Increased ratio of summer to winter deaths due to climate warming in Australia, 1968–2018

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Abstract

Objective: To determine if global warming has changed the balance of summer and winter deaths in Australia.

Methods: Counts of summer and winter cause-specific deaths of subjects aged 55 and over for the years 1968–2018 were entered into a Poisson time-series regression. Analysis was stratified by states and territories of Australia, by sex, age and cause of death (respiratory, cardiovascular, and renal diseases). The warmest and coldest subsets of seasons were compared.

Results: Warming over 51 years was associated with a long-term increase in the ratio of summer to winter mortality from 0.73 in the summer of 1969 to 0.83 in the summer of 2018. The increase occurred faster in years that were warmer than average.

Conclusions: Mortality in the warmest and coldest times of the year is converging as annual average temperatures rise.

Implications for public health: If climate change continues, deaths in the hottest months will come to dominate the burden of mortality in Australia.

Key words: season, extreme weather, climate change, time-series model, mortality ratio

The health impacts of rising temperatures are of increasing concern as climate change progresses. Heatwaves have been associated with increased mortality in multiple studies.[1,2] But little is known of the effects of long-term climate warming-derived increases in temperatures throughout the year.

In Australia, and in many other countries, winter mortality rates are generally higher than those in summer, but surges in mortality are a common consequence of heatwaves, particularly in populations with socioeconomic vulnerabilities, and although less dramatic, most deaths due to heat actually occur outside heatwaves.[2]

An increasing ratio of summer to winter mortality up to 2007 in Australia was previously reported by Bennett et al. (2013),[3] yet it is unknown whether this pattern extended through the recent decade, which was the hottest in the country's recorded history. We drew on a half-century of high-quality climate and health data, 1968–2018, to examine whether long-term increases in Australian temperatures have led to fewer deaths in winter relative to summer.

Methods

Mortality data were obtained from the Australian Bureau of Statistics for 1968–2018. Earlier data up to 2007 are from ABS Causes of Death Australia (3303.0; data available on request) and comparable data for 2008–2018 were sourced from the Australian Institute of Health and Welfare (AIHW) National Mortality Database Cause of Death Unit Record File data. These data were provided to the AIHW by the Registries of Births, Deaths and Marriages and the National Coronial Information System, which is managed by the Victorian Department of Justice, and include causes of death coded by the ABS.

Our study comprised of summer and winter mortality for 51 years. Ethics approval was not required for our use of non-identifiable mortality statistics. The unit of data analysis was seasonal (winter and summer) all-cause and cause-specific mortality (respiratory, cardiovascular, and renal diseases) in ten-year age groups of 55 and above, by sex and by state or territory of Australia (see Supplementary File). We used mean seasonal temperatures, which were calculated using gridded data from the Australian Water Availability Project (AWAP).[4] Counts of summer and winter cause-specific deaths of subjects aged 55 and over for the years 1968–2018 were modelled in a Poisson time-series regression, stratified by states and territories of Australia, and by sex, age and cause of death (respiratory, cardiovascular, and renal diseases). The warmest and coldest subsets of seasons were compared by using weather data to calculate the within-decade hottest and coldest seasons (see Supplementary File). Data analyses were performed using Stata (Statacorp, College Station, Texas).

Results

Summer to winter mortality ratios of all-cause deaths increased from 0.73 (95%CI 0.72, 0.74) based on the summer of 1968/69 to

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0.83 (95%CI 0.82, 0.85) in the summer of 2017/18. In our model, the seasonal mortality ratio increased by 3.82% per decade (95%CI 3.65%–4.00%, $p<0.001$). Increases in annual numbers of deaths since 1968 (Figure 1) reflect population growth.

Significant increases in mortality ratios were consistent across all age, sex and location groups (see Supplementary File). Changes in the all-cause mortality ratio for males were 25% greater than for females (0.42% per year and 0.33%, respectively). Mortality ratios increased by approximately 0.3% per annum in age groups from 55 to 74, with a larger annual increase of >0.4% per annum among those aged 75 and over. Annual rates of increase differed between Australian states and territories, with annual increases of 0.5% per annum in the Northern Territory and only 0.3% in South Australia.

During the study years, changes in summer to winter mortality ratios differed between causes of death. For cardiovascular deaths, the mortality ratio increased by 0.30% per year (95%CI 0.27%–0.32%, $p<0.001$), whereas this ratio increased by 0.72% per year (95%CI 0.65%–0.79%, $p<0.001$) for respiratory deaths and by 0.26% per year (95%CI 0.13%–0.38%, $p<0.001$) for renal causes of death.

Within each decade, summer to winter mortality ratios were greatest (closest to 1) when the warmest seasons were compared (see Supplementary File).

Discussion

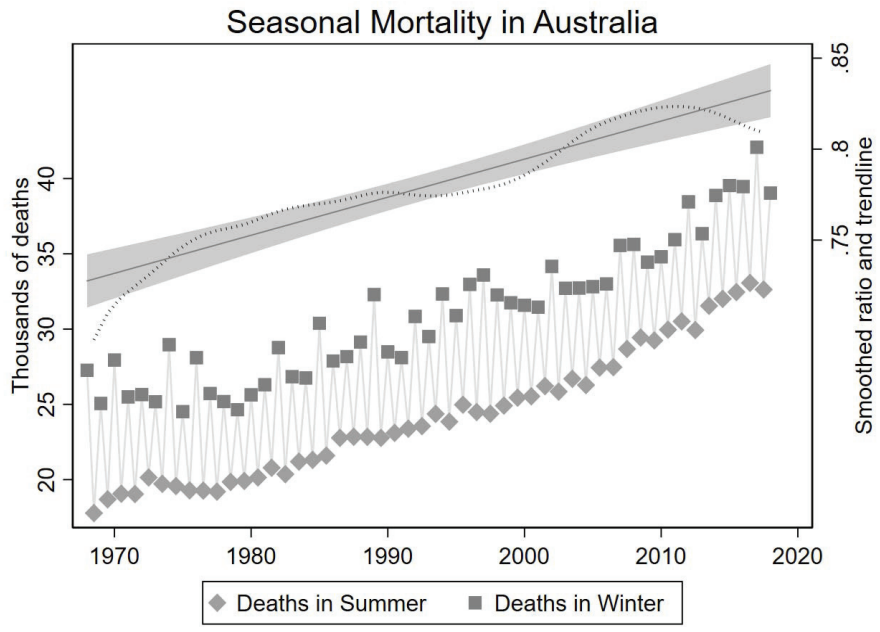
Drawing on 51 years of high-quality mortality data over a period in which annual average temperatures increased by 1.14°C, this is one of the first studies to associate decade-scale climate change with human health outcomes. There are few studies that show the observed impacts of climate change on human health; most have been focused on the effects of short-term weather exposures.

We have extended the previous findings by Bennett et al. (2013)[3] in the present study by including what has been the warmest (to date) decade in the country's recorded history. We find that the trend has continued with an increase from 0.73 in 1968 to 0.83 in 2018. Summer to winter mortality ratios increased significantly over time for both sexes (although more for men than women), in all regions of Australia (with some geographical variations), among all age groups (over 55) and for three major causes of death (cardiovascular, renal and – especially – respiratory diseases). Cardiovascular and respiratory conditions are leading causes of death and along with renal conditions have also been associated with high temperatures. The ratio changed fastest in years that were warmer than the decadal average.

The continuing shift toward a lower burden in winter relative to deaths in summer, in association with the progressive rise in average temperatures in Australia, is evidence in our view of the impact of long-term climate change on human mortality. These observations are in line with the expected impacts from scenario-based studies of future global warming.[5,6,7]

As climate change continues, we project that deaths in the warmest time of the year will come to dominate the burden of mortality in Australia. This has significant implications for healthcare, emergency services, housing, energy supplies and disaster preparedness. The variations we have observed in the speed of change in seasonal mortality between population groups, location and specific cause of death may be relevant to adaptation planning.

Figure 1: Deaths during 51 winters and 50 summers. Summer to winter mortality ratios are derived from the number of deaths in each summer divided by the average number of deaths in adjacent winter seasons. The dotted line is a moving average of the mortality ratios, with a simple linear regression line added to further clarify the trend.



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Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary File 1: Increased ratio of summer to winter deaths due to climate warming in Australia, 1968–2018.

Supplementary Table 1: Modelled annual changes in summer:winter all-cause mortality ratios.

Supplementary Table 2: Modelled annual changes in summer:winter disease-specific mortality ratios.

Supplementary Figure 1: Summer:winter mortality ratio in selected seasons of each decade. Comparisons of warmer seasons (both summers and winters (circles) are indicative of longer-term climate change. Mortality ratios from cooler seasons (diamonds) are lower than those of warmer seasons.