Australian Government
Australian Institute of Health and Welfare

Let’s talk about the weather: injuries related to extreme weather

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About

The past decade has seen increasing injuries related to extreme weather. In the ten years from 2012–13 to 2021–22 there were 9,119 hospitalisations in Australia with direct evidence of extreme weather-related injury. In three years out of the ten, hospitalisations for this type of injury exceeded 1,000 cases, with extreme heat causing the largest proportion of injuries. From 2011–12 to 2020–21 there were also 677 extreme weather-related injury deaths– an average of 68 per year.

Cat. no: INJCAT 236

Findings from this report:

- Most extreme weather-related injuries are due to extreme heat
- Total extreme weather-related hospitalisations exceeded 1,000 cases on average once every three years since 2013–14
- Injury patterns vary with localised weather events and hazards
- Opportunities exist to improve surveillance of extreme weather-related injuries

Summary

This report describes a subset of injuries which could reasonably be associated with specific extreme weather events or related natural hazards that occurred between June 2012 and 2022. The technical notes section of this report details how injuries and weather-related causes have been selected in this analysis. This subset of injuries was selected due to challenges in ascertaining direct causality between weather events and injury records from existing administrative datasets. This report also discusses existing and potential data sources on weather-related injury in Australia, along with opportunities to improve systematically collected data. It has been informed by consultation with stakeholders within the AIHW and external experts.

National data indicates that 9,119 hospitalisations (from July 2012 to June 2022) and 677 deaths (from July 2011 to June 2021) from injuries were directly related to extreme heat, extreme cold, bushfires and rain or storms.

Heatwaves are historically Australia's most dangerous natural hazard in terms of directly attributable loss of life (Coates et al. 2022; DAWE 2015) and create increased demand on the healthcare system (DEA 2016, Mason et al. 2022). Extreme heat accounted for 7,104 injury hospitalisations and 293 deaths in the 10-year period analysed in this report.

Although similar numbers of heatwave related hospitalisations occurred in El Niño and La Niña years, the number of injuries related to bushfires (a natural hazard associated with extreme heat) was higher in El Niño years. During the 2019–20 bushfires, in the week beginning 5 January 2020 there were 1,100 more hospitalisations than the previous 5-year average, an 11% increase. The greatest increase in the hospitalisation rate was 30% in the week beginning 15 December 2019—0.8 per 100,000 persons (about 210 hospitalisations), compared with the previous 5-year average of 0.6 per 100,000 (an average of 155 hospitalisations) (AIHW 2021).

348 injury hospitalisations and 77 deaths related to extreme rain or storms, and 773 injury hospitalisations and 242 deaths related to extreme cold, were identified in the 10-year period analysed in this report. When compared to other types of extreme weather in Australia, deaths due to storms and floods typically impact males and younger people (Peden et al. 2023). Age increased the likelihood of death from exposure to extreme cold (Peden et al. 2023)

References

AIHW (2021) Data update: Short-term health impacts of the 2019–20 Australian bushfires, AIHW, Australian Government, accessed 06 May 2022.

Coates L, van Leeuwen J, Browning S, Gissing A, Bratchell J and Avci A (2022) Heatwave fatalities in Australia, 2001–2018: An analysis of coronial records', International Journal of Disaster Risk Reduction, 67, doi: https://doi.org/10.1016/j.ijdrr.2021.102671.

DAWE (Department of Agriculture, Water and Environment) (2015) National Climate Resilience and Adaptation Strategy 2015, DAWE, Australian Government, accessed 1 April 2022.

DEA (Doctors for the Environment Australia) (2016) Heatwaves and Health in Australia, DEA, accessed 31 March 2022

Mason, H., C King, J., E Peden, A. *et al*. Systematic review of the impact of heatwaves on health service demand in Australia. *BMC Health Serv Res* **22**, 960 (2022). https://doi.org/10.1186/s12913-022-08341-3

Peden AE, Heslop D, Franklin RC. Weather-Related Fatalities in Australia between 2006 and 2019: Applying an Equity Lens. Sustainability. 2023; 15(1):813. https://doi.org/10.3390/su15010813

Introduction

Background: How weather impacts injury

Over the past three decades, extreme weather events have increased in frequency and severity (IPCC 2014, State of the Climate 2022: Bureau of Meteorology).

There is increasing awareness of the impacts of climate change on human health (MJA 2021). Some of the changes in the natural environment affecting Australia's health and welfare are detailed in the Natural environment and health report.

In 2021–22, there were 2.4 hospitalisations per 100,000 Australians for injuries caused by forces of nature, which includes natural disasters, lightning and extreme weather, but excludes bushfires. Injuries caused by forces of nature also led to 0.2 deaths per 100,000 in 2020–21 (Injury in Australia).

Weather factors can increase the risk of injury in multiple ways:

- extreme weather events such as storms and flooding, and bushfires (a hazard exacerbated by extreme weather events) can cause physical injury and death
- sustained adverse weather conditions are associated with an increase in the risk of intentional self-harm and assaults
- adverse conditions increase the risks associated with regular activities, such as heat stroke during sporting activity.

Scope of this report

This report reviews currently available data about injuries caused by extreme weather conditions or related hazards, specifically:

- Extreme heat
- Bushfires (a natural hazard associated with extreme heat)
- Rain and storm-related events, including high rainfall, floods, cyclones, and storms
- Extreme cold.

Extreme weather and natural hazards related to it can cause acute injuries as well as secondary or subsequent injury, such as traffic accidents due to road conditions. Identifying where weather directly caused injury can be challenging in currently available hospital and mortality datasets. This report suggests opportunities to develop weather-related injury surveillance systems and discusses limitations in the available data.

This analysis is limited to cases where it is reasonable to conclude injury was related to exposure to one of the four extreme weather-related conditions listed above.

- Causes of injuries may be multifactorial, but only the first recorded cause is considered in this report. This means injuries from road traffic accidents that occur due to adverse weather conditions are excluded due to the primary external cause of injury being recorded as transport.
- Available data does not preclude non-weather-related causes of injuries. For example, hypothermia is counted where there is exposure to extreme cold, but this may include cases where the exposure was swimming related.
- Only acute injuries where hospitalisation or death occurs are counted.

These, and related caveats are discussed further in the section of this report titled 'Limitations in ascribing injuries to weather'. Overall, this report presents an underestimate of extreme weather-related injuries. Injury definitions and codes used for this report are detailed in the technical notes section.

Australian government approaches

Australian government strategies increasingly acknowledge the effect of climate on human health, including the National Preventive Health Strategy 2021–2030 (DoH 2021c) and the National Obesity Prevention Strategy 2022–32 (DoH 2022b).

Different states and territories employ surveillance systems to monitor bushfires and heatwaves, and The Bureau of Meteorology issues heatwave warnings for local areas to Health and Emergency Management agencies if severe or extreme heatwaves are expected. (BoM 2023). The Bureau also issues Flood Watch which provides information about developing weather situations including forecast rainfall totals, catchments at risk of flooding, and indicative severity where required.

International monitoring

The United Nations Sendai Framework for Disaster Risk Reduction 2015–2030, which Australia endorsed in 2015, aims to prevent new risk, reduce existing risk, and strengthen resilience to natural disasters and hazards caused or exacerbated by human activity. The framework includes a monitoring component, whereby participating member states work towards reporting data for 38 indicators. These indicators

include rates of death, injury and illness arising from disasters.

Related information from the AIHW

Injury in Australia provides annual updates on injuries caused by forces of nature. Health conditions subsequent to weather events, such as thunderstorm asthma, are detailed elsewhere in reports such as Chronic respiratory conditions. Australian bushfires 2019–20 explores short term health impacts from specific extreme weather events. General trends in both natural and built environments are discussed in articles published on the topic of Environment and Health.

References

AIHW, Australian bushfires 2019–20

AIHW, Chronic respiratory conditions

AIHW, Environment and Health unit

AIHW, Injury in Australia

AIHW, Natural environment and health

Beggs et al (2021) The 2021 report of the MJA–Lancet Countdown on health and climate change: Australia increasingly out on a limb, Med J Aust 2021;215 (9):390-392.e22

Bureau of Meteorology, About the heatwave service

DoH (Department of Health) (2021c) National Preventive Health Strategy 2021–2030, DoH, Australian Government, accessed 27 May 2022

DoH (Department of Health) (2022b) National Obesity 2022–2030, DoH, Australian Government, accessed 27 May 2022.

IPCC (2014) Climate Change 2014: Synthesis Report, Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri RK and Meyer LA (eds.)], IPCC, Geneva, Switzerland.

UN (United nations) (2015) Sendai Framework for Disaster Risk Reduction 2015–2030, United Nations, accessed 31 May 2022

State of the Climate 2022: Bureau of Meteorology

An overview of extreme weather-related injuries

The terms ‘hospitalisation’ and ‘case’ in this report refer to incidents where a person was admitted to hospital with injury as the main reason. Injuries were selected for this analysis where it was reasonable to conclude an association between adverse weather conditions and the type of injury. The technical notes section of this report defines these terms, selected diagnosis and external cause of injury codes in more detail.

Defining extreme weather events

The Bureau of Meteorology defines extreme or severe weather as “potentially hazardous or dangerous weather that is not solely related to severe thunderstorms, tropical cyclones or bushfires” (BoM 2022a). In this report we have utilised administrative health and mortality datasets as well as BoM weather data, defining extreme weather or related natural hazards as extreme heat, extreme cold, rain or storms and bushfires.

In the ten years from 2012–13 to 2021–22, there were 9,119 hospitalisation records with evidence of extreme weather-related injury in Australia. From 2011–12 to 2020–21, there were 677 extreme weather-related injury deaths – an average of 68 per year (Table 1). Injury hospitalisations and deaths present underestimates of the burden of disease and public health impact of extreme weather (Cascio 2018).

Table 1: Hospitalisations for extreme weather-related injury and deaths over the past decade

Extreme weather event	Hospitalisations	Deaths
	2012-13 to 2021-22	2011-12 to 2020-21
Heat	7,104	293
Bushfire	894	65
Cold	773	242
Rain and storms	348	77
Total	**9,119**	**677**

Source: AIHW National Hospital Morbidity Database (NHMD) and AIHW National Morbidity Database (NMD).

Climate drivers

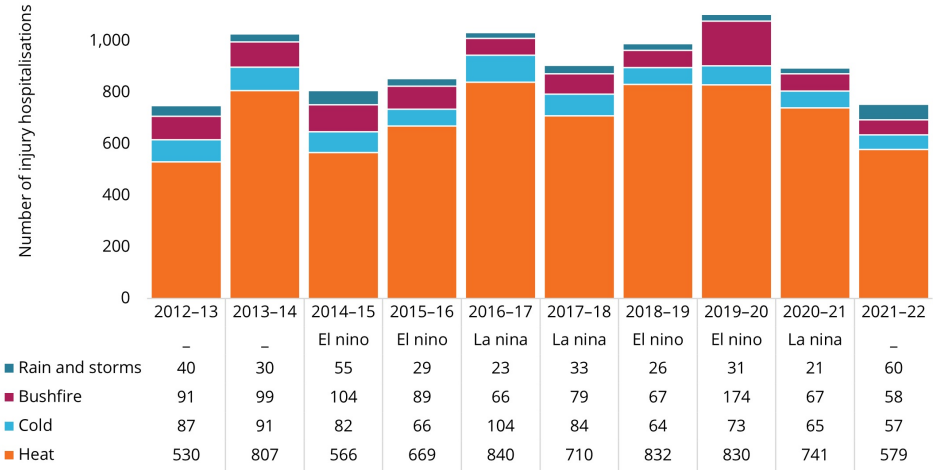
Hospitalisations and deaths from extreme weather-related injuries vary between years dependant on prevailing local conditions at the time. Local conditions are influenced by broader climate drivers such as the El Niño-Southern Oscillation (ENSO).

Total extreme weather-related hospitalisations are increasing over time and exceeded 1,000 cases three times in the ten years since 2012–13 (Figure 1, Figure 4).

Across all years, heat was by far the largest contributor to extreme weather-related injuries. Extreme heat can cause injuries both directly and by indirect effects on bushfires. The proportion of injury hospitalisations caused directly by extreme heat varied from 70% to 84% (Figure 1). Extreme heat also caused the most deaths, followed by cold weather.

Deaths directly attributable to bushfires and rain and storms are less common, accounting for only 1 in 5 extreme weather-related deaths (when combined). However, this may be dependent on the size and scale of the events – there was a 15-fold annual increase in bushfire-related deaths in 2019–20 as compared to 2018-19 (Figure 2). Deaths data relating to widespread flooding in 2022 was not available at time of reporting.

Figure 1: Extreme weather-related injury hospitalisations, 2012-13 to 2021-22

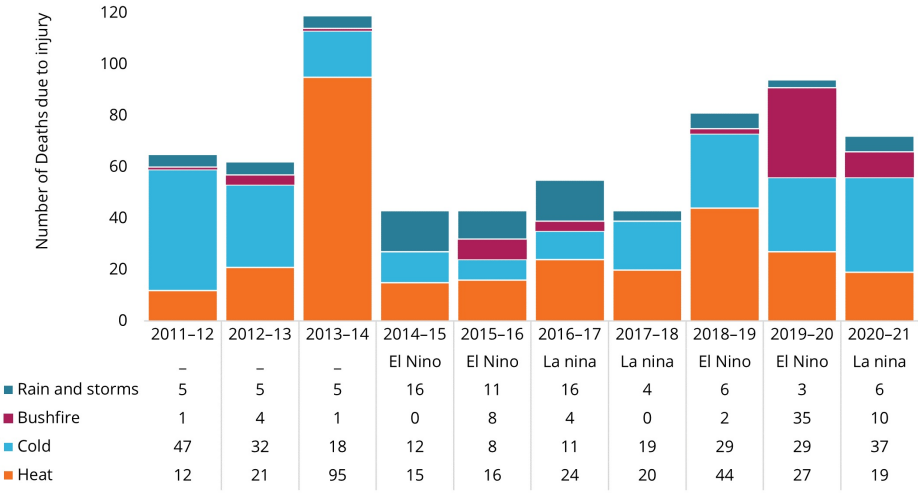


	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21	2021–22
	–	–	El nino	El nino	La nina	La nina	El nino	El nino	La nina	–
Rain and storms	40	30	55	29	23	33	26	31	21	60
Bushfire	91	99	104	89	66	79	67	174	67	58
Cold	87	91	82	66	104	84	64	73	65	57
Heat	530	807	566	669	840	710	832	830	741	579

Source: National Hospital Morbidity Database (NHMD)

For more information see Supplementary Data Table 1 (XLS 156KB)

Figure 2: Extreme weather-related injury deaths, 2011-12 to 2020-21



	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–20	2020–21
	–	–	–	El Nino	El Nino	La nina	La nina	El Nino	El Nino	La nina
Rain and storms	5	5	5	16	11	16	4	6	3	6
Bushfire	1	4	1	0	8	4	0	2	35	10
Cold	47	32	18	12	8	11	19	29	29	37
Heat	12	21	95	15	16	24	20	44	27	19

Source: National Hospital Mortality database (NMD)

For more information see Supplementary Data Table 6 (XLS 156KB)

An overview of extreme weather-related injuries

Australia's weather is influenced by many factors in both the long- and short-term. When considering annual variation, one of the largest drivers is the El Niño–Southern Oscillation (ENSO) cycle (BoM 2021, Figure 3). El Niño is driven by warmer water surface temperatures in the central eastern Pacific Ocean, while La Niña occurs when the water surface temperatures are higher in the western Pacific.

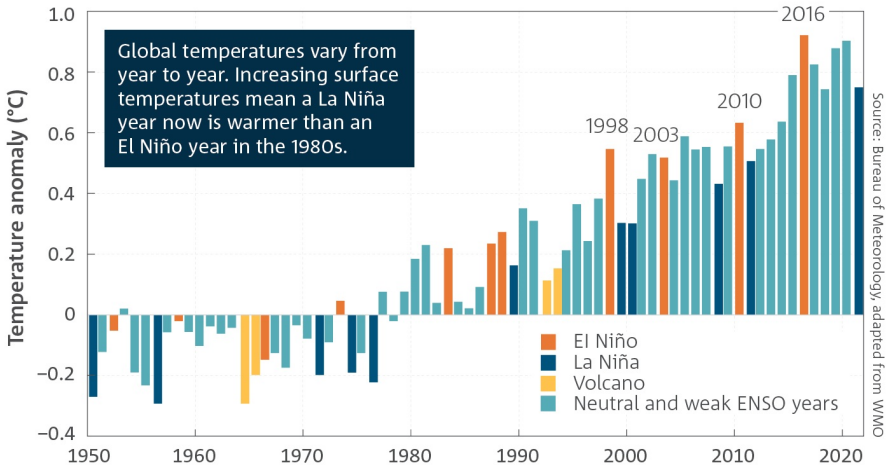
In Australia, El Niño drives a period of:

- Reduced rainfall
- Warmer temperatures
- Increased bushfire danger

While La Niña is associated with:

- Above average rainfall
- Cooler daytime temperatures
- Increased chance of tropical cyclones and flood events

Figure 3: Annual global surface temperature anomalies of the Earth (land and ocean), 1950–2021.



Source: BOM, State of the Climate 2022

Weather events leading to injury can occur under either phase of the ENSO cycle, however some are more likely under certain prevailing conditions.

On average, bushfire injuries occur 1.6 times as often in El Niño years (Table 2).

For more detail, see data table B1 (XLS 156KB)

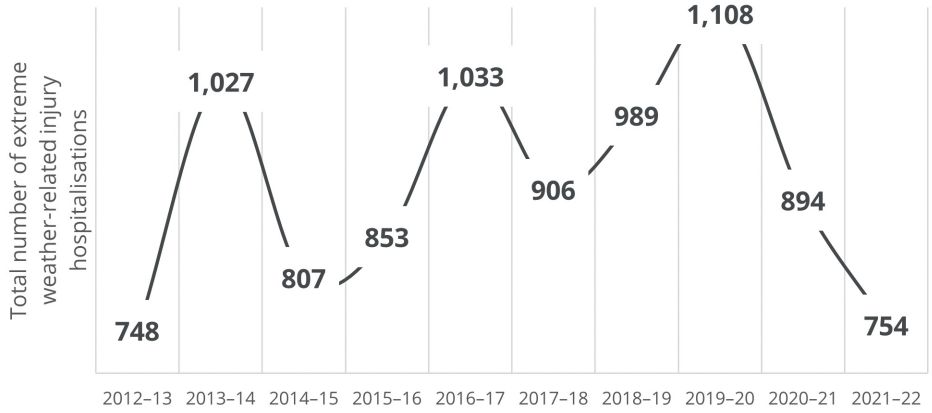
Table 2: Average annual extreme weather-related injury hospitalisations according to El Niño Southern Oscillation (ENSO) pattern, 2012–13 to 2021–22

	Heat	Cold	Bushfire	Rain and storms	Total
El Niño	724	71	108	35	938
La Niña	717	77	67	34	895
Ratio El Niño to La Niña	1.0	0.9	1.6	1.0	1.0

Source: AIHW National Hospital Morbidity Database (NHMD).

Total extreme weather-related injury hospitalisations are increasing over time, exceeding 1,000 cases three times in the ten years since 2012–13 (Figure 4).

Figure 4: Extreme weather- related injury hospitalisations are increasing and rose above 1,000 cases in 3 out of ten years over the past decade



For more information see Supplementary Data Table 1 (XLS 156KB)

References

Cascio W (2018) Wildland fire smoke and human health, Sci Total Environ 624:586-595 doi: 10.1016/j.scitotenv.2017.12.086.

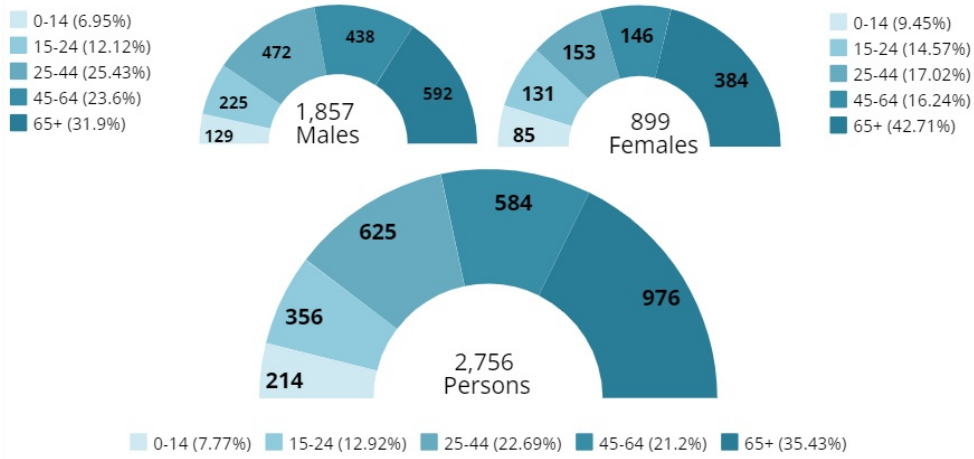
State of the Climate 2022: Bureau of Meteorology

An overview of extreme weather-related injuries

Males were hospitalised in two out of three (67%) extreme weather-related injury hospitalisations between 2019–20 and 2021–22. This is higher than the proportion of males in all injury hospitalisations, which was 54% (Injury in Australia).

Age increased injury hospitalisations – the highest numbers and proportions of cases hospitalised with extreme weather related injuries were aged 65 years or older (Figure 5).

Figure 5: Extreme weather-related injury hospitalisations by age and sex, Australia, 2019-20 to 2021-22

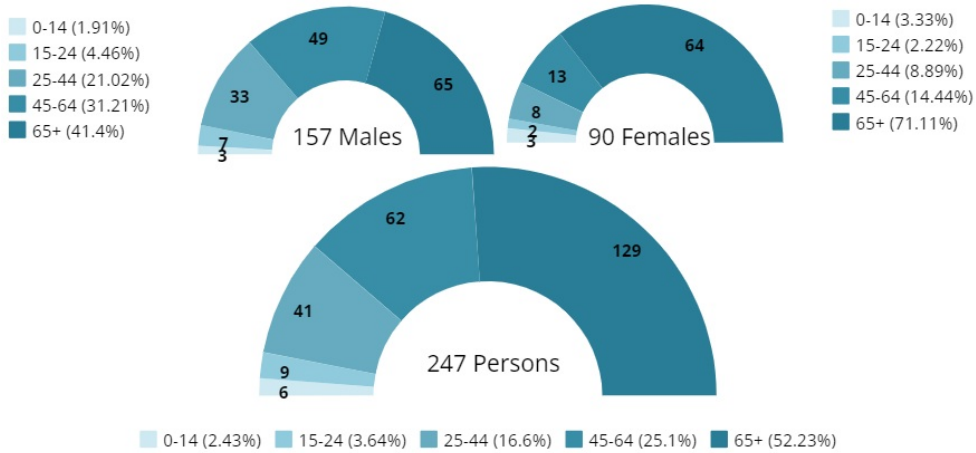


Source: National Hospital Morbidity database (NHMD)

For more information see Supplementary Data Table 2 (XLS 156KB)

About 3 in 5 (64%) extreme weather-related injury deaths between 2018–19 and 2020–21 were for males, similar to the proportion of males in injury deaths overall (Injury in Australia 2021-22). While deaths increased with age for both sexes, over three times the proportion of males aged 25-44 and 45-64 years died from extreme weather-related injuries as did females in comparable age groups (Figure 6).

Figure 6: Extreme weather-related injury deaths were predominantly among people aged 45 years and over, Australia 2018-19 to 2020-21



Source: National Hospital Morbidity database (NHMD)

For more information see Supplementary Data Table 7 (XLS 156KB)

An overview of extreme weather-related injuries

While anyone can be affected by extreme weather-related injuries, some population groups are more at risk than others – such as older people, children, people with disabilities, those with pre-existing or chronic health conditions, outdoor workers, and those with greater socioeconomic disadvantage. People in these groups may have reduced capacity to avoid or reduce the health impacts of extreme weather conditions, which can be described as thermal inequity.

Tanner et al. (2013) demonstrated that low income, poor-quality housing and fuel poverty (spending more than 10% of income on heating) are associated with adverse health and social outcomes related to cold weather. Exposure to and ability to cope with the risks of high temperatures is also subject to similar socioeconomic constraints (Byrne et al. 2016). Determinants of health, such as remoteness and socio-economic status also impact weather-related deaths and hospitalisations (Peden et al. 2023).

Outdoor workers are at increased risk of heatwave-related injury. Research on workers' compensation and heatwave data in South Australia from 2003–2013 found an increase in claims and work-related ambulance call-outs in low and moderately severe heatwaves. Male workers had a 13% increase in claims during moderate severity heatwaves and those with less than one year of work experience had a 31% increase in claims during moderately intense heatwaves (Varghese et al. 2018). Increased injury hospitalisations and deaths among males of working age may reflect the preponderance of males among professions that labour outdoors (Figure 5, Figure 6, Figure 8).

References

AIHW, Injury in Australia

Byrne J, Ambrey C, Portanger C, Lo A, Matthews T, Baker D and Davison A 2016. Could urban greening mitigate suburban thermal inequity?: the role of residents' dispositions and household practices. Environmental research letters, accessed 24 August 2022

Peden AE, Heslop D, Franklin RC. Weather-Related Fatalities in Australia between 2006 and 2019: Applying an Equity Lens. Sustainability. 2023; 15(1):813. https://doi.org/10.3390/su15010813

Tanner LM, Moffatt S, Milne E, Mills SDH and White M (2013) Socio-economic and behavioural risk factors for adverse winter health and social outcomes in economically developed countries: a systematic review of quantitative observational studies, Journal of Epidemiology and Community Health, 67(12): 1061–1067

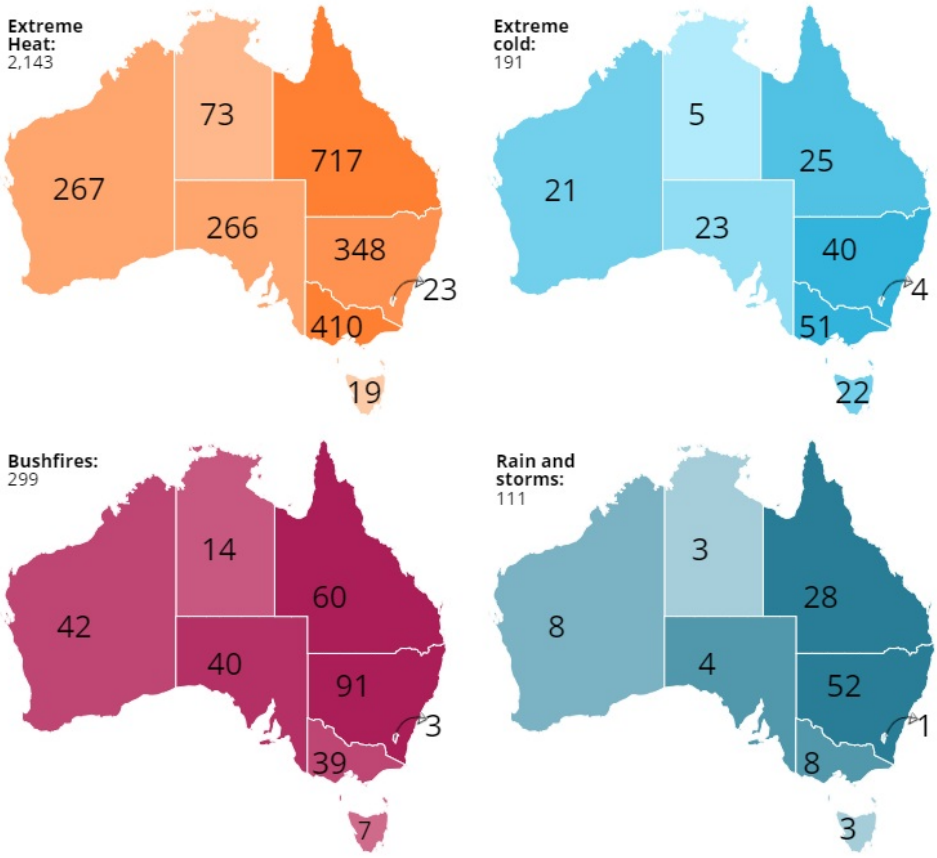
Varghese BM, Hansen A, Nitschke M, Nairn J, Hanson-Easey S, Bi P and Pisaniello D 2018,Heatwave and work-related injuries and illnesses in Adelaide, Australia: a case-crossover analysis using the Excess Heat Factor (EHF) as a universal heatwave index, International Archives of Occupational and Environmental Health, 92:262–272

An overview of extreme weather-related injuries

Specific extreme weather events vary geographically but in recent years Australia has seen large multi-state extreme weather events occur, such as the 2019-20 Black summer bushfires in Victoria, SA and NSW and the 2022 flooding across Queensland and NSW (BOM 2023). Multi-state, prolonged and sequential events can compound harm to human health and stretch available health and emergency management resources, further highlighting the need for cohesive national approaches to mitigate the effects of extreme weather conditions (MJA 2022).

Among people who had an extreme weather-related injury hospitalisation in 2019–20 to 2021–22, 1 in 3 usually lived in Queensland and almost 1 in 5 in Victoria (Figure 6). With the exception of Tasmania, exposure to excessive natural heat was the most common cause leading to injury hospitalisation for all states and territories.

Figure 7: Number of extreme weather-related injury hospitalisations, by state or territory of person's residence and type of extreme weather event or hazard, Australia, 2019–20 to 2021–22



Source: National Hospital Morbidity database (NHMD)

For more information see Supplementary Data Table 4 (XLS 156KB)

Extreme heat

Heat is the most frequent cause of extreme weather-related injury hospitalisations and deaths in Australia (Table 1).

Extreme heat often occurs in heatwaves, which the Australia's Bureau of Meteorology describes as three or more days of high maximum and minimum temperatures that are unusual for a given location (BoM 2022b).

How extreme heat affects injury

Exposure to prolonged or severe natural heat can result in physical conditions ranging from mild heat stroke symptoms to death (DEA 2016)
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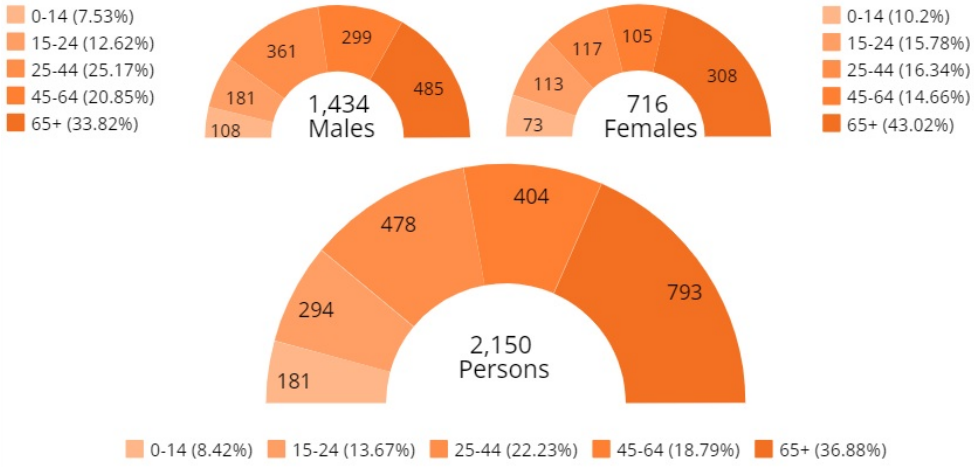
High temperatures are also linked to irritability, fatigue, and decreased performance, which can increase the risk of injury by impacting behaviour such as operating vehicles and power tools. There is evidence to suggests that higher daily temperatures are associated with an increased propensity for assault (Corcoran & Zahnow 2021). The risk of drowning deaths has also been shown to increase during heatwaves (Peden et al. 2023).

Heatwaves are Australia's most dangerous natural hazard in terms of loss of life (Coates et al. 2022; DAWE 2015). Heatwave-related deaths peak during severe El Niño years (Table 2). Since 2000, heatwave deaths in Australia have been concentrated in events that largely affected Victoria and South Australia (Coates et al. 2022).

Hospitalisations due to extreme heat by age and sex

For heat related injuries between 2019–20 and 2021–22, those aged 65 and over were the most commonly hospitalised followed by the 25–44 age group (Figure 6). Across age groups, males had higher numbers of heat related injury hospitalisations than females, but this difference was most notable among those aged 25-44 and 45-64 years, where over twice as many males were hospitalised due to extreme heat as were females.

Figure 8: Number of injury hospitalisations due to extreme heat by age and sex, Australia 2019-20 to 2021-22



Source: National Hospital Morbidity database (NHMD)

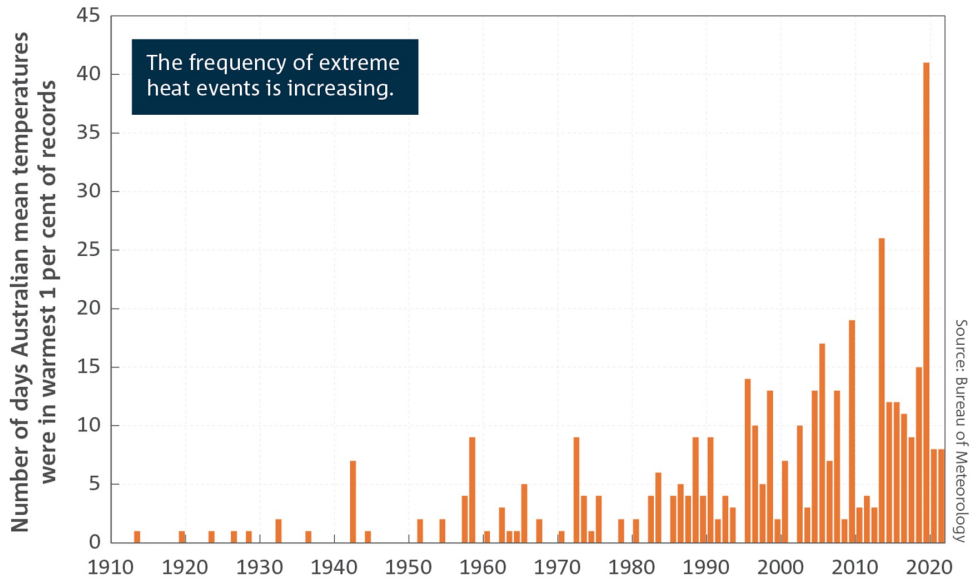
For more information see Supplementary Data Table 3 (XLS 156KB)

Trends in extreme heat

Of the weather events examined in this report, extreme heat has been responsible for the most injury hospitalisations over the last ten years across all states and territories, ranging from 5 to 10 times as many hospitalisations as the next most common extreme weather-related cause each year (Figure 1, Figure 2, Figure 8).

Extreme heat events are predicted to become more frequent, more intense and longer in duration (DEA 2016, BOM 2022).

Figure 9: The number of days with extreme heat are increasing across Australia over time



Source: BOM, State of the Climate 2022

Extreme heat

Some Australian governments have information systems which use administrative health system data to monitor heatwave-related health conditions, such as the Victorian Government's Heat Health Information Surveillance System (HHISS).

Between 14 and 17 January 2014, Victoria experienced the hottest 4-day period on record for the state (Department of Health Victoria, 2014). This resulted in a surge of health service use and deaths as compared to averages for the same week over the previous 3 years, including:

- a 25% increase in the Ambulance Victoria caseload in metropolitan Victoria and continuing higher than expected ambulance caseloads in days immediately following the heatwave.
- a 7% increase in all cause public hospital Emergency Department (ED) presentations. Among Victorians aged 75 years or older, this represented a 23% increase in ED presentations.
- 621 heat-related ED presentations, 5 times more than expected. 40% of these were in people aged 75 years or older.
- 858 deaths, an estimated 167 more than expected, representing a 24% increase in total mortality. In the Melbourne heatwave of early 2009 that preceded the Black Saturday bushfires, HHISS recorded 374 more deaths than would normally be expected at that time of year.
- 63 deaths prior to arrival at an ED and 27 deaths in ED.
- three times as many heat-related calls than expected to after-hours primary care services. 60% of these calls were related to heat exposure or injury.

For more information see The health impacts of the January 2014 heatwave in Victoria.

References

BoM (2022b) Understanding heatwaves, BoM, Australian Government, accessed 31 March 2022.

Coates L, van Leeuwen J, Browning S, Gissing A, Bratchell J and Avci A (2022) Heatwave fatalities in Australia, 2001–2018: An analysis of coronial records, International Journal of Disaster Risk Reduction, 67, doi: https://doi.org/10.1016/j.ijdrr.2021.102671.

Corcoran J & Zahnow R (2021) The effect of weather on assault. Environment and behaviour. Accessed 4 August 2022.

DAWE (Department of Agriculture, Water and Environment) (2015) National Climate Resilience and Adaptation Strategy 2015, DAWE, Australian Government, accessed 1 April 2022.

DEA (Doctors for the Environment Australia) (2016) Heatwaves and Health in Australia, DEA, accessed 31 March 2022.

DoH (Department of Health) (2014) The health impacts of the January 2014 heatwave in Victoria, State Government of Victoria, accessed 21 July 2023.

Peden AE, Mason HM, King JC, *et al*. Examining the relationship between heatwaves and fatal drowning: a case study from Queensland, Australia. *Injury Prevention* Published Online First: 07 September 2023. doi: 10.1136/ip-2023-044938.

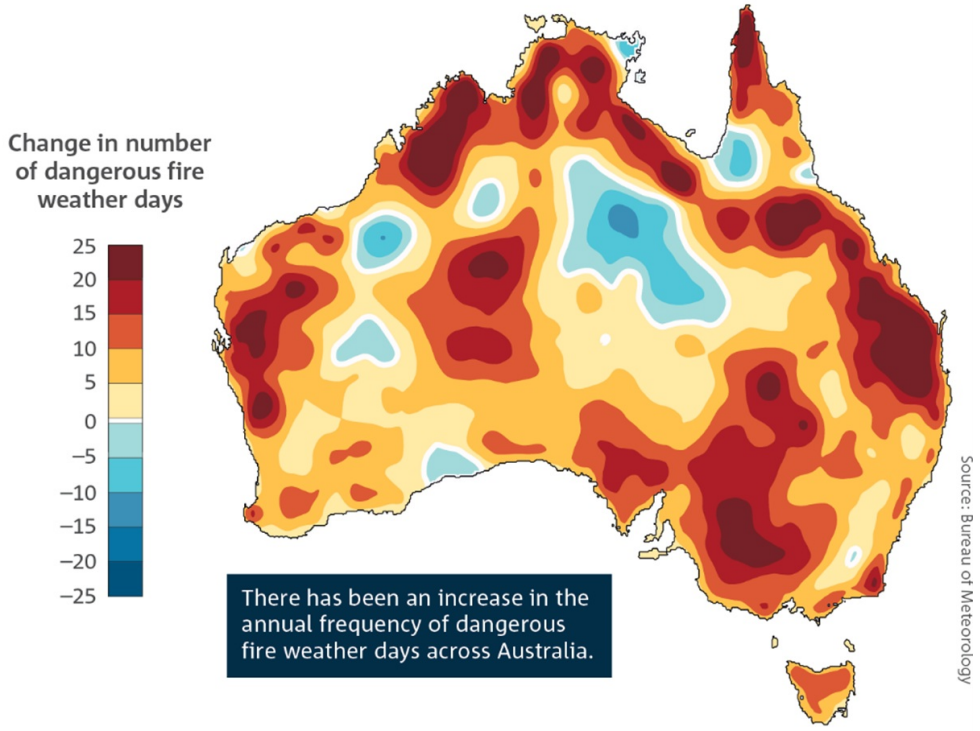
State of the Climate 2022: Bureau of Meteorology.

Bushfires

Australia is the most fire-prone country in the world and the risk of severe bushfires is increasing (Figure 10) (BOM 2022).

Weather-related factors (including high temperatures, low humidity, lack of recent rain, and strong winds) can contribute to increased risk of bushfire danger. Bushfires also require an ignition source, which can be either natural (such as a lightning strike) or human (such as discarded cigarettes, electrical faults, or deliberate ignition). Hence, bushfires frequently occur in conjunction with extreme weather events such as heatwaves, droughts, or storm activity such as lightning strikes and high winds.

Figure 10: The frequency of dangerous fire weather days has increased across Australia in the last century



Source: BOM, State of the Climate 2022

Bushfire-related injury hospitalisations and deaths peaked in 2019–20, an El Niño year (Figure 11, Figure 2). There was a 15-fold increase in bushfire-related deaths in 2019–20 as compared to 2018-19 (Figure 2).

The two most common injuries that result from bushfires are smoke inhalation and burns.

Smoke inhalation

Bushfire smoke inhalation leads to both acute and longer term health impacts (Rodney et al. 2021). Injury reporting counts acute hospitalisations and deaths, underestimating the overall health impacts of bushfires (AIHW 2020).

The smoke from bushfires comprises mainly water and gases, which condense on particles in the smoke. It forms clouds that subsequently contribute to various bushfire weather conditions such as strong winds, lightning and poor visibility (Da Silva 2020). These each contribute to the adversity of the environment, increasing the risk of injury from activities such as transport.

Carbon monoxide is found in smoke, formed from incomplete combustion. High concentrations of carbon monoxide bind to haemoglobin in the blood which can lead to asphyxiation and death (Da Silva 2020).

Burns

Burns in bushfires can result from radiant heat or ember attacks. More serious second- or third-degree burns are a risk with increasing fire intensity (DEA 2017).

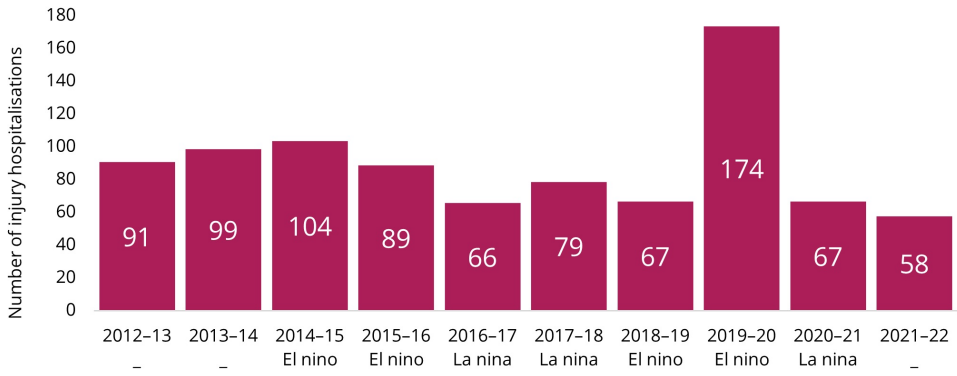
The AIHW compared hospitalisations for respiratory conditions and burns during the December 2019 to January 2020 bushfire period with data from previous years. The largest increase in the hospitalisation rate for respiratory conditions was 11% in the week beginning 5 January 2020, with 1,100 more hospitalisations than the previous 5-year average. Increases in burns also coincided with the 2019–20 bushfire activity. The greatest increase in burns totalled 30% above the previous 5-year average in the week beginning 15 December 2019, with 55 more hospitalisations (AIHW 2021).

Bushfires

2019-20 Bushfires

In 2019–20, the number of bushfire-related injuries increased by 61% from the previous reporting year, partially as a result of the NSW and Victorian summer bushfires (Figure 11).

Figure 11: Hospital admissions for bushfire-related injuries spiked in 2019-20 as a result of widespread fires



Source: National Hospital Morbidity Database (NHMD)
Bushfires are defined in this report as records where there was a principal diagnosis of T20 – T30 – Burns, T58 ¬– Toxic effect of carbon monoxide, T59.8 – Other specified gases, fumes, and vapours, AND there was an external cause of injury relating to bushfire or heat including X01 – Exposure to uncontrolled fire, not in building or structure, X30 – Exposure to excessive natural heat. This may differ from other AIHW reporting.

For more information see Supplementary Data Table 1 (XLS 156KB)

It is worth noting that injuries caused by exposure to excessive natural heat were also among their highest levels during this period– 830 in 2019–20 compared to a yearly average of 710 (Figure 1). This likely includes injuries occurring because of the extremely hot weather which contributed to the bushfires, if not directly due to the fires. The number of bushfire-related deaths was 15 times higher in 2019–20 as compared to 2018-19 (Figure 2).

References

Australian Institute of Health and Welfare (2021) Data update: Short-term health impacts of the 2019–20 Australian bushfires, AIHW, Australian Government, accessed 19 July 2023.

Australian Institute of Health and Welfare 2020. Australian bushfires 2019–20: Exploring the short-term health impacts. Cat. no. PHE 276. Canberra: AIHW.

Da Silva (2020), Bushfire smoke is everywhere in our cities. Here's exactly what you are inhaling, The Conversation, 15 January 2020.

DEA (Doctors for the Environment Australia) (2017) Bushfires and health in a changing environment, accessed 31 March 2022.

Rodney et al (2021) Physical and Mental Health Effects of Bushfire and Smoke in the Australian Capital Territory 2019–20, Frontiers in Public Health volume 9, 2021.

State of the Climate 2022: Bureau of Meteorology.

Rain and storms

348 injury hospitalisations and 77 deaths related to extreme rain or storms were identified in the 10-year periods analysed in this report (Figure 1, Figure 2).

Rain and storm events are often interrelated. They include thunderstorms, cyclones and heavy or prolonged rainfall, which can lead to flooding and landslides.

More frequent intense rainfall events increase the risk of floods in urban areas owing to large areas of non-permeable surfaces. In less urban areas, extreme multi-day rainfall is usually needed to cause flooding.

Intense or prolonged rainfall, floods and storms can cause the following types of acute injuries (CDC 2020; Healthy WA 2022):

- drowning
- falls due to more slippery surfaces or increased trip hazards
- contact with objects such as floating debris, submerged objects, trees or wind-borne objects (Way & Balogh 2022)
- bites and stings from displaced animals such as snakes
- burns, cardiac arrest, and respiratory complications resulting from lightning strikes
- exposure to electric current if powerlines or electronic devices are water-affected
- injuries caused by transport-related accidents, including on land or water.

While further injuries may occur subsequent to displacement, clean up activity and environmental upheaval caused by severe rains or storms, they are challenging to identify within administrative hospital and mortality datasets.

Peden et al. (2017) studied flood events in Australia finding that drowning is the leading cause of death in floods. Between 2002 to 2012, there were 129 (0.6 per 100,000 people) drowning deaths involving river flooding. Males, children, and people living in remote and very remote locations are at increased risk.

Severe flash flooding in Queensland in 2011–12 led to the deaths of 33 people.

In Australia from 2001–2017 there were 96 vehicle-related flood fatalities, which represented 50% of deaths related to flooding. Vehicle-related flood fatalities occurred mostly in NSW and Queensland, and demonstrate a seasonal peak in January. 87% occurred on creek crossings, bridges or causeways (Ahmed 2020).

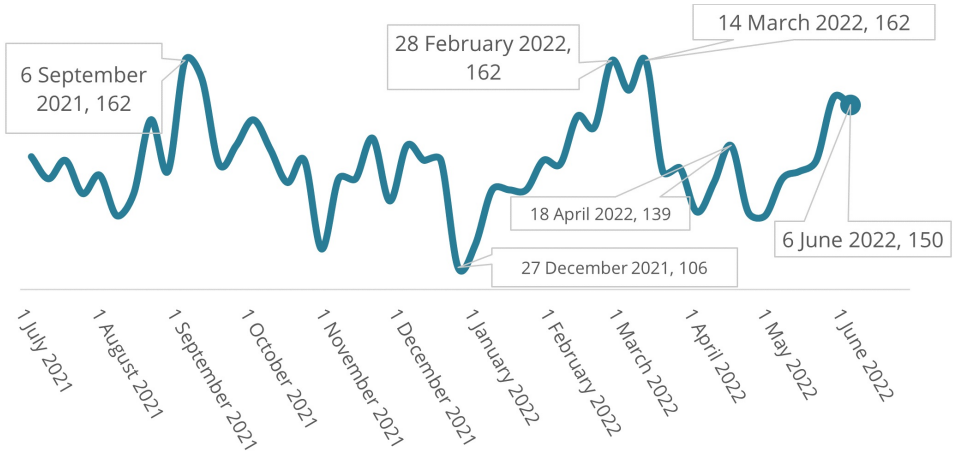
2022 Flooding in Eastern Australia

In 2021–22, there were 60 rain and storm-related injury hospitalisations, which is:

- the highest number for any year out of the 10 years examined
- 3 times the number in the previous year, and 1.9 times the yearly average over the 9 years before.

The Northern Rivers region of New South Wales was one of the areas hit hardest by the 2022 floods. By looking at total week-to-week injury admissions to hospitals within the affected area, we can identify an increase in admissions for the 3-week period in which flood levels peaked (Figure 12). Deaths data relating to widespread flooding in 2022 was not available at time of reporting.

Figure 12: Number of hospital admissions for injuries in the Northern Rivers region spiked during major flood events



Notes:
Data is presented by week of admission, from July 2021 to June 2022, from hospitals within the Northern Rivers region of NSW.
Source: AIHW National Hospital Morbidity Database.

Road conditions

Rowland et al. (2007) outlined how poor weather conditions increase road transport accidents, for example:

- Rainfall, storms, snow and ice can reduce visibility and road friction
- Rain following a dry spell can create slippery road surfaces due to a preceding build-up of oil and grime
- Storms and floods may damage road infrastructure.

Transport accidents are often multifactorial and determining causes can be challenging. Other than road conditions, factors that can contribute to a crash include fatigue, speed, phone use or consumption of alcohol or drugs. Rowland et al. (2007) reported that rain and wet roads contributed to (but were not the only factor in) 15% of road deaths nationally (2004), 20% of road deaths in New South Wales (2005), and 16% in Victoria (2001–2005).

Across three states during 2016-2020, considering run-off road crashes with casualties (BITRE, 2022):

- more than 10% occurred when it was raining
- around 20% occurred on wet or slippery roads

Information published by Transport for NSW (2021) indicates that the number of road accidents in NSW where it was raining or overcast or where the road surface was slippery have increased since 2019, while the overall number of accidents has decreased.

References

Ahmed MA, Haynes K and Taylor M (2020) Vehicle-related flood fatalities in Australia 2001-2017, Journal of Flood Risk Management, 13(3).

Bureau of Infrastructure and Transport Research Economics (BITRE) (2022). Run-off road crashes in Australia, Information Sheet 112, BITRE, Canberra.

CDC (Centres for Disease Control and Prevention) (2020) Natural Disasters and Severe Weather, CDC, USA Government, accessed 5 April 2022.

Healthy WA (2022) Recovering after the flood – clean-up for householders, Department of Health, Government of Western Australia, accessed 5 April 2022. https://www.healthywa.wa.gov.au/Articles/N_R/Recovering-after-the-flood-clean-up-information-for-householders.

Peden AE, Franklin RC, Leggat P and Aitken P (2017) Causal Pathways of Flood Related River Drowning Deaths in Australia, PLOS Currents Disasters, 1:1–24.

Rowland B, Davey J, Freeman J and Wishart D (2007) Road transport sensitivities to weather and climate change in Australia: A review of climate change effects, 30th Australasian Transport Research Forum.

Transport for NSW (2023) Road users by behavioural factors in crashes.

Way TL and Balogh ZJ (2022) The epidemiology of injuries related to falling trees and tree branches, ANZ Journal of Surgery, 92(3): 477–480.

Extreme cold

While cold weather conditions in Australia are generally not as extreme or prolonged as in other parts of the world, exposure to cold conditions is often the second most common extreme weather-related cause of death in a given year, after extreme heat (Table 1, Figure 2).

Deaths from injury due to extreme cold have risen gradually from 8 in 2015–16 to 29 in 2018–19 and 37 in 2020–21 (Figure 2). Research indicates people aged 65 years and older, and residents of major cities are at greater risk of death due to extreme cold (Peden et al.2023).

Exposure to extreme cold can lead to conditions including hypothermia and frostbite.

Hypothermia is when the body temperature (normally 37°C) drops below 35°C. A body temperature below 32°C is life threatening.

Hypothermia can occur due to exposure to air temperatures under 10°C or water temperatures under 20°C. Generally older people, children, people with conditions affecting circulation, people who are thin or with little body fat, outdoor workers or homeless people are more vulnerable to hypothermia (NSW Health 2022a).

Frostbite occurs after prolonged exposure to cold weather and extremely low temperatures; cold wind can exacerbate its progression. Frostbite can progress from symptoms of pain and loss of feeling, to severe situations where tissue dies and the treatment includes amputation.

For more information see Supplementary Data Table 6 (XLS 156KB)

References

NSW Health (2022a) Hypothermia, NSW Health, NSW Government, accessed 4 April 2022.

Peden AE, Heslop D, Franklin RC. Weather-Related Fatalities in Australia between 2006 and 2019: Applying an Equity Lens. Sustainability. 2023; 15(1):813. https://doi.org/10.3390/su15010813.

Opportunities for weather-related injury surveillance

There are no routinely published national-level data on weather-related injuries in Australia. The most viable existing sources that contain both injury and external cause data are hospitalisations data from the NHMD and deaths data from the NMD and National Coronial Information System (NCIS). However, there are limitations in associating injury and weather events (as outlined in the limitations discussion)

Improve existing data sources

Research to estimate the robustness of the NHMD and NMD would help validate these data sets as reliable sources of information on weather-related injuries. One way to validate NMD data would be to analyse it in conjunction with NCIS data. Access to standardised emergency management system datasets across regions (for example, ambulance call outs) and increased coded (rather than free text) emergency response data collection would provide valuable acute information related to natural hazards and associated health system responses.

Improving national ED data

External cause data is fundamental for understanding the causes and circumstances of over 2 million injury presentations in emergency departments (EDs) each year (AIHW 2022a). Jurisdictions do collect information about the external cause and circumstances of injury, but there is no national standard for this. One option for improving the National Non-Admitted Patient Emergency Department Care Database (NNAPEDCD) would be for the AIHW to create a pilot national best-endeavours (non-mandatory) data set add-on to the NNAPEDCD for injury cases.

Below are two examples, from Victoria and South Australia, on how jurisdictions collect weather-related injury data from EDs. Investment in national ED data improvement is needed to develop a useful national data source for injury reporting not only on weather-related injuries, but for all injury reporting.

Victorian Emergency Minimum Dataset

The Victorian Emergency Minimum Dataset (VEMD) contains the same data items as the NNAPEDCD as well as information on injury intent (unintentional, intentional, undetermined), cause (for example fall, poisoning), place of occurrence, activity (for example sport, work), body region and description of the injury event (as open text field) (VISU 2022). The inclusion of external cause information provides the potential to identify weather-related injury records in the VEMD.

South Australia Emergency Department Data Collection

South Australia's Non-Admitted Emergency Care (NAEC) data set contains information on patients presenting to EDs in public hospitals. The NAEC data set includes a non-mandatory data item where a heat-related condition can be flagged and defined as 'heat exhaustion', 'heat stroke' or 'other'. Staff can also enter further free-text information into the system.

Implementing real time surveillance systems

Real time data on weather events should be incorporated into surveillance systems at local levels to trigger system response alerts within the health system when injury presentations depart from the usual patterns.

Data linkage

Data linkage is another way to improve what we know about weather-related injury, either by using existing data linkage assets such as the Australian Institute of Health and Welfare (AIHW) National Integrated Health Services Information (NIHSI), Australian Bureau of Statistics (ABS) Multi-Agency Data Integration Project (MADIP, to be renamed Person-Level Integrated Data Asset, PLIDA) or by creating new linked data sets. For example, it would be possible to investigate topics such as:

- how many weather-related hospitalisations were immediately preceded by an emergency department presentation.
- how many deaths occur within a certain period following weather-related hospitalisations.
- what were the Medicare Benefits Schedule (MBS) and Pharmaceutical Benefits Schedule (PBS) utilisation patterns like for people who had been hospitalised for a weather-related injury. From this, linked data could be used for generating health service cost estimates.
- Linking Bureau of Meteorology data such as minimum and maximum temperatures and rainfall by location to usual place of residence in the NHMD and NMD would enable easier routine analysis of local weather around the time of a hospitalisation or death, bearing in mind that the area and time of the injury event will not always match up with usual place of residence. This type of analysis would result in potential correlations between some weather conditions and injury rates.

Using linked data can overcome some but not all the technical limitations of the component data sets.

Creating new linked data assets requires time, cooperative effort between data providers, and high levels of governance if there are data privacy issues to manage.

References

AIHW (2022a) Emergency department care, AIHW: Canberra.

Limitations in ascribing injuries to weather

When trying to identify a relationship between injury and weather patterns, the available data present a range of challenges.

Data fragmentation

In Australia, several agencies produce data relevant to weather-related injuries. Each agency has a different purpose and produces reports relating to its own remit.

The Bureau of Meteorology (BOM) does not produce data on injuries but provides weather forecasts, warnings and data that can be used to identify areas at risk. There are a range of organisations focused on specific injury mechanisms that collate data on deaths and injuries, but these are not routinely linked to indicators of extreme weather involvement.

The Australian Institute of Health and Welfare (AIHW) collects and analyses data on a wide range of health-related issues, including injury hospitalisations and deaths caused by severe weather events. It currently does not have access to consolidated data assets enabling analyses of injuries in the primary care or emergency management sectors.

NHMD data captures admitted hospital patients only. It is likely that only a small proportion of weather-related injuries lead to a stay in hospital, and these are typically more severe injuries. The data do not include information on people who sought treatment in the ED, general practices, outpatient settings or pharmacies.

The National Coronial Information System (NCIS) also provides data on deaths, including those caused by severe weather events such as heatwaves, storms, and floods.

The reports produced by these agencies are often using data that is collected by other organisations at the national and state levels, making it difficult to obtain a comprehensive picture of the problem. Additionally, some types of weather-related injuries, such as those caused by floods or landslides, may be underreported due to a lack of specific data collection efforts.

The use of data collected for other primary purposes

Administrative health datasets under-estimate the occurrence of weather-related injuries for the following reasons:

- limitations of ICD-10 external cause codes in capturing all weather-related injury hospitalisations (for example no transport accidents appeared in the results – this is discussed below).
- use of NMD data without comparison to NCIS data which can provide a more detailed picture of circumstances surrounding a death.
- the likelihood of there being cases where weather contributed to the injury, but where this was not reported by the patient, and/or not recorded in clinical notes or coded in the patient record.
- there is no standardised way to capture the level of contribution of a weather event to a diagnosis.

They may over-estimate the occurrence of some weather-related injuries because some codes include, alongside weather-related injuries, some injuries that may not have been weather-related, such as, for example, injuries caused by non-bush fires or hypothermia caused by sustained contact with a cold environment such as the ocean.

Available codes are not specific to weather-related events

The relative contributions of different types of weather to the data presented may in part reflect the available ICD-10 codes (methodological bias). For example, the fact that heat is the most frequent weather event may be due, in part, to heat being easier to record using the available codes. Available data do not allow for examination of transport injury hospitalisations with a weather-related external cause code. This is because there is no suitable ICD-10-AM code to indicate the involvement of weather in a transport injury.

Case type category for weather-related deaths

Typically, a doctor certifies deaths due to natural causes and a coronial investigation is not required. Deaths due to natural causes (for example, chronic condition exacerbation from a heatwave) are types of deaths that may not result in coronial investigation. Therefore, the NCIS is not suitable as a standalone data source for weather-related deaths.

Separation between weather and injury event data

Weather data and injury data are stored in separate databases. Weather conditions are linked to the location of events such as bushfires, droughts, floods, heatwaves, severe thunderstorms and cyclones. However, injury data are not explicitly linked to weather events.

Further, within health datasets, diagnosis and servicing information may be separate (e.g. the NHMD and the MBS/PBS datasets).

Confounding effects of adaptation

This analysis does not account for injury prevention or risk-reduction behaviour. For example, if weather-related injury numbers are higher in 2017–18 compared to 2018–19, it does not necessarily mean the weather was less extreme in 2018–19. Instead, this could be due to:

- the effectiveness of injury prevention initiatives.

- behavioural responses such as forgoing or rescheduling activities that were inappropriate for the weather conditions.

Causation and correlation

The extreme weather event-based approach enables health care data sets that contain no weather-related information to be used if time and place of injury information can be matched with the time and place of an extreme weather event. It is difficult to attribute causation of the injury directly to weather events using this approach, but it is possible to establish correlation. The secondary effects of extreme weather also need to be accounted for. For example, injuries may be sustained during clean-up operations undertaken due to the effects of adverse weather events, or existing health conditions may be exacerbated by extreme weather events hampering access to health care.

Dataset size and granularity

Bureau of Meteorology data are fine-grained, with thousands of data points collected daily. The data are available on demand with no privacy restrictions, however the size of the national dataset, combined with health service data may pose issues relating to the computing power and processing time required to run such analyses.

Data quality

Statistical analysis of NHMD and NMD data is a secondary use. As such, some data are missing or limited due to data quality issues, in particular, activity and place-of-occurrence data.

In 2021–22 data, 66% of NHMD injury cases have a missing or unspecified value for activity at the time of injury, and 39% have a missing or unspecified value for place of occurrence. This may be because the information was not reported by the patient, and/or the information was not recorded in the clinical notes or the information was not coded into the hospital record.

There are similar data quality issues with these data items in the NMD. The NMD only contains summary data on the cause of injury deaths in terms of ICD-10 cause-of-death codes. More detailed information is available on the circumstances and causes of most injury deaths from the National Coronial Information System.

The NNAPEDCD covers ED presentations at public hospitals, but diagnosis information may be incomplete where a definitive diagnosis is not possible within the ED episode of care (for example, where further diagnostic tests are needed), and it does not include any information on the external cause or circumstances of the injury event. Therefore, no weather-related information is included in the data set.

Technical notes

Defining extreme weather events

The Bureau of Meteorology defines extreme or severe weather as "potentially hazardous or dangerous weather that is not solely related to severe thunderstorms, tropical cyclones or bushfires" (BoM 2022a). In this report we have utilised administrative health and mortality datasets as well as BoM weather data, defining extreme weather or related natural hazards as extreme heat, extreme cold, rain or storms and bushfires.

Data sources

Table 4 summarises the extent to which weather-related injuries can be identified in existing individual national data sources.

Other existing data sets with the potential to contribute to the weather-related injury knowledge base include:

- transport databases
- drowning databases
- workplace compensation claim data
- Medicare Benefits Schedule (MBS) and Pharmaceutical Benefits Scheme (PBS) data
- Ambulance and other emergency management services datasets

Most of these do not include weather-related information but could be of use within a weather-event based approach to analysis. Some of these data sets do not include injury information either (for example, MBS and PBS data) but could provide supporting context where there has been an extreme weather event.

Table 4: National data sources with injury and/or weather-related information

Data source	Injury information included	Weather-related information included	Temporal data included	Location data included
Hospitalisation data: AIHW National Hospital Morbidity Database	Type of injury (for example, fracture of femur) External cause of injury (for example, fall on same level) Limited information on activity being conducted at time of injury may be included (for example, playing basketball, working for income) Limited place of occurrence information may be included (for example, home, school, roadway)	External cause of injury may broadly specify a weather event (for example, storm)	Date of hospitalisation Note: date of injury event is not included	Area of person's usual residence (using ABS Statistical Area Level 2 (SA2) categories) Hospital location Note: place of injury event is not included
Deaths data: AIHW National Mortality Database	Type of injury External cause Information on activity and place of occurrence has data quality issues.	External cause of injury may broadly specify a weather event	Date of death Note: date of injury event is not included	Area of person's usual residence (SA 2) State of registration of the death Note: place of injury event is not included

Deaths data: National Coronial Information System (NCIS)	Mechanism of injury Object or substance producing injury Activity being conducted at time of incident Cause of death Police narrative of circumstances, autopsy report, toxicology report, and coroner's findings	Mechanism of injury or object may broadly specify weather events	Date and time of death Date and time of incident Date and time body found Date and time person last known alive	Place of person's usual residence (at SA2 level and street level) Location where body was found Location of death Location of incident Location where person was last known alive
Bureau of Meteorology: Weather data	None	Extensive records on rainfall, temperature, humidity, evaporation, wind, sunshine, cyclones, and thunderstorms which inform data systems on specific climate-related hazards. BOM also publishes the State of the Climate report and multiple tools such as the Heatwave Service for Australia.	Data may be recorded multiple times a day	Data is available from over 7,000 weather stations across the country which take daily measurements. Meteorological conditions are linked to location of events such as bushfires, droughts, floods, heatwaves, severe thunderstorms and cyclones.
Emergency department data: AIHW National Non-Admitted Patient Emergency Department Care Database	Injury diagnosis information is available (for example, concussion), but external cause of injury is not included for most jurisdictions	None currently. A connection to weather would need to be made by matching time and place information with the time and place of a weather-specific event	Date and time of ED presentation	Area of person's usual residence (SA2) Hospital location Note: place of injury event is not included for most jurisdictions
Bureau of Infrastructure, Transport Research Economics Data: Australian Road Deaths Database and the National Crash Database	Some road transport deaths and hospitalisations are identified. No information on the injury is included.	Some states record whether it was raining at the time of the crash.	Time, day of the week, month and year. Date is not included.	Location of injury event (ABS SA4) and local government area
Safe Work Australia Data: National Dataset for Compensation-based Statistics	Nature of injury, body location and mechanism	Type of occurrence classification may broadly specify weather events and environmental factors	The date of report to employer, date of claim, first day off work and first day back at work. No time of incident information is provided	State or territory of the injury event. Postcode of residence and of workplace

Inclusion criteria

Hospitalisations

National hospital separations data were sourced from the Australian Institute of Health and Welfare (AIHW) National Hospital Morbidity Database (NHMD).

Please refer to the technical notes for Injury in Australia for more detail.

Weather-related ICD code inclusion criteria for hospitalisations

Temperature extremes – heatwaves:

Records were included when there was a principal diagnosis of:

E86 – Volume depletion

L55 – Sunburn

L56 – Other acute skin changes to ultraviolet radiation

P74.1 – Dehydration of newborn

T67– Effects of heat and light

T79.4 – Traumatic shock (including shock (immediate)(delayed) following injury) (including dehydration with shock)

And there was an external cause of injury relating to heat:

X30 – Exposure to excessive natural heat

X32 – Exposure to sunlight

Temperature extremes – excessive cold:

Records were included when there was a principal diagnosis of:

T33–T35 – Frostbite

T68 – Hypothermia

T69 – Other effects of reduced temperature

And there was an external cause of injury relating to excessive cold:

X31 – Exposure to excessive natural cold

Rain- and storm-related injuries:

Records were included when there was a principal diagnosis of:

S00 – T75, T79 – Injury, poisoning and certain other consequences of external causes

And there was an external cause of injury relating to rain and storms:

X33 – Victim of lightning

X36 – Victim of avalanche landslide and other earth movements

X37 – Victim of cataclysmic storm

X38 – Victim of flood

Bushfires:

Records were included when there was a principal diagnosis of:

T20 – T30 – *Burns*

T58 – *Toxic effect of carbon monoxide*

T59.8 – *Other specified gases, fumes, and vapours*

And there was an external cause of injury relating to bushfire or heat:

X01 – Exposure to uncontrolled fire, not in building or structure

X30 – Exposure to excessive natural heat

Note: ICD-10-AM classifications experts were consulted in the compilation of this list. X00 – Exposure to uncontrolled fire, in building or structure was intentionally not included, based on advice received.

Deaths

Please refer to the technical notes for injury in Australia for our standard case ascertainment criteria.

Death data are commonly recorded according to the calendar year in which the death was registered. However, in this report data are presented according to the financial year in which each death occurred, because:

- presenting data by year of occurrence is more meaningful than by year of registration, because some cases are registered much later than when the death occurred (sometimes years later).
- reporting by financial year aligns with AIHW reports on injury morbidity, enabling deaths and hospitalisations to be presented for the same period.

The sum of the counts of death by cause may be greater than the total number of injury deaths because some deaths have multiple causes.

The *'Persons'* total includes deaths for which sex was not reported. All age totals include deaths where age is not reported.

Outlined below are the ICD-10 codes included in the analysis in Chapter 3 (WHO 2019).

Weather-related inclusion for deaths

Temperature extremes - heatwaves:

Records were included for preliminary analysis when there was:

an UCoD of Exposure to excessive natural heat or Exposure to sunlight (X30, X32) or

a MCoD of Exposure to excessive natural heat or Exposure to sunlight (X30, X32) and an injury-related cause of death (S00-T75; T79).

Temperature extremes - cold:

Records were included for preliminary analysis when there was: an UCoD of Exposure to excessive natural cold (X31) or

a MCoD of Exposure to excessive natural cold (X31) and an injury-related cause of death (S00-T75; T79).

Rain and storm-related injuries:

Records were included for preliminary analysis when there was:

an UCoD of Victim of lightning or Victim of avalanche, landslide and other earth movements or Victim of cataclysmic storm or Victim of flood (X33, X36–X38) or

a MCoD of Victim of lightning or Victim of avalanche, landslide and other earth movements or Victim of cataclysmic storm or Victim of flood (X33, X36–X38) and an injury-related cause of death (S00-T75; T79).

Bushfires:

Records were included for preliminary analysis when there was:

an UCoD of Exposure to uncontrolled fire, not in building or structure (X01) or

a MCoD of Exposure to uncontrolled fire, not in building or structure (X01) and an injury-related cause of death (S00-T75; T79).

Defining and counting injury in this report

Some of the ICD10 and external cause coding combinations outlined above could apply to injuries sustained during 'normal' weather conditions when combined with inappropriate behaviour or unintended exposure. For example, it is possible to sustain hypothermia due to exposure to cold water in a situation such as falling into the water from a boat.

The codes for bushfires given would also apply to types of outdoor fires other than bushfires, such as an injury from a briefly uncontained campfire. It is not possible to distinguish bushfire-related from other injuries within these codes.

State and territory

State and territory data are based on the state of usual residence of the case. The exception to this is the analysis of hospitalisations in the Northern Rivers region of NSW during 2021-2022, which is based on state of establishment.

Approaches to linking an injury event with weather conditions

With the data currently available in Australia, there are three approaches to linking an injury event with weather conditions. This report takes an injury-based approach.

1. An injury-based approach, where injuries with explicitly weather-related diagnoses or external causes are identified in health care, workers' compensation and deaths databases. Health care providers record the involvement of weather in an injury event.
2. A weather event-based approach, where significant weather events are identified and health care and deaths databases are investigated for any trends or changes in injury data at the time period and location of the weather event.
3. Burden-of-disease methodology uses modelling to attribute injuries to weather-related exposures. The Australian Burden of Disease Study currently attributes injuries like those due to fire, burns and scalds to the risk factors of occupational exposures and hazards, and alcohol use. Work is currently underway to develop this methodology in regard to heat-related workplace injuries. This indirect method requires sufficient evidence of a causal association between exposure and health outcomes from high-quality epidemiological studies and to meet a number of criteria to enable estimation and inclusion in the Australian Burden of Disease Study (AIHW 2022).

References

Australian Institute of Health and Welfare (2022) *Australian Burden of Disease Study 2022*, AIHW, Australian Government, accessed 19 July 2023.

Bureau of Meteorology (2022) *Severe weather hazards*, BoM, Australia Government, accessed 10 July 2023.

WHO (World Health Organization) (2019) *The international statistical classification of diseases and related health problems, 10th revision (ICD-10)*, Geneva: WHO, accessed 12 May 2022.

Glossary

Injury – Glossary

Abbreviations

ABS	Australian Bureau of Statistics
ACCD	Australians Consortium for Classification Development
AIHW	Australian Institute of Health and Welfare
ARDD	Australian Road Deaths Database
BITRE	Bureau of Infrastructure and Transport Research Economics
DALY	Disability Adjusted Life Years
DAWE	Department of Agriculture, Water and Environment
ED	Emergency Department
EDDC	Emergency Department Data Collection
EHF	Excess Heat Factor
HHISS	Heat Health Information Surveillance System
ICD	International Classification of Disease and Related Health Problems
IPCC	International Panel on Climate Change
MBS	Medicare Benefits Scheme
MCoD	Multiple Cause of Death
NAEC	Non-Admitted Emergency Care
NCD	National Crash Database
NCIS	National Coronial Information System
NDS	National Dataset for Compensation-based Statistics
NHISI AA	National Integrated Health Services Information Analysis Asset
NHMD	National Hospital Morbidity Database
NMD	National Mortality Database
NNAPEDCD	National Non-Admitted Patient Emergency Department Care Database
NSW	New South Wales
PBS	Pharmaceutical Benefits Scheme
POLAR	Population Level Analysis and Reporting
QLD	Queensland
SNOMED-CT	Systematized Nomenclature of Medicine-Clinical Terms
SWA	Safe Work Australia
UCoD	Underlying Cause of Death
VEMD	Victorian Emergency Minimum Dataset
WHO	World Health Organization

Notes

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