications for Public Health. Asia Pac J Public Health. 2011 Mar;23(2_suppl):27S-36S.

3. Cheng J, Xu Z, Bambrick H, Su H, Tong S, Hu W. Heatwave and elderly mortality: An evaluation of death burden and health costs considering short-term mortality displacement. Environment International. 2018;115:334–42.

4. Behrens G, Beggs PJ, Zhang Y. The Lancet Countdown on Health and Climate Change Policy brief for Australia [Internet]. 2020. Available here.

5. McInnes JA, Ibrahim Joseph E. Minimising harm to older Victorians from heatwaves: A qualitative study of the role of community-based health profession and carer organisations. AJA. 2010 Sep;29(3):104–10.

6. Wilson L, Black D, Veitch C. Heatwaves and the elderly: The role of the GP in reducing morbidity. Australian Family Physician. 2011;40(6):637–40.

7. Hansen A, Bi P, Nitschke M, Ryan P, Pisaniello D, Tucker G. The Effect of Heat Waves on Mental Health in a Temperate Australian City. Environ Health Perspect. 2008 Oct;116(10):1369–75.

8. Zhang Y, Nitschke M, Krackowizer A, Dear K, Pisaniello D, Weinstein P, et al. Risk factors of direct heat-related hospital admissions during the 2009 heatwave in Adelaide, Australia: a matched case–control study Ying. BMJ Open [Internet]. 2016;6(e010666). Available here.

9. Hansen A, Bi P, Nitschke M, Pisaniello D, Newbury J, Kitson A. Perceptions of Heat-Susceptibility in Older Persons: Barriers to Adaptation. Int J Environ Res Public Health. 2011;8:4714–28.

10. Bennetts H, Pullen S, Zillante G. Design Strategies for Houses Subject to Heatwaves. Open House International. 2012;37(4):29–38.

11. Nitschke M, Tucker GR, Bi P. Morbidity and mortality during heatwaves in metropolitan Adelaide. Medical Journal of Australia. 2007 Dec;187(11–12):662–5.

12. Nitschke M, Tucker GR, Hansen A, Williams S, Zhang Y, Bi P. Impact of two recent extreme heat episodes on morbidity and mortality in Adelaide, South Australia: a case-series analysis. Environmental Health. 2011;10(42).

13. Wang XY, Barnett AG, Yu W, FitzGerald G, Tippett V, Aitken P, et al. The impact of heatwaves on mortality and emergency hospital admissions from non-external causes in Brisbane, Australia. Occup Environ Med. 2012;69:163–9.

14. Coates L, Haynes K, O'Brien J, McAneney J, Dimer de Oliveira F. Exploring 167 years of vulnerability: An examination of extreme heat events in Australia 1844–2010. Environmental Science & Policy. 2014;42:33–44.

15. Tong S, Wang XY, FitzGerald G, McRae D, Neville G, Tippett V, et al. Development of health risk-based metrics for defining a heatwave: a time series study in Brisbane, Australia. BMC Pblic Health [Internet]. 2014;14(435). Available here.

16. Toloo G (Sam), Guo Y, Turner L, Qi X, Aitken P, Tong S. Socio-demographic vulnerability to heatwave impacts in Brisbane, Australia: a time series analysis. Aust NZ J Public Health. 2014;38(5):430–5.

17. Dalip J, Phillips GA, Jelinek GA, Weiland TJ. Can the Elderly Handle the Heat? A Retrospective Case-Control Study of the Impact of Heat Waves on Older Patients Attending an Inner City Australian Emergency Department.

18. McInnes JA, Ibrahim Joseph E. Preparation of residential aged care services for extreme hot waether in Victoria, Australia. Australian Health Review. 2013;37:442–8.

19. Climate change and an ageing population create perfect storm [Internet]. Institute of Actuaries of Australia; 2019 [cited 2021 May 4]. Available here.

20. Bureau of Meteorology [Internet]. [cited 2021 Jun 1]. Understanding heatwaves. Available here. l

21. Australian Association of Gerontology. Overview of AAG Research Evidence Review Approaches. Melbourne: AAG; 2020. 2020.

22. Australian Association of Gerontology. Position Paper: Promoting Older People's Resilience and Post-Traumatic Growth following Disasters, Trauma and Adversity. 2022.

23. Australian Government Disaster Response Plan [Internet]. Australian Government; 2020. Available here.

24. Hansen A, Bi P, Pisaniello D, Nitschke M, Tucker GR, Newbury J, et al. Heat-health behaviours of older people in two Australian states. AJA. 2015;34(1):E19–25.

25. ACT Extreme Heat Plan. Australian Capital Territory Government; 2019.

26. NSW State Heatwave Subplan [Internet]. New South Wales Government; 2018. Available here

27. Northern Territory Emergency Plan [Internet]. Northern Territory Government; 2021. Available here.

28. Heatwave Management Sub-Plan [Internet]. Queensland Government; 2019. Available here.

29. SA Health Extreme Heat Strategy [Internet]. Government of South Australia; 2016. Available here.

30. Tasmanian Emergency Management Arrangements: Issue 1 [Internet]. Tasmanian Government; 2019. Available here.

31. State Emergency Response Plan: Extreme Heat Sub Plan [Internet]. Victorian Government; 2017. Available here.

32. State Hazard Plan: Heatwaves [Internet]. Government of Western Australia; 2020. Available here.

33. Thomas P, Swaminathan A, Lucas RM. Climate change and health with an emphasis on interactions with ultraviolet radiation: a review. Global Change Biology. 2012;18:2392–405.

34. Evidence for Policy and Practice Information and Co-ordinating (EPPI) Centre. Keywording Strategy for Classifying Education Research [Internet]. University of London; 2003 [cited 2020 Aug 7]. Report No.: Version 0.9.7. Available here.

35. Tong S, Wang XY, Yu W, Chen D, Wang X. The impact of heatwaves on mortality in Australia: a multicity study. BMJ Open. 2014;4(e003579).

36. Heat health plan for Victoria [Internet]. State Government of Victoria; 2020. Available here.

37. Heatwave Planning Guide: Development of heatwave plans in local councils in Victoria [Internet]. Department of Human Services; 2009. Available here.

38. Geelong Sustainability [Internet]. [cited 2021 Aug 27]. Climate Safe Rooms. Available here.

39. Vulnerable Persons Registers Evaluation Summary of key findings and next steps [Internet]. Department of Health and Human Services; 2020. Available here

40. NBN. nbnco. [cited 2021 Jul 16]. What happens during power blackout. Available here.

41. Australian Bureau of Statistics. Population Projections, Australia 2017-2066 [Internet]. 2018 [cited 2021 Jul 21]. Available here.

42. Department of Health. Caring for older people in warmer weather [Internet]. 2017 [cited 2021 Jul 21]. Available here.

43. Aged Care Quality and Safety Commission. Preparing for heatwave conditions [Internet]. 2019 [cited 2021 Jul 21]. Available here.

44. Department of Health and Human Services. Residential aged care services – heatwave ready resource [Internet]. 2013 [cited 2021 Jul 21]. Available here.

45. Department of Health. Heatwave ready Tasmania: resources for residential aged care facilities in Tasmania' [Internet]. Tasmanian Government; 2016 [cited 2021 Jul 21]. Available here.

46. Guyatt G, Oxman AD, Akl EA, Kunz R, Vist G, Brozek J, et al. GRADE guidelines: 1. Introduction—GRADE evidence profiles and summary of findings tables. Journal of Clinical Epidemiology. 2011 Apr 1;64(4):383–94.

47. Guyatt GH, Oxman AD, Kunz R, Atkins D, Brozek J, Vist G, et al. GRADE guidelines: 2. Framing the question and deciding on important outcomes. Journal of Clinical Epidemiology. 2011 Apr 1;64(4):395–400.

48. Balshem H, Helfand M, Schünemann HJ, Oxman AD, Kunz R, Brozek J, et al. GRADE guidelines: 3. Rating the quality of evidence. Journal of Clinical Epidemiology. 2011 Apr 1;64(4):401–6.

49. Guyatt GH, Oxman AD, Vist G, Kunz R, Brozek J, Alonso-Coello P, et al. GRADE guidelines: 4. Rating the quality of evidence—study limitations (risk of bias). Journal of Clinical Epidemiology. 2011 Apr 1;64(4):407–15.

50. Guyatt GH, Oxman AD, Montori V, Vist G, Kunz R, Brozek J, et al. GRADE guidelines: 5. Rating the quality of evidence—publication bias. Journal of Clinical Epidemiology. 2011 Dec 1;64(12):1277–82.

51. Guyatt GH, Oxman AD, Kunz R, Brozek J, Alonso-Coello P, Rind D, et al. GRADE guidelines 6. Rating the quality of evidence—imprecision. Journal of Clinical Epidemiology. 2011 Dec 1;64(12):1283–93.

52. Guyatt GH, Oxman AD, Kunz R, Woodcock J, Brozek J, Helfand M, et al. GRADE guidelines: 7. Rating the quality of evidence—inconsistency. Journal of Clinical Epidemiology. 2011 Dec 1;64(12):1294–302.

53. Guyatt GH, Oxman AD, Kunz R, Woodcock J, Brozek J, Helfand M, et al. GRADE guidelines: 8. Rating the quality of evidence—indirectness. Journal of Clinical Epidemiology. 2011 Dec 1;64(12):1303–10.

54. Guyatt GH, Oxman AD, Sultan S, Glasziou P, Akl EA, Alonso-Coello P, et al. GRADE guidelines: 9. Rating up the quality of evidence. Journal of Clinical Epidemiology. 2011 Dec 1;64(12):1311–6.

55. Brunetti M, Shemilt I, Pregno S, Vale L, Oxman AD, Lord J, et al. GRADE guidelines: 10. Considering resource use and rating the quality of economic evidence. Journal of Clinical Epidemiology. 2013 Feb 1;66(2):140–50.

56. Guyatt G, Oxman AD, Sultan S, Brozek J, Glasziou P, Alonso-Coello P, et al. GRADE guidelines: 11. Making an overall rating of confidence in effect estimates for a single outcome and for all outcomes. Journal of Clinical Epidemiology. 2013 Feb 1;66(2):151–7.

57. Guyatt GH, Oxman AD, Santesso N, Helfand M, Vist G, Kunz R, et al. GRADE guidelines: 12. Preparing Summary of Findings tables—binary outcomes. Journal of Clinical Epidemiology. 2013 Feb 1;66(2):158–72.

58. Guyatt GH, Thorlund K, Oxman AD, Walter SD, Patrick D, Furukawa TA, et al. GRADE guidelines: 13. Preparing Summary of Findings tables and evidence profiles—continuous outcomes. Journal of Clinical Epidemiology. 2013 Feb 1;66(2):173–83.

59. Andrews J, Guyatt G, Oxman AD, Alderson P, Dahm P, Falck-Ytter Y, et al. GRADE guidelines: 14. Going from evidence to recommendations: the significance and presentation of recommendations. Journal of Clinical Epidemiology. 2013 Jul 1;66(7):719–25.

60. Andrews JC, Schünemann HJ, Oxman AD, Pottie K, Meerpohl JJ, Coello PA, et al. GRADE guidelines: 15. Going from evidence to recommendation—determinants of a recommendation's direction and strength. Journal of Clinical Epidemiology. 2013 Jul 1;66(7):726–35.

61. Barends E, Rousseau DM, Briner RB. CEBMa Guideline for Rapid Evidence Assessments in Management and Organizations [Internet]. Amsterdam: Center for Evidence Based Management; 2017 [cited 2020 Sep 15]. Report No.: Version 1.0. Available here.

62. Higgins JPT, Green S, editors. Cochrane Handbook for Systematic Reviews of Interventions. Chichester: Wiley/Blackwell; 2008. (Cochrane Book Series).

63. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med. 2009;6(7):e1000097.

APPENDIX 1: Approach to assessing the quality of the evidence

The approach adopted by AAG for assessing evidence quality is based on the EPPI-Centre Keywording Strategy for Classifying Education Research(34), the GRADE approach (46–60) and the Centre for Evidence-Based Management (CEBMa) Guideline for Rapid Evidence Assessments in Management and Organisations (61).

In line with the selected approaches, the assessment of the quality of the evidence for each research publication in this review involved assigning a base evidence quality grading based on the study design/research methodology. Relevant quality criteria regarding risk of bias and other limitations (including imprecision, inconsistency, indirectness, and publication bias) were taken into account based on Cochrane Collaboration's 'risk of bias' tool (62) and GRADE guidelines (46–60), unless the publication was a review, in which case The PRISMA Statement criteria (63) were used as the basis for the quality appraisal. For systematic literature reviews, the overall quality rating was also informed by the quality of the research included in the review as stated by the author of the included systematic literature review. Each criterion considered is reported against in Appendix 2.

APPENDIX 2: List of publications by year and assessment criteria

Appendix 2 provides an overview of the different criteria assessed for each publication, including assessment against quality criteria.
Please note that AAG avoids the term 'elderly'. The use of 'elderly' in this report reflects the original author. Papers are listed by year of publication and numbered in order. Reference citations are provided in (brackets)

Assessment of publications	
Publication 1(11)	
Year	2007
Author	Nitschke M, Tucker GR, Bi P
Title	Morbidity and mortality during heatwaves in metropolitan Adelaide
Publication	The Medical Journal of Australia
Type of study	Exploration of relationships: studies examining statistical associations between different variables in order to develop hypotheses
Number of people/studies	'Our data included 4748 observation days for ambulance transports and hospital admissions, and 4193 days for mortality. Applying our definition, there were 31 heatwaves, extending over a total of 120 days.' p.662.
Region	Adelaide, South Australia
Overview of key points as provided by the author(s) in the abstract	**Objective:** To investigate morbidity and mortality associated with heatwaves in metropolitan Adelaide using ambulance, hospital admission, and mortality data. **Design, participants and setting:** Case-series study comparing health risks in the Adelaide metropolitan population during heatwaves and non-heatwave periods. Main outcome measures: Daily observations for ambulance transports (1993–2006), hospital admissions (1993–2006), and mortality (1993–2004), categorised using international classification of diseases (ninth and tenth revisions) codes for the relevant disease groups. **Results:** During heatwaves, total ambulance transport increased by 4% (95% CI, 1%–7%), including significant assault-related increases for people aged 15–64 years. Reductions were observed in relation to cardiac, sports- and falls-related events. Total hospital admissions increased by 7% (95% CI, −1% to 16%). Total mental health admissions increased by 7% (95% CI, 1%–13%), and total renal admissions by 13% (95% CI, 3%–25%). Ischaemic heart disease admissions increased by 8% (95% CI, 1%–15%) among people aged 65–74 years. Total mortality, disease- and age-specific mortality did not increase, apart from a small increase in mental health-related mortality in people aged 65–74 years. Significant decreases were observed in cardiovascular related mortality.

Assessment of publications	
	Conclusion: In contrast to evidence from extreme heatwaves in the northern hemisphere, we found no excess mortality during heatwaves in metropolitan Adelaide, perhaps because of adaptive behaviour to regular hot weather spells. Projected temperature increases and evidence of modest increases in morbidity during heatwaves indicate the need for a heatwave response plan for Adelaide.
Evidence quality grading	Low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** This case- cross over analyses compared health data from heatwave to non-heatwave seasons during 13 years in Adelaide, to understand their impact on health outcomes measured by independent assessors (ambulance callouts, hospital admissions, and mortality data). **Selective outcome reporting:** The study focuses on the analysis of health data from 1993 to 2006 for ambulance callouts and admissions. However, for mortality, the data were from 1993 to 2004 (p. 662). The report does not explain this discrepancy. **Other limitations:** In this study, diseases are categorised into group, leading to a '…limited resolution in relation to more detailed disease information, and is not able to explore heatwave effects beyond the acute hazard period. Furthermore, we could not address the issue of potential confounding by air pollution because of limited availability of relevant air quality data before 2001.' (p.664). The methodological approach assumes that the exposure temperature was the same for the whole population and does not explore other potential confounding factors that may increase the incidence of adverse health effects (e.g. comorbidities, living conditions). It also assumes that the general population has access to phones, to call an ambulance, transport to reach hospitals and the population has general knowledge/capacity to approach health issues and death during heatwaves. The data analysed did not allow for delayed health impairments and mortality linked to the heatwaves to be captured. **Other strengths:** The data sources used are unlikely to have been biased by the hypothesis being tested by this author, as they are largely objective measures (e.g. temperature) or outcomes that would have had to be verified by independent assessors (e.g. causes of death).
Experiences and needs of older people	There is an increase in hospital admissions in general, including older people of 65+ years. The reasons of admission were mental health, renal failure. Interestingly, there was a decrease in cardiovascular admissions in people aged 75 years and older while the group of 65 to 74 showed increased admissions for ischemic heart disease. Respiratory admissions also decreased in the people aged 75 years or older (p.663). Overall, mortality remained the same in the window of time assessed except of the group of people aged 75 years or older, the mortality decreased (p.663). Mortality category that increased during the heatwave is mental disease-related in the group of people aged 65 to 74 (p. 663). Overall mental health should be protected during heatwaves.
Publication 2 (7)	

Assessment of publications	
Year	2008
Author	Hansen A, Bi P, Nitschke M, Ryan P, Pisaniello D, Tucker G
Title	The effect of heat waves on mental health in a temperate Australian city
Publication	Environmental Health Perspectives
Type of study	Exploration of relationships: studies examining statistical associations between different variables in order to develop hypotheses
Number of people/studies	'Hospital admission data spanned the period 1 July 1993 to 30 June 2006, and mortality data were obtained for 1 July 1993 to 22 December 2004. During this time, there were 31 and 29 heat waves, respectively, ranging in duration from 3 to 8 days…' (p. 1370).
Region	Adelaide, South Australia
Overview of key points as provided by the author(s) in the abstract	**Objective:** The goal of this study was to identify mental, behavioural, and cognitive disorders that may be triggered or exacerbated during heat waves, predisposing individuals to heat-related morbidity and mortality. **Design:** Using health outcome data from Adelaide, South Australia, for 1993–2006, we estimated the effect of heat waves on hospital admissions and mortalities attributed to mental, behavioural, and cognitive disorders. We analysed data using Poisson regression accounting for overdispersion and controlling for season and long-term trend, and we performed threshold analysis using hockey stick regression. **Results:** Above a threshold of 26.7°C, we observed a positive association between ambient temperature and hospital admissions for mental and behavioural disorders. Compared with non–heat-wave periods, hospital admissions increased by 7.3% during heat waves. Specific illnesses for which admissions increased included organic illnesses, including symptomatic mental disorders; dementia; mood (affective) disorders; neurotic, stress related, and somatoform disorders; disorders of psychological development; and senility. Mortalities attributed to mental and behavioural disorders increased during heat waves in the 65- to 74-year age group and in persons with schizophrenia, schizotypal, and delusional disorders. Dementia deaths increased in those up to 65 years of age. **Conclusion:** Our results suggest that episodes of extreme heat pose a salient risk to the health and well-being of the mentally ill. **Relevance to clinical or professional practice:** Improvements in the management and care of the mentally ill need to be addressed to avoid an increase in psychiatric morbidity and mortality as heat waves become more frequent.
Evidence quality grading	Low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** This case-cross over analyses compared health data from heatwave to non-heatwave seasons during 13 years in Adelaide, to understand their impact on health outcomes measured by independent assessors (hospital admissions and mortality data) focusing on mental, behavioural, and cognitive disorders.

Assessment of publications	
	Selective outcome reporting: The study focuses on the analysis of morbidity data from 1993 to 2006. However, for mortality, the data were from 1993 to 2004 (p. 1369). The report does not explain this discrepancy. In the report, it is mentioned that 'Data relating to individuals who resided outside of the Adelaide metropolitan area were excluded from the study' (p. 1369). **Other limitations:** The methodological approach assumes that the exposure temperature was the same for the whole population and does not explore other potential confounding factors that may increase the incidence of adverse health effects (e.g. comorbidities, living conditions like financial hardship). It also assumes that the general population has access to phones, to call an ambulance, transport to reach hospitals and the population has general knowledge/capacity to approach health issues and death during heatwaves. The data analysed did not allow for delayed health impairments and mortality linked to the heatwaves to be captured. In the report, it was mentioned several times that the sample sizes were small for some categories, challenging their statistical power. In the Discussion they mention: 'we advise cautious interpretation of some results, especially mortality results.' (p. 1374). **Other strengths:** The data sources used are unlikely to have been biased by the hypothesis being tested by this author, as they are largely objective measures (e.g. temperature) or outcomes that would have had to be verified by independent assessors (e.g. causes of death). This was the first effort in Australia to question the impact of mental health and heatwaves in hospital admissions and mortality.
Experiences and needs of older people	Hospital admissions: - 'Compared with control periods, we found that hospitalizations for organic, including symptomatic, mental disorders increased by 21.3% during heat waves (Table 1) with increases in both male and female admissions (Table 2) and in the ≥ 75-year age group.' (p. 1371). - 'MBDs due to psychoactive substance use (ICD-10 codes F10–F19). In this category, older people (≥ 75 years of age) were the only age group to show an increase in hospitalizations during heat waves (IRR 1.567; 95% CI, 1.002–2.450), with female admissions of this age also showing a significant increase (Table 2).' (p. 1371). - MDBs due to Mood (affective) disorders also increased in general although the highest estimates were found in people aged 15-64 years old (p.1371). - MBDs due to anxiety, panic disorder, agoraphobia, obsessive compulsive disorder and posttraumatic stress disorder also increased specially in in very young people and the elders (p.1371). - MDBs due to syndromes including eating and sleep disorders also increased for elder females (p. 1371). - MDBs due to 'senility' including senescence, asthenia and debility also increased with the strongest effect in the elders and elder females (p.1372). Mortality: - Mortalities attributed to MBDs were relatively infrequent in Adelaide (p.1372). 'In the present study, we observed an increase in deaths classified as MBDs in the 65- to 74-year age group during heat waves.' (p.1373).

Assessment of publications	
Publication 3 (5)	
Year	2010
Author	McInnes JA, Ibrahim Joseph E
Title	Minimising harm to older Victorians from heatwaves: A qualitative study of the role of community-based health profession and carer organisations
Publication	Australasian Journal on Ageing
Type of study	Description: studies which aim to describe a state of affairs or phenomenon and/or document characteristics
Number of people/studies	Analyses included 12 people interviewed from four organisation groups: General Practice, Royal District Nursing Service (RDNS), Baptcare, and Home and Community Care (HACC)-funded Local Government services, 'senior and middle levels of management of these organisations' (p.105)
Region	Victoria
Overview of key points as provided by the author(s) in the abstract	**Objective:** To investigate the role of community-based health profession and carer organisations in Victoria in minimising harm to older people from heatwaves. **Methods:** A qualitative study based on semi-structured interviews was conducted in Victoria, Australia. Twelve people were interviewed, representing four professional groups that support the health of older Victorians who reside at home. **Results:** None of the health profession and carer organisations studied had formalised heatwave strategies; however, their staff conduct a range of activities before and during heatwaves that may reduce harm to older clients. Interviewees discussed roles their organisations could play in a heatwave response plan, including coordination, identification of high-risk individuals and education. All saw a need for extra resources and training if responses to heatwaves were required more frequently. **Conclusion:** It may be feasible to utilise the existing services and infrastructure of community-based health profession and carer organisations operating in Victoria within a state-wide heatwave response plan. However, this will require extra resources, training and coordination.
Evidence quality grading	Very low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** The quality of the evidence was considered very low due to the descriptive study design and study limitations. The base quality rating based on the study design was downgraded from low to very low as the sample size was small, the study did not use standardised instruments with known psychometric properties, and participants self-selected to participate.

Assessment of publications	
	Incomplete outcome data: One person interviewed was excluded from the analyses 'Data collected from 12 of 13 interviewees, representing four of these organisations, were suitable for inclusion in the study.' (p.105). No further details on why this person was excluded are provided in the publication. Semi-structured interview approach and thematic analysis precludes further assessment of incomplete outcome data. 'Semi-structured interviews were based on open-ended questions developed following review of relevant literature. Issues addressed during semi-structured interviews included: • Current strategies used by organisations to minimise harm to older clients during heatwaves • Current capacity of organisations for communication • Current capacity of organisations for identification of vulnerable groups • Potential role of organisations in heatwave response plan • Perceived effectiveness of organisations when responding to a heatwave Participants were provided with an outline of the question headings several days prior to the interview.' (p. 105). **Selective outcome reporting:** The interpreted the interviews and condensed them into an integrated report section. 'For each category the information from participants representing the same organisation was combined, carefully scrutinised for themes and distilled into chart format. These charts were used to compare themes across organisations, with particular attention being paid to consistent patterns, variations in practice and capacity, and innovative ideas.' (p.105). The mentioned charts are not available in the report. Interview transcripts are also missing. Semi-structured interview approach and thematic analysis precludes further assessment of selective outcome reporting. **Other limitations:** *Recruitment bias:* The organisation selection criteria were limited by their 'willingness to participate in the study' (p.105). *'*A sample of employees representing senior and middle levels of management of these organisations, from a range of metropolitan and regional areas of Victoria, was selected for possible inclusion in the interview process on the advice of senior executive members of participating organisations.' (p.105). *Other limitations are:* 'Limitations of this study arise from the small number of interviewees, and from the potential for inaccuracies to occur during data collection and analysis. Data consisted of self-reported perceptions, and could have been influenced by a participant wanting to present their organisation in a 'good light' or by preconceptions of the interviewer.'(p.108). In conducting this study, the researchers attempt to address these limitations by 'selecting participants from multiple levels of management with extensive experience of the organisations they were representing, allowing participants to verify the content of written interview transcripts, and the use of feedback from Project Reference Group members as a source of triangulation.' (p.108). Nonetheless, bias due to the participant recruitment may still exist. As funding was linked to reported organisation responses, the data were not deidentified before analysis.

Assessment of publications	
Experiences and needs of older people	As observed / interpreted / reported via professionals working with older people.
Publication 4 (2)	
Year	2011
Author	Peng Bi, Williams S, Loughnan M, Lloyd G, Hansen A, Kjellstrom T, et al.
Title	The effects of extreme heat on human mortality and morbidity in Australia: Implications for public health
Publication	Asia-Pacific Journal of Public Health
Type of study	Literature review with non-systematic approaches to extracting, analysing and reporting evidence
Number of people/studies	This study focuses on 13 studies. 58 references are provided.
Region	Australia
Overview of key points as provided by the author(s) in the abstract	Most regions of Australia are exposed to hot summers and regular extreme numerous studies have associated high ambient temperatures with adverse Australian cities. Extreme environmental heat can trigger the onset of acute conditions, heat stroke and dehydration, as well as exacerbate a range of underlying illnesses. Consequently, in the absence of adaptation, the associated mortality and morbidity are expected to increase in a warming climate, particularly within the vulnerable populations of the elderly, children, those with chronic diseases, and people engaged in physical labour in noncooled environments. There is a need for further research to address the evidence needs of public health agencies in Australia. Building resilience to extreme heat events, especially for the most vulnerable groups, is a priority. Public health professionals and executives need to be aware of the very real and urgent need to act now.
Evidence quality grading	Very low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** This a multidisciplinary effort into understanding the consequences and potential prevention of the impact of heatwaves. This publication discusses a non-systematic literature review which summarises key messages from the included articles, without describing the methodological approach used for extracting, analysing and reporting the evidence. **Limitations:** There is a lack of information on the methodological approach used for extracting, analysing and reporting the evidence. By 2023, although this paper is an important piece, it is not updated with current policies. **Strengths:** The authors of this review are also authors of most of the research regarding the health impact of heatwaves in Australia. The review is multidisciplinary, it discusses the health impacts as well as projections and policy offering a clear overview of the matter.

Assessment of publications	
Experiences and needs of older people	As mentioned in the overview.
Publication 5 (12)	
Year	2011
Author	Nitschke M, Tucker GR, Hansen A, Williams S, Zhang Y, Bi P
Title	Impact of two recent extreme heat episodes on morbidity and mortality in Adelaide, South Australia: A case-series analysis
Publication	Environmental Health
Type of study	Exploration of relationships: studies examining statistical associations between different variables in order to develop hypotheses
Number of people/studies	For the following outcome sources for Adelaide, South Australia (population of 1,145,812): Hospital admissions and ambulance call-out data from July 1993 to March 2009. Health outcomes-specific mortality data were only available up to December 2007. Emergency department presentation data were only available from July 2003 onwards.
Region	Adelaide, South Australia
Overview of key points as provided by the author(s) in the abstract	**Background:** Extreme heatwaves occurred in Adelaide, South Australia, in the summers of 2008 and 2009. Both heatwaves were unique in terms of their duration (15 days and 13 days respectively), and the 2009 heatwave was also remarkable in its intensity with a maximum temperature reaching 45.7°C. It is of interest to compare the health impacts of these two unprecedented heatwaves with those of previous heatwaves in Adelaide. **Methods:** Using case-series analysis, daily morbidity and mortality rates during heatwaves (≥35°C for three or more days) occurring in 2008 and 2009 and previous heatwaves occurring between 1993 and 2008 were compared with rates during all non-heatwave days (1 October to 31 March). Incidence rate ratios (IRRs) were established for ambulance callouts, hospital admissions, emergency department presentations and mortality. Dose response effects of heatwave duration and intensity were examined. **Results:** Ambulance callouts during the extreme 2008 and 2009 events were increased by 10% and 16% respectively compared to 4.4% during previous heatwaves. Overall increases in hospital and emergency settings were marginal, except for emergency department presentations in 2008, but increases in specific health categories were observed. Renal morbidity in the elderly was increased during both heatwaves. During the 2009 heatwave, direct heat-related admissions increased up to 14-fold compared to a three-fold increase seen during the 2008 event and during previous heatwaves. In 2009, marked increases in ischaemic heart disease were seen in the 15–64-year age group. Only the 2009 heatwave was associated with considerable increases in total mortality that particularly affected the 15–64-year age group (1.37; 95% CI, 1.09, 1.71), while older age groups were unaffected. Significant dose-response relationships were observed for heatwave duration (ambulance, hospital and emergency setting) and intensity (ambulance and mortality).

Assessment of publications	
	Conclusions: While only incremental increases in morbidity and mortality above previous findings occurred in 2008, health impacts of the 2009 heatwave stand out. These findings send a signal that the intense and long 2009 heatwave may have exceeded the capacity of the population to cope. It is important that risk factors contributing to the adverse health outcomes are investigated to further improve preventive strategies.
Evidence quality grading	Low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** This case- cross over analyses compared health data from heatwave to non-heatwave seasons and among the 2008 heatwave, 2009 heatwave and other averaged heatwaves in Adelaide, to understand their impact on health outcomes measured by independent assessors (ambulance callouts, hospital admissions, emergency department presentations and mortality). The analysis approach allowed for an intrinsic control for some confounding variables 'Cases are used as their own controls in non-risk periods, thus implicitly controlling for all fixed confounders' (p.2). **Incomplete outcome data:** The study focuses on the analysis of health data from July 1993 to March 2009. However, 'While hospital admissions and ambulance call-out data were available for the whole study period, health outcomes-specific mortality data were only available up to December 2007, and emergency department presentation data were only available from July 2003 onwards.' (p. 2). No further information on response rates/attrition for specific outcomes was provided. **Selective outcome reporting:** The publication does not specify whether all data collected and analysed is reported on. **Other limitations:** No other limitations were identified that would result in a down-grading of the evidence quality. **Analysis approach:** The methodological approach assumes that the exposure temperature was the same for the whole population (p.2) and does not explore other potential confounding factors that may increase the incidence of adverse health effects (e.g. comorbidities, living conditions), assuming the case-series analysis allowed for an intrinsic control for these factors. The data analysed did not allow for delayed health impairments and mortality linked to the heatwaves to be captured. **Other strengths:** The data sources used are unlikely to have been biased by the hypothesis being tested by this author, as they are largely objective measures (e.g. temperature) or outcomes that would have had to be verified by independent assessors (e.g. causes of death).
Experiences and needs of older people	Data were grouped by age in the comparison among heatwaves. Two categories span the elder stage of life (groups 65-74 and 75+).
Publication 6 (9)	
Year	2011
Author	Hansen A, Bi P, Nitschke M, Pisaniello D, Newbury J, Kitson A
Title	Perceptions of heat-susceptibility in older persons: Barriers to adaptation

Assessment of publications	
Publication	International Journal of Environmental Research and Public Health
Type of study	Description: studies which aim to describe a state of affairs or phenomenon and/or document characteristics
Number of people/studies	35 stakeholders involved in aged care, community services, government, emergency services and policy
Region	Adelaide, South Australia
Overview of key points as provided by the author(s) in the abstract	The increase in the frequency of very hot weather that is a predicted consequence of climate change poses an emerging threat to public health. Extreme heat can be harmful to the health of older persons who are known to be amongst the most vulnerable in the community. This study aimed to investigate factors influencing the ability of older persons to adapt to hot conditions, and barriers to adaptation. A qualitative study was conducted in Adelaide, Australia, involving focus groups and interviews with stakeholders including key personnel involved in aged care, community services, government sectors, emergency services and policy making. Findings revealed a broad range of factors that underpin the heat-susceptibility of the aged. These were categorised into four broad themes relating to: physiology and an age-related decline in health; socioeconomic factors, particularly those influencing air conditioning use; psychological issues including fears and anxieties about extreme heat; and adaptive strategies that could be identified as both enablers and barriers. As a consequence, the ability and willingness to undertake behaviour change during heatwaves can therefore be affected in older persons. Additionally, understanding the control panels on modern air conditioners can present challenges for the aged. Improving heat-health knowledge and addressing the social and economic concerns of the older population will assist in minimizing heat-related morbidity and mortality in a warming climate.
Evidence quality grading	Low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** This study was assessed as low due to the type of study. **Strengths:** Objective was to identify stakeholder perspectives, and adopted methodology was well-designed to provide selected perspectives. **Limitations:** Qualitative interviews conducted as face to face, by phone or via focus groups with selected stakeholder groups. 50% of participants were interviewed in a public forum with peers. This potentially restricts liberty to report and constrains accuracy.
Experiences and needs of older people	As reported via professionals working with older people as direct care providers and in management or policy roles.
Publication 7 (6)	
Year	2011
Author	Wilson L, Black D, Veitch C
Title	Heatwaves and the elderly: The role of the GP in reducing morbidity

Assessment of publications	
Publication	Australian Family Physician
Type of study	Literature review with non-systematic approaches to extracting, analysing and reporting evidence
Number of people/studies	43 articles were fully reviewed
Region	Not stated
Overview of key points as provided by the author(s) in the abstract	**Background:** Heatwaves are increasing in frequency, intensity and duration, and are associated with an increase in mortality and morbidity, particularly in the very young and the very old. Concurrently, the Australian population is aging, with the prediction that by 2036 approximately 27% of Australians will be aged over 65 years. **Objective:** This article reviews the evidence on heat related health risk and discusses the role of the general practitioner in reducing morbidity in older people as a result of heatwaves. **Discussion:** Heatwaves are associated with increased mortality and morbidity in people aged over 65 years, and more so in those aged over 75 years. Older people are more vulnerable to the effects of extreme heat through a range of physiological and physical factors. As key providers of healthcare to older people, GPs play a crucial role in identifying those at risk and implementing strategies to minimise the risks of mortality and morbidity during periods of extreme heat.
Evidence quality grading	Very low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** This publication discusses a non-systematic literature review which summarises key messages from the included articles, without describing the methodological approach used for extracting, analysing and reporting the evidence. **Limitations:** There is a lack of information on the methodological approach used for extracting, analysing and reporting the evidence. The authors report that 43 articles were fully reviewed (p.637), however a list of these articles is not provided. Furthermore, only 40 references are included in the reference list and some of these only seem to be referenced in the introduction, not the discussion of key findings. **Strengths:** This publication describes the systematic search strategy, including the terms used and databases searched, and selection criteria for the studies included 'Studies eligible for review included peer reviewed journal articles that reported the effects of heatwaves with specific reference to risk factors in older people, or with reference to the role of primary healthcare professionals. Only English language articles were included for review. Forty-three articles were fully reviewed.' (p.637) This publication clarifies the definition a heatwave definition 'A heatwave is usually considered to be a period of at least 3 successive days where the temperature is at least 5°C above expected, and with an associated increase in night temperature.8–9' (p.638) as it mentions other definitions used within Australia (Table 1).

Assessment of publications	
Experiences and needs of older people	As captured in the metanarrative summary of included study findings.
Publication 8 (10)	
Year	2012
Author	Bennetts H, Pullen S, Zillante G
Title	Design strategies for houses subject to heatwaves
Publication	Open House International
Type of study	Description: studies which aim to describe a state of affairs or phenomenon and/or document characteristics
Number of people/studies	Pilot study of one house 'The focus of the pilot case study is an existing small, two-bedroom house in Adelaide, South Australia' (p.32)
Region	Adelaide, South Australia
Overview of key points as provided by the author(s) in the abstract	Over the last two decades the average floor area of new houses in Australia has increased significantly. This has coincided with greater expectations of thermal comfort in homes. In certain locations, the result has been an escalation of the use of large mechanical air conditioning systems in houses. Since it is predicted that climate change will lead to an increase in the frequency and severity of extreme weather events such as heatwaves, the future maintenance of thermal comfort in houses in an affordable manner is likely to be challenging. This will have implications not only for the health and comfort of the occupants but also for peak energy loads. A compounding factor is the likelihood of increased energy prices caused, in part, by financial mechanisms aimed at minimising greenhouse gas emissions. There will be sections of the community, such as the elderly and the less well off, that will be particularly vulnerable to these combined factors. This paper explores design strategies that could be incorporated in new and existing houses to improve thermal comfort for residents during heatwaves. It is shown that during such periods, behaviour change, thermal comfort requirements and extra energy consumption have a strong influence on devising solutions for this challenge. The results of a pilot study are given that indicate opportunities for creating cool refuges in the existing dwelling stock.
Evidence quality grading	Low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** The quality of the evidence was considered low due to the descriptive study design, the low sample size, and other limitations. This report starts with a non-systematic literature review followed by a case-study measuring thermal properties of one house in Adelaide. This house is used as an example of public housing for people on low incomes, including older people. **Incomplete outcome data:** No information on modelling parameters' attrition is provided. **Selective outcome reporting:** There was no information on whether all outcomes were included.

Assessment of publications	
	Other limitations: *Sample size/study design:* Sample size is one dwelling: '[…] a pilot case study based on one strategy i.e. cool refuge was undertaken.' 'The focus of the pilot case study is an existing small, two-bedroom house in Adelaide, South Australia' (p.32) 'The energy use is calculated for whole house cooling and for cooling one area of the house ('cool refuge').' (p.33). *Lack of information on materials and methods:* The report does not offer a clear materials and methods section. However, it does specify the parameters used. *Requirements for a heatwave in Adelaide not met:* Although the scope of this report is heatwaves 'The pilot investigates the temperatures in the house during a heatwave' (p.32-33), in the modelling section they do not use 'heatwave' parameters: 'The climate file does not have a period that corresponds to the current Bureau of Meteorology definition of a heat wave for Adelaide (i.e. 3 days with a maximum greater than 40 °C or 5 days with greater than 35 °C). However, it does have a period that would trigger high watch conditions under Adelaide's Extreme Heat Plan as the maximum temperature is ≥ 35°C for 3+ consecutive days and the minimum ≥ 21°C for 3+ consecutive nights giving an average daily temperature (ADT) of 28°C (SA Government 2011). The maximum outdoor temperature during the study period is 44°C, it is more than 35°C for 25 hours of the 96-hour period and there are three very hot nights.' (p. 33).
Experiences and needs of older people	This study conclusion proffers an opinion that older people might be at heightened vulnerability. A reference for this assumption is provided in the introduction and background sections, but it was not tested.
Publication 9 (13)	
Year	2012
Author	Wang XY, Barnett AG, Yu W, FitzGerald G, Tippett V, Aitken P, et al.
Title	The impact of heatwaves on mortality and emergency hospital admissions from non-external causes in Brisbane, Australia
Publication	Occupational and Environmental Medicine
Type of study	Exploration of relationships: studies examining statistical associations between different variables in order to develop hypotheses
Number of people/studies	Impact of three heatwaves on 'cause-specific mortality and emergency hospital admissions (EHAs) from non-external causes (NEC) using daily data collected in Brisbane' (p.163) in Brisbane 1996-2005 'population of 991 260 on 30 June 2006. At that time, 18% of the population were aged 0-14, 71% were aged 15-64 and 11% were aged 65+.' (p.164)
Region	Brisbane, Queensland
Overview of key points as provided by the author(s) in the abstract	**Objectives:** Heatwaves can have significant health consequences resulting in increased mortality and morbidity. However, their impact on people living in tropical/subtropical regions remains largely unknown. This study assessed the impact of heatwaves on mortality and emergency hospital admissions (EHAs) from non-external causes (NEC) in Brisbane, a subtropical city in Australia. **Methods:** We acquired daily data on weather, air pollution and EHAs for patients aged 15 years and over in Brisbane between January 1996 and December 2005, and on mortality between January 1996 and November 2004. A locally derived definition of heatwave (daily

Assessment of publications	
	maximum >37 degrees C for 2 or more consecutive days) was adopted. Case-crossover analyses were used to assess the impact of heatwaves on cause-specific mortality and EHAs. **Results:** During heatwaves, there was a statistically significant increase in NEC mortality (OR 1.46; 95% CI 1.21 to 1.77), cardiovascular mortality (OR 1.89; 95% CI 1.44 to 2.48), diabetes mortality in those aged 75+ (OR 9.96; 95% CI 1.02 to 96.85), NEC EHAs (OR 1.15; 95% CI 1.07 to 1.23) and EHAs from renal diseases (OR 1.41; 95% CI 1.09 to 1.83). The elderly were found to be particularly vulnerable to heatwaves (e.g., for NEC EHAs, OR 1.24 for 65e74-year-olds and 1.39 for those aged 75+). **Conclusions:** Significant increases in NEC mortality and EHAs were observed during heatwaves in Brisbane where people are well accustomed to hot summer weather. The most vulnerable were the elderly and people with cardiovascular, renal or diabetic disease.
Evidence quality grading	Low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** The case- crossover analyses used '10-year time series of climate, air pollution and EHA [Emergency Hospital Admissions] data from 1 January 1996 to 31 December 2005' (p.164) for Brisbane, Queensland, Australia. These outcomes were therefore measured by independent assessors. 'Three heatwaves (7 heatwave days) were identified using the local heatwave definition during the study period.' (p.164). The analysis approach allowed for an intrinsic control for some confounding variables, as individuals act as their own control in non-heatwave periods. **Incomplete outcome data:** 'The data used in this study were 10-year time series of climate, air pollution and EHA [Emergency Hospital Admissions] data from 1 January 1996 to 31 December 2005.' (p.164). It was reported that: 'Mortality data were only obtainable up to November 2004 due to the time lag between deaths and their registration by state authorities.' (p.164). For air pollution data it is reported that 'Approximately 5% of values were missing. When data were missing for a particular monitoring station on a given day, the observations recorded from the other monitoring stations were used to calculate the daily average values.' (p.164) **Selective outcome reporting:** Mortality data 'included date of death, sex, age, statistical local area of residence and cause of death' (p.164). However, the authors note: 'Stratified analysis by gender was not possible since the release of this information from the EHA datasets was considered a potential breach of confidentiality.' (p.164). **Other limitations:** *Low statistical power.* Authors note that: 'As there were only three heatwaves with a total of 7 case days and 21 control days, only 28 days were used in the final analysis (table 1). This did reduce the statistical power and meant that the CIs for some findings were wide (tables 3 and 4).' (p.165). **Other strengths:** The data sources used are unlikely to have been biased by the hypothesis being tested by this author, as they are largely objective measures (temperature, air pollution, humidity) or outcomes that would have had to be verified by independent assessors (e.g. causes of death).
Experiences and needs of older people	Heat-related health burden data generated for age groups 65-74 and 75+.

Assessment of publications	
Publication 10 (14)	
Year	2014
Author	Coates L, Haynes K, O'Brien J, McAneney J, Dimer de Oliveira F
Title	Exploring 167 years of vulnerability: An examination of extreme heat events in Australia 1844–2010
Publication	Environmental Science & Policy
Type of study	Exploration of relationships: studies examining statistical associations between different variables in order to develop hypotheses
Number of people/studies	Mortality data during heatwave seasons across Australia from 1844-2010. This publication reports three sources: PerilAUS; Cause of Death data from ABS; National Coronial Information Service (NCIS)
Region	Australia
Overview of key points as provided by the author(s) in the abstract	Despite their relative importance in terms of human mortality, extreme heat events have not attracted the same level of study compared with other natural hazards for vulnerability and implications for emergency management and policy change. Definitional confusion and inconsistencies in defining heat related deaths over time have made it difficult to determine an absolute death toll. Notwithstanding these issues, this study employs PerilAUS – Risk Frontiers' database of natural hazard event impacts – in combination with official sources in an attempt to provide a lower-bound estimate of heat-associated deaths in Australia since European settlement. From 1844 to 2010, extreme heat events have been responsible for at least 5332 fatalities in Australia and, since 1900, 4555: more than the combined total of deaths from all other natural hazards. Over 30% of those deaths occurred in just nine events. Both deaths and death rates (per unit of population) fluctuate widely but show an overall decrease with time. The male to female death-rate ratio has fluctuated and approaches but does not reach equality in more recent times. In line with other studies, seniors have been the most vulnerable age group overall, with infants also over-represented. Policy implications in view of a warming climate and an ageing population are discussed.
Evidence quality grading	Low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** This study is that it based on an extensive data set and limitations of this dataset and how they were addressed by the authors are transparently reported. Although the data available significantly limits the ability of authors to reliably explore relationships between variables in depth without bias (e.g. gender/age trends), the authors have made efforts to transparently report on the limitations of the data and address these limitations through choice of outcomes where possible, including an operational definition of heat-associated deaths. **Incomplete outcome data:** Some outcomes were reported as only being available for certain time periods and/or as being incomplete, with the authors noting 'Even after official data sources became available (post 1907), data quality and/or completeness is uneven.'

Assessment of publications	
	(p.37). For example: 'ABS data were available in different formats and detail from 1907 to 2009 (see also Section 2.4). The NCIS is an internet- based data system containing information about every death reported to an Australian coroner since July 2000 (January 2001 for Queensland) […]' (p.35) **Selective outcome reporting:** The authors report making decisions as to which outcomes to report on based on their quality and applicability to the study question and these are transparently reported and detailed in the publication, including: 'ABS and NCIS data represented the best estimates of heat associated deaths available, and, as official data sources, their reported totals were preferentially used. Prior to 1907, PerilAUS figures were utilised, where deaths were recorded as heat, heat-related or heat-associated deaths according to the description given in news media/government reports. However, death totals for the 2009 Southern Australia heat event were taken from PerilAUS as, in this instance, data were available from the South Australian Coroner, who recorded 58 heat-related deaths in South Australia [reference], and from the Victorian Registry of Births, Deaths and Marriages and the Victorian Coroner's Office, who estimated 374 excess deaths in Victoria [reference]. […]The other exception is the use of a report by BoM [reference], which gives a figure of 145 attributed deaths for a Melbourne, Victoria heat event in 1959: nationally, the ABS lists but 43 for the entire year.' (p.36) and note that 'Exact ages of victims have rarely been recorded in media and other accounts...'(p.36) so age ranges are used. Due to the large size and variation in the data outcomes included, it is nonetheless difficult to make an assessment of the extent of selective outcome reporting. **Other limitations:** The authors outline historical limitations of the available datasets that may have introduced bias as to the included people in the study and limited their ability to explore relationships between different variables: '[…] Indigenous Australian being included only from 1968, occupations of females being included only from 1989, etc.' (p.37) **Other strengths:** This study utilises an extensive dataset: 'This study draws from Risk Frontiers' PerilAUS database of impacts and consequences of natural hazards in Australia. PerilAUS is based on material collected from news media, government reports, published literature, state Coroner records, ABS and registries of Births, Deaths and Marriages for Australia's States and Territories. Where available, data are collected on economic, social and environmental impacts of the event and number of people injured, evacuated and/or homeless. Data range from European settlement (1788) to the present, with more complete records from 1900, and cover bushfires, earthquakes, floods, hailstorms, extreme heat events, landslides, lightning strikes, rainstorms, tornadoes, tropical cyclones, tsunamis and windstorms.' (p.35). 'In addition to PerilAUS data, and in order to capture the most comprehensive dataset possible, Cause of Death data were sourced from ABS [reference] and the National Coronial Information Service (NCIS) [reference]' (p.35). This study clearly defines how heat-associated deaths are calculated (see also notes under 'selective outcome reporting': 'This paper adopts the following operational definitions: A heat deaths – deaths directly attributed (by news media, government departments, etc.) to extreme heat: for example, heat stroke; B heat-related deaths – deaths reported (by news media, government departments, etc.) as resulting indirectly from extreme heat: for example, from heat exacerbation of a pre-existing illness, and C heat-associated deaths – all deaths attributed, directly or indirectly, to extreme heat: the sum (C = A + B) of the above.' (p.36).

Assessment of publications	
Experiences and needs of older people	The data were grouped by age (or predicted age), including a group of people over 64 years.
Publication 11 (16)	
Year	2014
Author	Toloo G (Sam), Guo Y, Turner L, Qi X, Aitken P, Tong S
Title	Socio-demographic vulnerability to heatwave impacts in Brisbane, Australia: A time series analysis
Publication	Australian and New Zealand Journal of Public Health
Type of study	Exploration of relationships: studies examining statistical associations between different variables in order to develop hypotheses
Number of people/studies	Data from 10 public emergency departments in Brisbane during 2000-2008
Region	Brisbane, Queensland
Overview of key points as provided by the author(s) in the abstract	**Objective:** Examining the association between socioeconomic disadvantage and heat-related emergency department (ED) visits during heatwave periods in Brisbane, 2000–2008. **Methods**: Data from 10 public EDs were analysed using a generalised additive model for disease categories, age groups and gender. **Results:** Cumulative relative risks (RR) for non-external causes other than cardiovascular and respiratory diseases were 1.11 and 1.05 in most and least disadvantaged areas, respectively. The pattern persisted on lags 0–2. Elevated risks were observed for all age groups above 15 years in all areas. However, with RRs of 1.19–1.28, the 65–74 years age group in more disadvantaged areas stood out, compared with RR=1.08 in less disadvantaged areas. This pattern was observed on lag 0 but did not persist. The RRs for male presentations were 1.10 and 1.04 in most and less disadvantaged areas; for females, RR was 1.04 in less disadvantaged areas. This pattern persisted across lags 0–2. **Conclusions:** Heat-related ED visits increased during heatwaves. However, due to overlapping confidence intervals, variations across socioeconomic areas should be interpreted cautiously. **Implications:** ED data may be utilised for monitoring heat-related health impacts, particularly on the first day of heatwaves, to facilitate prompt interventions and targeted resource allocation.
Evidence quality grading	Low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** This study utilised a large data set: public hospital emergency department presentations, the Index of Relative Socioeconomic Disadvantage and meteorological data from the Bureau of Meteorology for July

Assessment of publications	
	2000 to 30 June 2008 for Brisbane, the study 'identified 112 heatwave days with an average 28.4°C temperature.' (p.431). The data were therefore collected by independent assessors and unlikely to be biased by the research hypothesis. **Incomplete outcome data:** No information on response rates/attrition for specific outcomes was provided. **Selective outcome reporting:** The publication does not specify whether all data collected and analysed is reported on. **Other strengths:** The data sources used are unlikely to have been biased by the hypothesis being tested by this author, as they are largely objective measures (e.g. temperature) or outcomes that would have had to be verified by independent assessors (e.g. emergency department disease classifications).Including: 'health data, in the form of public hospital ED presentations, were provided by Queensland Health' (p.430), 'The health data included patients' residential postcodes. The Index of Relative Socioeconomic Disadvantage (IRSD) for postcodes was obtained from the Australian Bureau of Statistics (ABS) […]' (p.431). The analysis approach also explored lagged effects of heatwaves, humidity and air pollutants (p.431).
Experiences and needs of older people	Some data provided for people aged 65-74 and 75+.
Publication 12 (15)	
Year	2014
Author	Tong S, Wang XY, FitzGerald G, McRae D, Neville G, Tippett V, et al.
Title	Development of health risk-based metrics for defining a heatwave: A time series study in Brisbane, Australia
Publication	BioMed Central Public Health
Type of study	Exploration of relationships- studies examining statistical associations between different variables in order to develop hypotheses
Number of people/studies	Mortality and hospital admissions data for Brisbane 1996 to 2005. Data of daily mortality and hospital entry admissions from the Office of Economic and Statistical Research of the Queensland Treasury and the Health Information Centre of Queensland Health, respectively.
Region	Brisbane, Queensland
Overview of key points as provided by the author(s) in the abstract	**Background:** This study attempted to develop health risk-based metrics for defining a heatwave in Brisbane, Australia. **Methods:** Poisson generalised additive model was performed to assess the impact of heatwaves on mortality and emergency hospital admissions (EHAs) in Brisbane. **Results**: In general, the higher the intensity and the longer the duration of a heatwave, the greater the health impacts. There was no apparent difference in EHAs risk during different periods of a warm season. However, there was a greater risk for mortality in the 2nd half of a warm season than that in the 1st half. While elderly (≥75 years) were particularly vulnerable to both the EHA and mortality

Assessment of publications	
	effects of a heatwave, the risk for EHAs also significantly increased for two other age groups (0 – 64 years and 65 – 74 years) during severe heatwaves. Different patterns between cardiorespiratory mortality and EHAs were observed. Based on these findings, we propose the use of a tiered heat warning system based on the health risk of heatwave. **Conclusions:** Health risk-based metrics are a useful tool for the development of local heatwave definitions. This tool may have significant implications for the assessment of heatwave-related health consequences and development of heatwave response plans and implementation strategies.
Evidence quality grading	Low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** The quality of the evidence was considered low due to it being an exploration of relationships. **Incomplete outcome data:** The report states that 'Mortality data were only obtainable to November 2004 due to the time lag between deaths and their registration by state authorities when we collected these data.' (p.2) 'Non-external causes (NEC) of mortality and EHAs were categorised according to the International Classification of Diseases (ICD), ninth version (ICD-9) before December 1996 and tenth version (ICD-10) since December 1996 (ICD 9, < 800; and all ICD 10 codes excluding S00-U99 for external causes), cardiovascular diseases (ICD-9, 390–459; ICD-10, I00-I99), and respiratory diseases (ICD-9,460–519; ICD-10, J00-J99).' (p.2). 'When data were missing for a particular monitoring station on a given day (5% of missing data), the observations recorded from the other monitoring stations were used to calculate the daily average values.' (p.2) **Selective outcome reporting:** The publication does not specify whether all data collected and analysed is reported on. **Other limitations:** *Recruitment bias:* This paper does not take into consideration socio-economic confounding variables. **Strengths:** The study uses parameters that were peer-reviewed previously. 'In this study, we used daily mean temperature (calculated using maximum and minimum temperatures) since our previous work suggests that the mean temperature appears to be a reliable indicator of the temperature-health relation [reference].' (p.2). The data sources used are unlikely to have been biased by the hypothesis being tested by this author, as they are largely objective measures (temperature) or outcomes that would have had to be verified by independent assessors (e.g. causes of death). The report shows some of its weaknesses transparently. 'Two major weaknesses of this study must also be acknowledged. Only one city was considered in this assessment. However, the idea of defining a heatwave using readily available empirical data may inspire further research in this field. The second weakness was that aggregated data were used in assessing the effect of heatwaves on mortality and EHAs. Detailed spatial analysis might give a more precise estimate of the health impacts of a heatwave.'- (p. 9).
Experiences and needs of older people	Some data provided for age group 65-74 and 75+.

Assessment of publications	
Publication 13 (35)	
Year	2014
Author	Tong S, Wang XY, Yu W, Chen D, Wang X
Title	The impact of heatwaves on mortality in Australia: A multicity study
Publication	British Medical Journal Open
Type of study	Exploration of relationships: studies examining statistical associations between different variables in order to develop hypotheses
Number of people/studies	Mortality data for Brisbane, Melbourne and Sydney for the period 1988-2009 from the Australian Bureau of Statistics (ABS)
Region	Queensland (Brisbane), Victoria (Melbourne) and New South Wales (Sydney)
Overview of key points as provided by the author(s) in the abstract	**Objectives:** To assess the heterogeneity of heatwave-related impacts on mortality across different cities. **Design:** A multicity time series study. **Setting:** Three largest Australian cities: Brisbane, Melbourne and Sydney. **Participants:** All residents living in these cities. **Main outcome measures:** Non-external causes mortality data by gender and two age groups (i.e., 0–75 and 75+) for these cities during the period 1988–2009 were obtained from relevant government agencies. **Results:** Total mortality increased mostly within the same day (lag 0) or a lag of 1 day (lag 1) during almost all heatwaves in three cities. Using the heatwave definition (HWD) as the 95th centile of mean temperature for two or more consecutive days in the summer season, the relative risk for total mortality at lag 1 in Brisbane, Melbourne and Sydney was 1.13 (95% CI 1.08 to 1.19), 1.10 (95% CI 1.06 to 1.14) and 1.06 (95% CI 1.01 to 1.10), respectively. Using the more stringent HWD—the 99th centile of mean temperature for two or more consecutive days, the relative risk of total mortality at the lags of 0–2 days in Brisbane and Melbourne was 1.40 (95% CI 1.29 to 1.51) and 1.47 (95% CI 1.36 to 1.59), respectively. Elderly, particularly females, were more vulnerable to the impact of heatwaves. **Conclusions:** A consistent and significant increase in mortality was observed during heatwaves in the three largest Australian cities, but the impacts of heatwave appeared to vary with age, gender, the HWD and geographical area.
Evidence quality grading	Low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** The quality of the evidence was considered low due to the report being an exploration of relationships. This study compared the heatwave mortality impact in grouping by age and gender in the 3 largest cities of Australia. Populations served as their own self- control group.

Assessment of publications	
	Incomplete outcome data: 'Owing to privacy protection reason, the data obtained from the ABS were limited for the Statistical Division of usual residence by gender and two age groups (i.e., 0–75 and 75+) for the three metropolitan areas.' (p.3). **Selective outcome reporting:** The publication does not specify whether all data collected and analysed is reported on. **Other limitations:** *Confounding variables not considered:* 'We did not control for the potential confounding effects of air pollution (e.g., ozone), as these data were not complete for the whole study period in all three cities' (p.5). *Grouping bias:* The population is divided into two groups, <75 and >75. '… the mortality data for three cities only included two age groups (0–74 and 75+) by gender. Thus, we were unable to divide the data into smaller age groups.' (p. 6). **Other strengths:** The data sources used are unlikely to have been biased by the hypothesis being tested by this author, as they are largely objective measures (temperature) or outcomes that would have had to be verified by independent assessors (e.g. causes of death).
Experiences and needs of older people	Some data provided for age group 75+.
Publication 14 (17)	
Year	2015
Author	Dalip J, Phillips GA, Jelinek GA, Weiland TJ
Title	Can the elderly handle the heat? A retrospective case-control study of the impact of heat waves on older patients attending an inner-city Australian emergency department
Publication	Asia-Pacific Journal of Public Health
Type of study	Case-controlled studies with no repeated measurements
Number of people/studies	1296 emergency department presentations during heatwaves and 3888 control cases of people aged 65+ in one hospital in Melbourne during the period 2005-2010
Region	Victoria (Melbourne)
Overview of key points as provided by the author(s) in the abstract	The elderly have a higher mortality rate during heat waves and may, therefore, have higher morbidity. We investigated the effects of high ambient environmental temperature on emergency department (ED) function and patient (age >64 years) morbidity. A retrospective case-control study of ED presentations at an Australian metropolitan hospital from September 2005 to May 2010 was undertaken. Cases comprised 1297 ED presentations surrounding heat threshold days. These were compared with randomly selected presentations on non-threshold days (3 controls: 1 case), analysing patient morbidity and ED function variables: triage category, presenting complaint, demographics, arrival mode, time to doctor, ED length of stay (LOS), ED disposition, and discharge diagnoses. A greater proportion of cases presented with 'weakness,' and were diagnosed with 'dehydration.' There was little effect on ED function,

Assessment of publications	
	with ED LOS 24 minutes longer for cases and time to doctor 3 minutes shorter. This study found limited evidence of increased morbidity in the elderly during heat wave conditions.
Evidence quality grading	Medium
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** The quality of the evidence was considered medium due to the case-controlled studies with no repeated measurements reported. **Blinding of participants, personnel and outcome assessors:** There is no evidence of any measure taken to blind the outcome assessors and personnel. **Incomplete outcome data:** The report mentions that 'All patients aged ≤64 years were also excluded.' (p. 839) and that 'PPEs lacking a hospital unit record number and age were excluded.' (p. 839). 'Many older patients discharged from the ED have multiple discharge diagnoses. The data set obtained from the hospital's health information service and used in this study only quoted the primary diagnosis on discharge; it excludes all secondary diagnoses because it is not a mandatory field of our health information system and is therefore subject to omissions. Any of our assessed discharge diagnoses could potentially have been listed as a secondary diagnosis and would therefore be missed by our study.' (p.-844). The information was further filtered by 'Using pre-existing evidence on the morbidity effects of heat waves and looking at common presenting complaints among the elderly during hot weather, a list of 13 'most likely' presenting complaints was made. These included weakness, chest pain, shortness of breath, limb pain, collapse, altered conscious state, cerebrovascular accident/transient ischemic attack, dizziness, febrile state, arrhythmia, dysuria/urinary retention, urinary retention, and falls. Similarly, a list of 'most likely' discharge diagnoses was compiled using available evidence. These included cerebrovascular accident/transient ischemic attack, ischemic heart disease, heatstroke, exhaustion, urinary tract infection, syncope, chronic obstructive airway disease, and asthma. Because discharge diagnoses other than the primary discharge diagnosis are not mandatory fields in the hospital's ED data surveillance system, they are often incomplete. For this reason, only primary (mandatory) discharge diagnoses were analysed. ICD-10 codes for discharge diagnoses analysed are included in the appendix.' (p.840). **Selective outcome reporting:** This publication mentions that their dataset contains… 'the data set contained demographic information (age, date of birth, gender, marital status, usual accommodation, and postcode) as well as information pertaining to the medical complaint (presenting complaint and primary discharge diagnosis) and ED presentation (mode of arrival, triage category, time to doctor, ED LOS, and disposition).' (p.839). However, they do not report on all of them. The report does mention the following: 'A clinical reference group comprising 3 senior emergency physicians working at the hospital decided on variables to analyse that would reflect the effect of high ambient temperature on both morbidity of older patients and ED function as well as what difference in these variables between the test and control groups would be considered clinically significant.' (p.839). **Other limitations:** 'This study was performed based on data from a single hospital site within Melbourne and may not reflect the total experience of this UHI.' (p.844) 'Given the uncertain validity of our assumption that morbidity may have a delayed onset of up to 2 days

Assessment of publications	
	following the threshold day, this time period may have been too generous, skewing our data. Analysis that only includes the threshold day and the day that immediately follows may be more valid. A variable not assessed in this study, which has the potential to have a major impact on ED functioning, is the total number of ED PPEs.' (p. 844). **Other strengths:** The report specifies the thresholds used 'minimum temperature of >24°C or a mean of >30°C were extracted and called 'threshold' days' (p.839). The report also considers the biological delay between the stimulus (heat) and the parameter chosen (death): 'Loughnan et. al. noted an increase in the average daily mortality of people aged more than 64 years not only on threshold days but also in the 24 and possibly 48 hours that immediately followed. Based on this observation, the test days (TDs) were expanded to include threshold days as well as the 2 days that followed, for a total of 45 TDs.' (p.839). Finally, the study examines variables of clinical relevance, with ED management focus, using accepted statistical methods.
Experiences and needs of older people	Data provided for people aged 65+.
Publication 15 (24)	
Year	2015
Author	Hansen A, Bi P, Pisaniello D, Nitschke M, Tucker GR, Newbury J, et al.
Title	Heat-health behaviours of older people in two Australian states
Publication	Australasian Journal on Ageing
Type of study	Exploration of relationships: studies examining statistical associations between different variables in order to develop hypotheses
Number of people/studies	499 residents of South Australia and 498 residents of Victoria aged over 65 and living independently (i.e. not in residential aged care)
Region	South Australia and Victoria
Overview of key points as provided by the author(s) in the abstract	**Aim:** A major heatwave occurred in Australia in early 2009 with considerable and varied health impacts in South Australia (SA) and Victoria. The aim of this study was to investigate the heat-adaptive behaviours of older people in these states. **Methods:** A computer-assisted telephone survey of 1000 residents of SA and Victoria aged 65 years or older was conducted at the end of summer 2010–2011. **Results:** The majority of respondents reported undertaking heat-adaptive behaviours. In SA, there was a significantly higher proportion of households with air conditioning compared to Victoria, and a higher recall of heat-health messages. In both states, self-reported morbidity during heatwaves was higher in women, persons with poorer health and those with cardiovascular conditions. **Conclusion:** An increase in global temperatures in conjunction with an ageing population is a concern for public health. Our findings suggest acclimatisation to hot weather may influence behaviours and health outcomes in older people.

Assessment of publications	
Evidence quality grading	Low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** The assessment of this report is low considering it is an exploration of relationships. **Incomplete outcome data:** The report states that: 'To reach the target of 500 telephone interviews in each state, 4200 random households were initially selected in SA (with 47% of eligible persons completing the interview) and 5640 random households in Victoria (with a participation rate of 36% of the eligible sample).' The survey questionnaire is not provided and it is not specified whether or not all participants answered all questions. **Selective outcome reporting:** The publication does not specify whether all data collected and analysed is reported on. **Other limitations:** *Recollection bias*: 'The 2009 heatwave occurred 2 years prior to our survey that was undertaken during an unusually mild summer. Hence, respondents' recollection of behaviours during serious heatwaves may have introduced the possibility of recall bias.' (p.24). *Recruitment bias:* 'Close to 70% of the respondents in each state resided in the metropolitan area with the remainder living in rural areas of the respective states' (p.20).This information is valuable but confounding variables were not taken into consideration. The following limitations are provided by the authors: 'The survey was administered over the telephone, thereby excluding persons without a listed household telephone number. The vulnerable including the frail and those with physical or cognitive impairments would likely not have been captured in the study population, a factor recognised previously as being a limitation of public surveys [reference]. Furthermore, a number of older people affected by the heatwave 2 years previously may now be deceased or in aged care. Accordingly, these findings may be an underestimate of the vulnerability of older people,' (p.24). *Inaccurate or incomplete data:* The interviews format captured '…self-reported health status, air conditioning use, adaptive capacity, self-reported morbidity during recent heatwaves, and heat advisory recall.'(p.20). However, to minimise the potential bias given by the self-reporting method, the interviewers also asked for prescribed medication. The questionnaire is not provided. **Other strengths: '**The questionnaire was peer reviewed and piloted in December 2010 and recommended guidelines regarding the involvement of older people in research were followed [14]. All apparent difficulties were resolved and a second pilot was conducted in January 2011.' (p.20). 'The survey was managed by Population Research and Outcome Studies at the University of Adelaide, and administered by professional health interviewers.' (p.20). However, there might be a risk for variation between interviewers that needs to be accounted for in analyses.
Experiences and needs of older people	Direct survey responses from 997 people aged over 65.
Publication 16 (8)	
Year	2016
Author	Zhang Y, Nitschke M, Krackowizer A, Dear K, Pisaniello D, Weinstein P, et al.

Assessment of publications	
Title	Risk factors of direct heat-related hospital admissions during the 2009 heatwave in Adelaide, Australia: A matched case–control study
Publication	BMJ Open (British Medical Journal)
Type of study	Case-controlled studies with no repeated measurements
Number of people/studies	143 hospital patients and 143 matched controls from Adelaide
Region	South Australia (Adelaide)
Overview of key points as provided by the author(s) in the abstract	**Objective:** The extreme heatwave of 2009 in South Australia dramatically increased morbidity, with a 14-fold increase in direct heat-related hospitalisation in metropolitan Adelaide. Our study aimed to identify risk factors for the excess morbidity. **Design:** A matched case–control study of risk factors was conducted. Setting: Patients and matched community controls were interviewed to gather data on demographics, living environment, social support, health status and behaviour changes during the heatwave. **Participants:** Cases were all hospital admissions with heat-related diagnoses during the 5-day heatwave in 2009. Controls were randomly selected from communities. **Outcome measures:** Descriptive analyses, simple and multiple conditional logistic regressions were performed. Adjusted ORs (AORs) were estimated. **Results:** In total, 143 hospital patients and 143 matched community controls were interviewed, with a mean age of 73 years (SD 21), 96% European ethnicity, 63% retired, 36% with high school or higher education, and 8% institutional living. The regression model indicated that compared with the controls, cases were more likely to have heart disease (AOR=13.56, 95% CI 1.27 to 144.86) and dementia (AOR=26.43, 95% CI 1.99 to 350.73). The protective factors included higher education level (AOR=0.48, 95% CI 0.23 to 0.99), having air-conditioner in the bedroom (AOR=0.12, 95% CI 0.02 to 0.74), having an emergency button (AOR=0.09, 95% CI 0.01 to 0.96), using refreshment (AOR=0.10, 95% CI 0.01 to 0.84), and having more social activities (AOR=0.11, 95% CI 0.02 to 0.57). **Conclusions:** Pre-existing heart disease and dementia significantly increase the risk of direct heat-related hospitalisations during heatwaves. The presence of an air-conditioner in the bedroom, more social activities, a higher education level, use of emergency buttons and refreshments reduce the risk during heatwaves.
Evidence quality grading	Medium
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** The grade of this report is medium since it is a matched case-control study of socio-economic risk factors that excludes several socio-economic factors that are associated with heat and health vulnerability. **Blinding of participants:** 'All personal information was removed before the data were passed on for analysis.' (p.2). **Incomplete outcome data:** 'In total, there were 298 patients admitted to the public hospitals over the study exposure period. Among these patients, 31 deceased, 25 under 18 years and 3 aboriginal patients were excluded, leading to 239 eligible cases to recruit. 'The

Assessment of publications	
	main reason for not being able to participate (90% of the non-participants) was due to their incomplete hospital records or unknown address so that we could not reach them. The reason for cases refusing to participate included three patients with dementia, six who died close to the interview dates (not recorded in the collected hospital record data) and one non-English speaking case.' (p.3). **Selective outcome reporting:** The report does not evidence selective outcome reporting. **Other limitations:** 'The limitations of a case–control study are mainly due to recall bias. However, we have reviewed patients' hospital medical records to increase the accuracy of individual information, including their diagnoses and some sociodemographic data, as recorded by nurses when being admitted to hospitals.' (p.6) *Recruitment bias:* Only people of the Adelaide metropolitan area were included. Aboriginal patients were excluded while the questionnaire was only provided in English while they assessed for ethnicity, working status and education level (p.3). The questionnaire was applied either by face-to-face or by phone in a non-consistent fashion (p.3). 'There might also be limitations from recruiting 60% of eligible patients and we could not have a full comparison between those who refused to participate with the participants due to incomplete records.' (p.6). **Strengths:** 'A major strength of our study is the matched case–control study design, with data of potential risk factors collected at an individual level, thus providing a stronger evidence base than previous ecological studies using data at a population level.' (p.6).
Text here?	Direct survey evidence from 286 people aged 18+ (with a median age of 73 years).
Publication 17 (3)	
Year	2018
Author	Cheng J, Xu Z, Bambrick H, Su H, Tong S, Hu W
Title	Heatwave and elderly mortality: An evaluation of death burden and health costs considering short-term mortality displacement
Publication	Environment International
Type of study	Exploration of relationships: studies examining statistical associations between different variables in order to develop hypotheses
Number of people/studies	368,767 deaths of people aged 75+ during November to March in the period 1988 to 2011. Daily death counts were acquired from Australian Bureau of Statistics in different periods between 1988 and 2011.
Region	New South Wales (Sydney), Victoria (Melbourne), Queensland (Brisbane), Western Australian (Perth) and South Australia (Adelaide)
Overview of key points as provided by the author(s) in the abstract	**Background:** A heatwave can be a devastating natural disaster to human health, and elderly people are particularly vulnerable. With the continuing rise in earth's surface temperature alongside the world's aging population, research on the mortality burden of heatwave for the older population remains relatively sparse. The potential magnitude of benefits of averting such deaths may be considerable. **Objectives:** This paper examined the short-term mortality displacement (or 'harvesting') of heatwave, characterised the heatwave-mortality relationship, and estimated death burden and health costs attributable to heatwave among the elderly in Australia.

Assessment of publications	
	Methods: We collected daily data on the temperature and deaths of people aged ≥75 years in the five largest cities of Australia (Sydney, Melbourne, Brisbane, Perth and Adelaide), totalling 368,767 deaths in different periods between 1988 and 2011. A total of 15-tiered heatwave definitions, based on intensity (95th to 99th percentiles of temperature distribution) and duration (two or more consecutive days), were used to quantify heatwave effects, using time-series regression and random-effects meta-analysis. We calculated attributable deaths for each city and by different types of heatwave. Potential economic benefits in monetary terms were also estimated, considering that heat-related deaths are avoidable. **Results:** Among the Australian elderly population, we found significant associations between heatwave and deaths, with raised mortality immediately in the first few days followed by lower-than-expected mortality. In general, heatwave was associated with an average death increase of 28% (95% confidence interval: 15% to 42%), and greater increases were mostly observed for more intense heatwaves across multiple megacities. During the study period, there were dozens to hundreds of deaths attributable to heatwave for each city, equating to an economic loss of several million Australian dollars every year. Although the estimated attributable deaths varied by heatwave intensity and duration, the pattern was not consistent across cities. **Conclusions:** Heatwave caused harvesting effects on mortality in the elderly population of Australia, and contributed to a substantial amount of death burden and indirect financial costs. To lessen the health impacts of heatwave in the affected regions, effective heatwave early warning systems and interventions targeted at the elderly population could be beneficial, both now and in the future.
Evidence quality grading	Low
Summary of assessment that led to evidence quality grading	**Summary of overall evidence quality assessment:** The grade of this report is low since it is an exploration of relationships study. **Incomplete outcome data:** Several figures of importance are in the supplementary figures, which are not part of the main text. **Selective outcome reporting:** The report does not evidence selective outcome reporting (sup fig). **Other limitations:** Confounding variables were not accounted for, such as pollution and humidity (p.340). 'For each heatwave type we assumed that the heatwave effects remain unchanged over time' (p.341)
Experiences and needs of older people	Data from 368,767 deaths of people aged 75+.