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Heatwave fatalities in Australia: a new analysis

Lucinda Coates, Jonathan van Leeuwen, Stuart Browning, Ashley Avci, Andrew Gissing

Risk Frontiers has recently published the latest in its series of scholarly research articles on the fatalities caused by Australian natural hazards. The current work expands on previous our work on Australian heatwave fatalities from 1844 to 2010 (Coates et al, 2014), where it was determined that heatwaves were second only to disease epidemics in lives lost from natural hazards.

The risk of dying in a heatwave increases with:

- age
- socio-economic disadvantage
- social isolation
- geographical remoteness
- the presence of disabilities (physical or mental)
- the presence of some prescribed medications
- the absence or non-use of air conditioning.

The new work (Coates et al, 2021) analyses statistics of fatalities associated with extreme heat in Australia from 2001-2018, as identified by a Coroner: the first longitudinal study of heat-related deaths utilising coronial records in Australia. The detail in coronial reports, including demographic information on the decedent and contextual details on the nature of the fatality, enables a better understanding of circumstances around such fatalities.

Heatwaves are recognised as one of the key natural hazard risks to human health. They have increased in frequency and intensity in recent decades, a trend projected to continue under most future climate scenarios (e.g., Perkins-Kirkpatrick et al, 2016). This, in combination with Australia's population growth, greater urbanisation and an aging population – with the elderly more likely to experience poor health and to be living alone with fewer social contacts and limited finances – places an increased importance on research-based risk reduction strategies.

Method

Defining a heatwave can be tricky. This study employed one of the most widely used metrics for the definition of heatwaves: the Excess Heat Factor (EHF), which is the basis for the Bureau of Meteorology heatwave warning system (Nairn and Fawcett, 2015). The EHF index identifies conditions significantly hotter than usual and is location-specific – see Coates et al (2021) for details of the methodology and the definitions of heat-related and heatwave fatalities used.

Assigning deaths can also be tricky. Heat-associated deaths are generally not well documented; heat often contributes to death without being the direct cause and heat may not be considered as a potential cause of death. With respect to coronial records, it is not generally possible to identify heat-related deaths through autopsy alone: the circumstances around the death must also be understood. Thus, many deaths that are in fact heat-related will not necessarily be recorded as such.

Our research was based on closed case records[1] from 1 July 2000 to 30 June 2018 (i.e., financial years FY2001-FY2018) from the National Coronial Information System (NCIS) database. NCIS maintains a secure online database storing deaths reported to a coroner from all Australian jurisdictions beginning July 2000 (Queensland from January 2001) and New Zealand beginning July 2007. Due to the sensitive nature of the data, ethics approvals were obtained from the human research ethics committees of Australia's jurisdictions.

Raw numbers of fatalities were normalised by viewing the fatality numbers against a background population of the particular group of interest. Normalisation enables the comparison of fatalities over time and across jurisdictions by taking into account any changes in population over time and population differences from place to place.

Limitations other than those mentioned included the relatively large proportion of coronial cases in the more recent years of record that were unavailable for viewing, and the fact that data available for analysis in accessed coronial files was limited due to differences in recording data over time and between jurisdictions, meaning that data presented may represent a lower bound.

[1] Closed cases are those finalised (i.e., investigations are no longer open) and thus available for viewing

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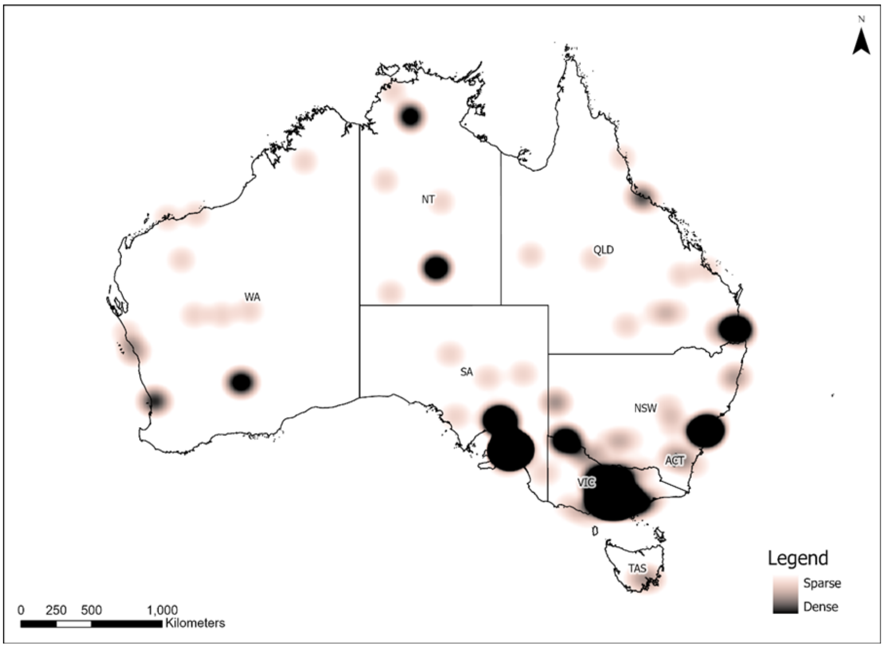

Figure 1: Heatwave incident locations in Australia, FY2001 to FY2018.
Higher densities of heatwave fatalities are indicated by larger/ darker hotspots.

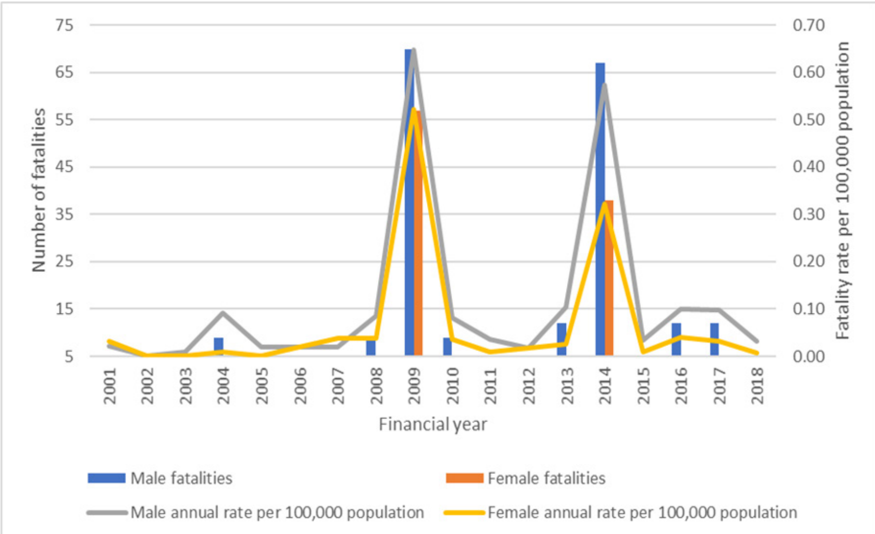

Figure 2: Heatwave fatalities and fatality rates per 100,000 population by sex in Australia, FY2001 to FY2018
Note: in more recent years, less NCIS cases were closed and thus available for analysis
Note: The y-axis has been set to a minimum value of five to exclude any values <5, as requested by NCIS

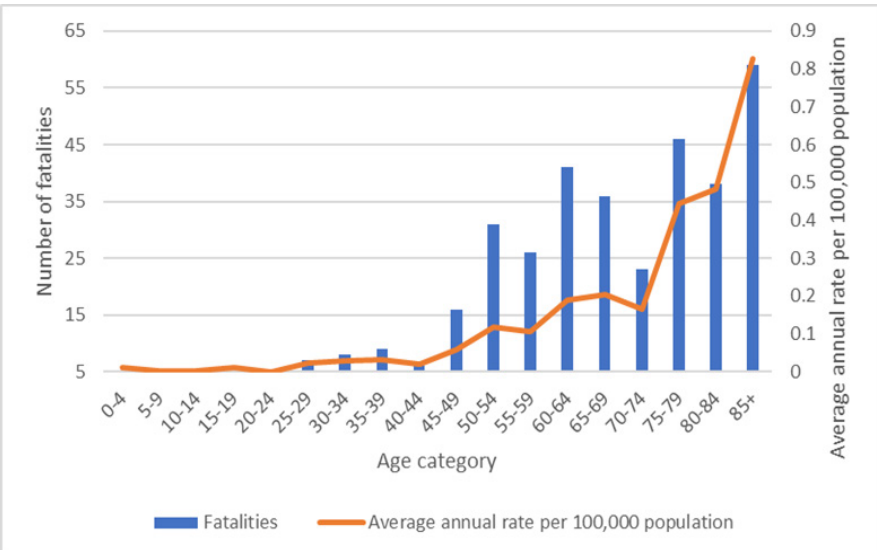

Figure 3: Heatwave fatalities by age bracket in Australia, FY2001 to FY2018
Note: The y-axis has been set to a minimum value of five, as requested by NCIS. There were <5 fatalities in the 0-4 to 15-19 groups and nil fatalities in the 20-24 group

Results

At least 473 heat-related deaths were reported to a coroner in Australia in the 18 years from July 2000 to June 2018, 354 occurred during heatwave conditions, as defined by Nairn and Fawcett (2015) and, of these, 244 occurred within or near buildings. There was no overall trend in the number or rate of fatalities, but a record of generally low numbers is interspersed with periodic excursions into very high numbers. Unless otherwise indicated, statistics below refer to the 354 heatwave fatalities.

The locations of heatwave fatalities are shown in Figure 1. Areal hotspots occurred mainly in the coastal capitals, especially in south-eastern Australia.

Half of the heatwave fatalities occurred in Victoria (VIC), and a quarter in South Australia (SA). Just two heatwave events – in 2009 and 2014, across VIC and SA – accounted for almost two-thirds (63%) of the total fatalities and 82% of building-related fatalities. Considering population statistics and utilising annual average fatality rates, the Northern Territory (NT) and SA had the highest fatality rates – 0.32 and 0.31 deaths per 100,000 population respectively – followed by VIC (0.18). All other jurisdictions were below the national average of 0.09.

Data available on cooling sources were limited. No type of air conditioning was present in most of the 50% of cases for which air conditioner ownership was known. In 4% of cases, air conditioning was known to be present and functional but not in use. In at least seven of these cases, data within police and/ or Coroner's reports stated that the deceased had a habit of not using air conditioning. Importantly, of the cases for which it was known if any type of air conditioning was present, it was not present for 81% of fatalities. This contrasts with the 26% of households in Australia reported as not having air conditioning.

Some 63% of fatalities were male, although this differed across individual years: e.g., 55% in FY2009 but 63% in FY2014 – the two extreme heatwave years. Figure 2 shows the number of male and female fatalities and the fatality rates, which also peaked in FY2009 and FY2014.

In general, the most deaths per five-year age category occurred in those aged 50 years and above (Figure 3); notably in the 85+ and 75-79 age categories. Some 243 (69% of) fatalities occurred in the 60-

plus age group; of the 244 fatalities that occurred indoors, 80% occurred in this group.

The vulnerability of older Australians to heatwaves is further shown in Figure 3 by the fatality rate (calculated as the average annual fatality rate per 100,000 people for each of the 5-year age groups), which stepped up slightly for the 50-54 and 55-59 age groups, again for the 60-64 to 70-74 age groups, more sharply to approximately 0.46 deaths per 100,000 population for the 75-79 and 80-84 age groups and then to 0.83 for those aged 85-plus.

A low SEIFA/ IRSAD index score[2] indicates lack of advantage and relatively greater disadvantage, and a high score indicates greater advantage and a relative lack of disadvantage. Use of the IRSAD index clearly showed that more deaths occurred amongst those locations showing the greatest socio-economic disadvantage and least socio-economic advantage. Some 64% of fatalities occurred in the top 50% most socio-economically disadvantaged areas and 32% in the top 20% most socio-economically disadvantaged areas (Figure 4).

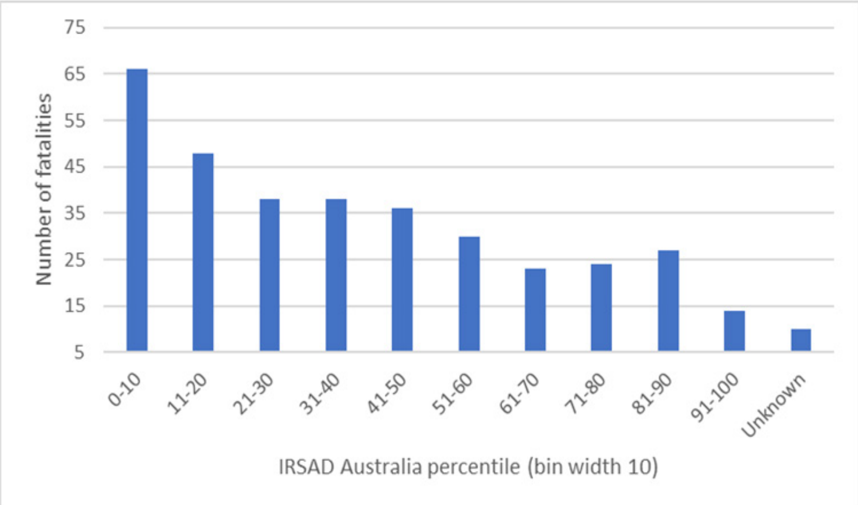

Figure 4: Heatwave fatalities by socio-economic location (IRSAD) in Australia, FY 2001 to FY 2018.

Data source: ABS 2016a. Socio-economic disadvantage decreases to the right of the x-axis: 0-10 is most disadvantaged and 91-100 is least disadvantaged.

Most commonly, decedents were carrying out "business as usual" (48%), with no precautions taken in at least 38 cases and some precautions taken in at least 18 cases. The next most common behaviours were no/ limited action (11%) and attempting to cool themselves without leaving the building (11%). Other behaviours which may have contributed to heat-related deaths included a lack of air circulation, exercising or strenuous activity in the heat, living in squalor, refusing assistance and/ or medications or not using home air conditioning.

Discussion

We found that heatwaves still pose a greater threat to Australian mortality than any other natural hazard. Australia has no national heatwave risk management framework, although groundwork has been laid by many of Australia's jurisdictions. Heatwaves are a complex hazard and thus an integrated, collaborative management approach, consisting of risk assessment, care for vulnerable people, urban planning, landscape management, emergency and recovery planning, community awareness and resilience and organisation and business resilience, is necessary.

Our results are in accord with other Australian and international studies: those more likely to die in heatwave events are the elderly, young children, people with existing medical conditions and/ or disabilities, the isolated, and people who experience social and financial disadvantage. An added difficulty is that those most vulnerable to heatwaves are generally also vulnerable to other risks in society and are often overlooked or difficult to access.

Our study results emphasises the importance of retrofitting existing housing stock in order to better cater for the greater proportion of the elderly who use them as refuge. The implementation of targeted awareness campaigns with a particular focus on those who are older and/ or socially or geographically isolated, socio-economically disadvantaged or living with a disability – as a partnership between local councils, public health authorities, general practitioners, pharmacies, community organisations and public/ social housing providers – could improve these conditions.

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[2] The Socio-Economic Indexes for Areas (SEIFA) data product, derived from the ABS five-yearly Census of Population and Housing, enables the assessment of the relative welfare of Australian communities. The Index of Relative Socio-economic Advantage and Disadvantage (IRSAD), created from 2016 census data to summarise socio-economic conditions within defined areas, is used when the topic being analysed is likely to be affected by both advantage and disadvantage

A new look at the impact of extreme weather

Lucinda Coates, Jonathan van Leeuwen, Andrew Gissing

The World Meteorological Organisation (WMO), an agency within the United Nations, has recently published a global atlas of mortality and economic losses from meteorological extreme events (WMO, 2021). In brief, from 1970 to 2019, 11,072 weather, climate- and water-related disasters caused 2.06 million deaths.

This second iteration of the WMO Atlas reports increased exposure, increased economic losses – but significant reduction in mortality due to the implementation of multi-hazard early warning systems (MHEWSs). The Sendai Framework for Disaster Risk Reduction 2015–2030 (Sendai Framework) recognised the benefits of MHEWSs by incorporating them into one of its seven global targets but, it was reported, only half of the 193 WMO member nations have MHEWSs.

The report also recognises that, under a changed climate, the number of weather, climate and water extremes will become more frequent and severe in many parts of the world.

The analysis is based on Centre for Research on the Epidemiology of Disasters' Emergency Events Database (EM-DAT), which contains data on natural and technological disasters from 1900. For an event to be included in EM-DAT, at least one of the following criteria must be satisfied:

- 10 or more people reported killed
- 100 or more people reported affected
- Declaration of a state of emergency
- Call for international assistance.

Results

The WMO Atlas opens with a discussion of the attribution of extreme events to climate change. It noted that, while few studies have found any anthropogenic climate signal in small-scale severe weather events such as thunderstorms, there has been progress in attributing individual extreme events that occur over larger scales. For example, 62 of the 77 events reported to the Bulletin of the American Meteorological Society over the period 2015 to 2017 show a significant anthropogenic influence on the event's occurrence. Almost every study of significant heatwaves since 2015 has found that probability has been significantly increased by anthropogenic climate change. Also, an increasing number of studies are also finding human influence on extreme rainfall events, sometimes in conjunction with other major climate influences such as the El Niño Southern Oscillation.

The past few decades have seen rapid growth in global populations living in flood- and cyclone-exposed areas, particularly in cities in developing countries. The WMO Atlas notes that, together, these trends will increase the risk of weather, climate and water hazards to human health.

Of those events contained in EM-DAT 1970 to 2019, 50% of events (11,072), 45% of deaths (2.06 million) and 74% of economic losses (US$3.64 trillion) were due to weather, climate and water hazards. Table 2 sets out the top ten disasters by number of fatalities.

Considering the top ten deadliest global weather-related hazard events, drought has been responsible for the greatest number of deaths (650,000), closely followed by storms[1] (577,232) and then floods (58,700) and extreme temperature (55,736) (Table 1 (a)). It should be noted that, as the WMO analysis excludes geological hazards, Table 1 may well change if events such as, for example, the 2004 Boxing Day tsunami were included.

[1] This includes hail, lightning, rain, tornado, wind, tropical cyclone

Table 1: Top ten global weather-related disasters ranked according to reported deaths, 1970–20191 (source: WMO Atlas)

(a)	Disaster event	Year	Country	Deaths	Percentage[3]
1[2]	Drought[1]	1983	Ethiopia	300 000	14.45%
1[2]	Storm (Bhola)	1970	Bangladesh	300 000	14.45%
3	Drought[1]	1983	Sudan	150 000	7.28%
4	Storm (Gorky)	1991	Bangladesh	138 866	6.74%
5	Storm (Nargis)	2008	Myanmar	138 366	6.72%
6[2]	Drought[1]	1973	Ethiopia	100 000	4.85%
6[2]	Drought[1]	1981	Mozambique	100 000	4.85%
8	Extreme temperature	2010	Russian Federation	55 736	2.71%
9	Flood	1999	Bolivarian Republic of Venezuela	30 000	1.45%
10	Flood	1974	Bangladesh	28 700	1.39%

1. A drought that lasts for more than a year is recorded with its beginning year (year of onset) following EM-DAT guidance
2. Countries with identical death figures are ranked jointly
3. Percentage of total deaths for the period 1970-2019

From 1970-2019, PerilAUS has recorded a total of 2464 deaths from natural hazards[2].

In contrast to the EM-DAT global results, the Australian experience (for the top ten deadliest disasters, 1970-2019) has extreme temperature events as the number one killer (748; 30.36%), followed by bushfires (293; 11.89%) and then storms (including floods resulting from storms, which includes cyclones) (138; 5.60%) (Table 2 (a)). As reported below (Figure 2), heatwaves have been responsible for 40% of weather-related fatalities from 1970-2019.

[2] This includes geological hazards such as landslides and earthquakes; excess heat-related death estimates for the 2004, 2009 and 2014 heatwave events and nine deaths attributable to bushfires that occurred in January 2020 of the 2019-20 bushfire season

Trends

The WMO Atlas investigated trends by decade, and noted that, while the number of global weather, climate and water disasters increased by a factor of five over the period of study, deaths decreased almost threefold: from over 50 thousand deaths in the 1970s to less than 20 thousand in the 2010s (Figure 1). Important advances in early warning systems worldwide have been credited with reducing the deaths from weather, climate and water hazards (Intergovernmental Panel on Climate Change (IPCC) (2012)).

Table 2: Top ten Australian weather-related disasters ranked according to reported deaths, 1970–2019 (source: PerilAUS[3], as at August 2021)

(a)	Disaster event	Year	Australian location	Deaths	Percentage[1]
1	Extreme temperature	2009	SA, VIC	435	17.65%
2	Bushfire (Black Saturday)	2009	VIC	173	7.02%
3	Extreme temperature	2014	VIC	167	6.78%
4	Extreme temperature	2004	NSW, Qld, Vic, SA, WA	116	4.71%
5	Bushfire (Ash Wednesday)	1983	VIC; SA	86	3.49%
6	Storm (Tracy)	1974	Darwin, NT	71	2.88%
7	Storm & floods (Tasha)	2010	QLD	41	1.66%
8	Bushfire	2019	NSW, VIC, SA	34	1.38%
9	Extreme temperature	1994	Sydney; Southern NSW	30	1.22%
10	Storm (Fifi)	1991	Offshore WA	26	1.06%

1. Percentage of total deaths for the period 1970-2019

[3] The PerilAUS database is described at the end of this article.

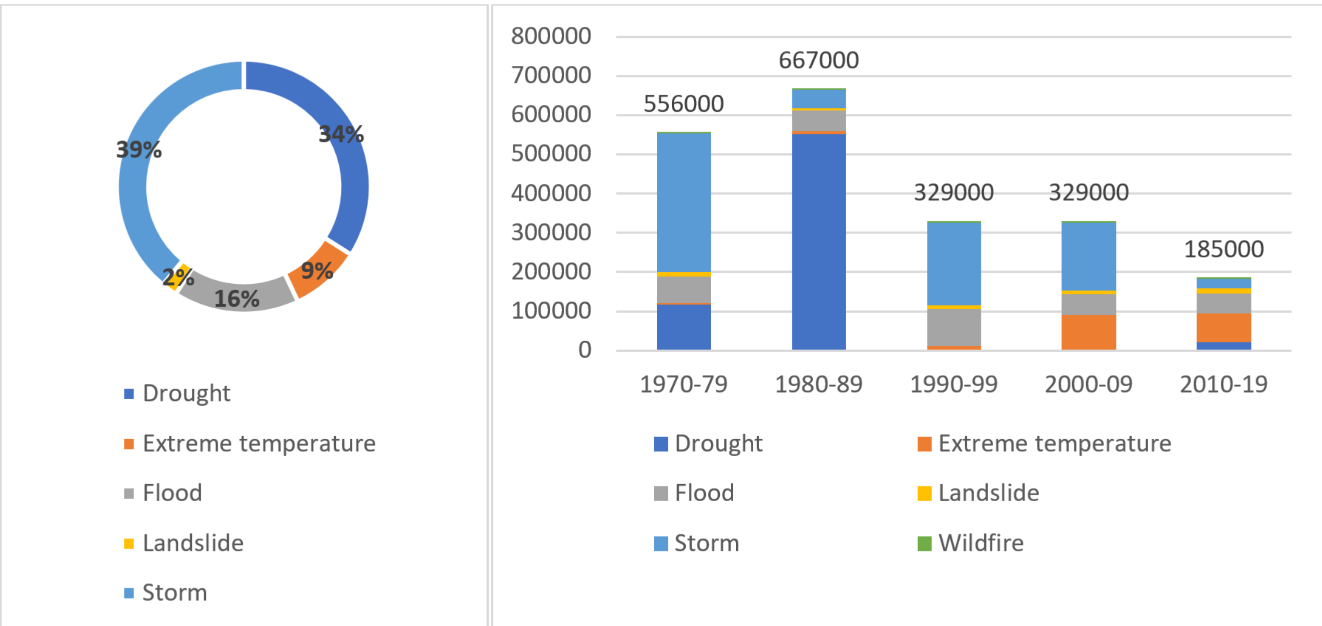

Figure 1: Distribution of number of deaths by hazard type by decade globally, 1970-2019 (source: WMO Atlas). Total reported deaths = 2,064,929

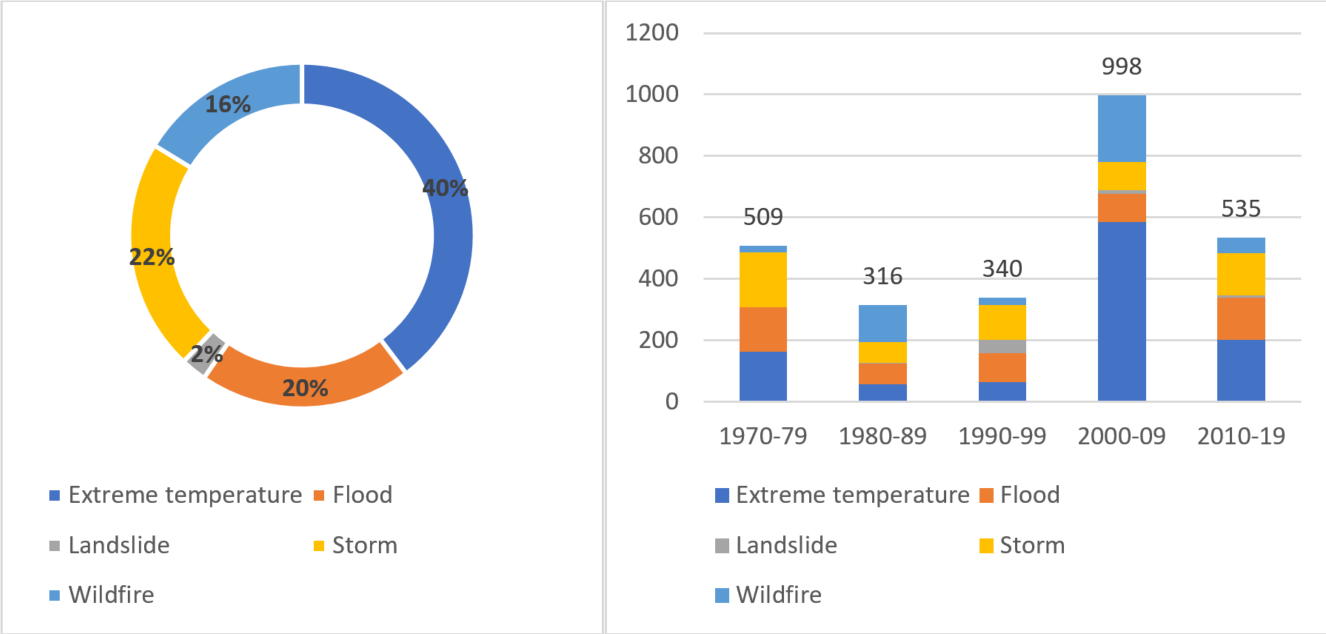

Figure 2: Distribution of number of deaths by hazard type by decade in Australia, 1970-2019 (source: PerilAUS database, 8/12/2021). Total reported deaths = 2698

Statistics from the PerilAUS database (see Figure 2) show no particular trend, with very similar death totals for both the 1970s and the 2010s. The 2000s included the disastrous extreme heat and bushfire events of 2009. In the 50 years since 1970, heatwaves have been responsible for 40% of weather-related fatalities. (As an aside, these figures do not change significantly when geological hazards are included: Australia, as a relatively stable land mass, has had very few earthquake deaths and none from volcano or tsunami.)

PerilAUS

Risk Frontiers' PerilAUS is a series of event-based databases on the occurrence and consequences of natural hazards in Australia, providing hard evidence, with the required breadth and depth, to inform risk management, understand past hazard impacts and examine trends over time and space. It is distinguished from many other databases by its length of record (with best confidence from 1900 but, for example, the PerilAUS lightning database is the longest continual national record in the world, dating from 1788), wealth of descriptive detail around hazard impact and deaths and a unique building damage "housing equivalent" calculator, enabling comparison of the impacts of hazard events of different types and at different times.

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Wishing you a very Merry Christmas and a peaceful and prosperous New Year

from the staff at Risk Frontiers