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DO HEAT ALERTS SAVE LIVES?

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ABSTRACT: Short-term heat events (e.g. heat waves) and cold events cause more loss of life in Australia than any other weather or climate extreme. They are also, relative to other extremes, easier to predict, exhibit larger spatial scales and thus affect more people, and responses that can reduce the excess mortality associated with them are better understood and more readily actionable. There is evidence that the heat-event alert system introduced in Victoria in 2009, and subsequently enhanced, saves lives. Improving and further enhancing heat-alert systems will reduce the costs, both human and financial, associated with heat events. This paper discusses whether a cold alert system is required, along with the possible reasons why the excess mortality after a hot event is of shorter duration than after a cold event, and why winter mortality typically exceeds summer mortality even for similar temperatures.

Keywords: heatwave, mortality, alerts, forecasting, extreme weather

A HEAT-ALERT SYSTEM FOR VICTORIA

The excess mortality associated with extreme heat events such as heatwaves far exceeds that associated with any other weather or climate extreme event (or geophysical extreme event such as an earthquake) in Australia (Coates et al. 2014). Figure 1 shows the mortality rate (per 100,000 people) of Melbourne residents aged 64 years or more, plotted against the overnight temperature of the previous night. Winter and summer days are plotted separately. A single summer night where the temperature does not fall below 24°C is sufficient to cause substantial extra deaths among the elderly.

Heat (and cold) extremes tend to cover larger areas, relative to many other weather and climate extremes (e.g. storms), and thus affect many more people. The vulnerable parts of the population (including the elderly and very young) are well known to public health officials, who also understand the responses to hot weather required to reduce the associated mortality and morbidity, which include ensuring the vulnerable members of the population remain hydrated and cool. So it would appear relatively easy to include in a heat-alert system actions that could reduce these impacts. Finally, forecasts of maximum and minimum temperature provided by the Bureau of Meteorology are usually accurate and provide useful information some days in advance — certainly more so than forecasts of other extremes such as storms or flash floods. These features all suggest that a heat-alert system initiated when the forecast temperature overnight is anticipated to remain above the threshold indicated in Figure 1 could save lives.

Recognising this, the Victoria Government, in 2008, commissioned research (from which Figure 1 derives) at Monash University to provide the basis for a simple and easily implemented heat-alert system (Nicholls et al. 2008). An alert would be initiated when the Bureau of Meteorology's temperature forecast for Melbourne exceeded a specified threshold temperature, based on Nicholls et al. (2008). A prototype heat-alert system was in place in time for an extreme heat wave in January 2009. The research was subsequently extended to determine

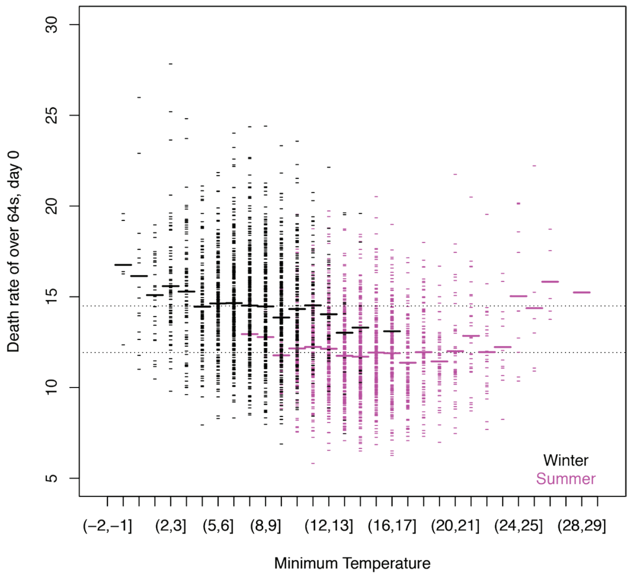

Figure 1: Daily death rate (per 100,000 in affected population) of Melbourne residents aged 64 years and above, plotted against overnight temperature in one-degree boxes. Summer (magenta) and winter (black) are plotted separately. Data are from 1978–2001. Individual dots are the results for an individual day. The short bars indicate the average daily death rate for the two seasons, in the indicated temperature range. The two thin dotted lines indicate the mean seasonal mortality for all temperatures — the upper line is the mean daily winter mortality while the lower line shows the summer mean mortality (after Nicholls et al. 2008).

Table 1: Numbers of obituaries in *Herald Sun* after and prior to heatwaves.

Year	Obituaries in 3 days following heatwave	Obituaries in same 3 days but in the 2 weeks prior to the heatwave (averaged)	% increase in obituaries after heatwave
2009	438	275	59%
2014	364	281	30%
2018	376	318	18%

heat thresholds in other parts of Victoria (e.g. Loughnan et al. 2010), and the heat-alert system was enhanced and improved, especially in its delivery to vulnerable members of the population.

IS THE HEAT-ALERT SYSTEM EFFECTIVE?

It is difficult to obtain official mortality information fast enough to quickly assess the impacts of a specific heat event, but alternatives do exist that allow rapid estimates of the impact of extremes on Victorian mortality. Table 1 shows the results of an analysis of death notices published in the Melbourne *Herald Sun* newspaper, for three heat waves, in 2009, 2014 and 2018. In each case, mortality increased substantially after the heat wave. The smaller increases in mortality after the 2014 and 2018 heatwaves suggest that the heat-alert system may be saving lives, although the 2018 heatwave was somewhat less intense than the two other heatwaves. Further study of future heatwaves will be required to more completely determine the effectiveness of the heat-wave alert system.

DO WE NEED A COLD-ALERT SYSTEM?

Recent research (e.g. Gasparrini et al. 2015) has shown that across much of the world the excess mortality associated with unusually low temperatures in many places exceeds that associated with unusually high temperatures. The data examined here suggest that, in Victoria, cold-event mortality is of a similar magnitude to hot-event mortality. For instance, Figure 1 also shows the impact of a cold winter night on mortality among the elderly. When the overnight temperature does not exceed 5°C, mortality on the following day increases above the usual winter mortality rate, to levels similar to those reached following a hot summer night. However, winter mortality typically exceeds summer mortality, for similar overnight temperatures, as can be seen by comparing the black and magenta bars: the black bars (indicating average mortality for winter days following specific overnight minimum temperatures) invariably lie above the magenta bars for summer mortality for the same overnight temperature. So the increase in winter mortality above the 'typical' winter mortality, following a cold night, is less than the increase in mortality associated with hot summer nights. Nevertheless, the excess mortality associated with the cold nights does suggest that lives could be saved if an effective cold-event alert system were introduced. The components of this alert system, other than the forecasts of overnight temperature, would need to be considered. Unlike the situation with the summer heat alerts, it may be more problematic to identify actions that, given a cold night prediction, could save lives.

OTHER QUESTIONS

The excess mortality associated with high summer temperatures only comes into effect a day or two after the high temperatures (Figure 2). By day five after the high overnight temperatures, the death rate matches the 'typical', all-temperature summer daily mortality. One might have expected some short-term advancement of mortality, with lower mortality in the days subsequent to the peak mortality associated with the high overnight temperatures. On the other hand, one might also expect some continued excess mortality, from causes associated with the high temperatures taking a slightly longer time to take effect (i.e. more than 1–2 days). Are these two possible influences offsetting each other, resulting in neither lower nor higher mortality after 1–2 days following high overnight temperatures? It is challenging to disentangle these two potential and offsetting impacts — the possible short-term advancement of mortality and the 'hangover' effect of delayed excess mortality triggered by the high temperatures.

In contrast to the summer and high temperature situation, excess mortality after low overnight temperatures in winter continues for some days after the cold temperatures. Figure 2 shows that even at day five, excess mortality is higher than a typical winter day. Why does the winter excess mortality continue so much longer than is the case after high summer temperatures? Does this suggest there is no short-term advancement of mortality associated with the cold winter temperatures? Again, this is a difficult question to address.

Finally, why is winter mortality typically higher than summer mortality, at the temperatures that overlap the two seasons (i.e. in the middle temperature ranges of the two graphs)? Is this because the illnesses triggered by the cold winter temperatures simply have longer effect duration than the illnesses or causes of death triggered by summer hot events? Or is it because the temporal structure of cold

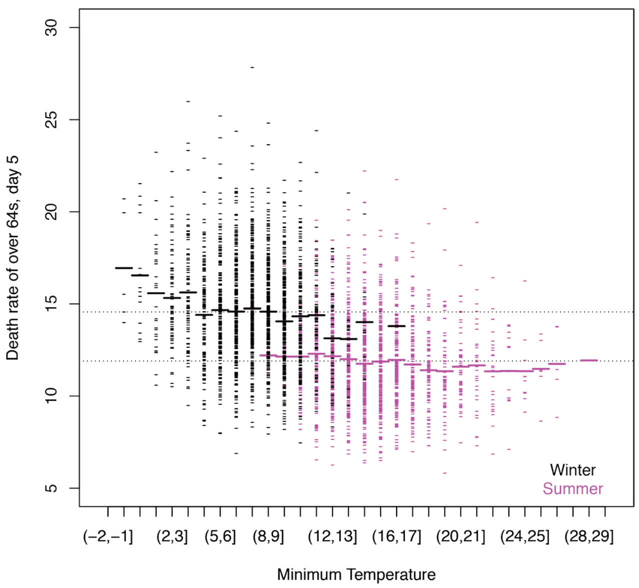

Figure 2: As for Figure 1, except for death rate five days after the specified overnight temperature.

events differs from that of hot events (i.e. do cold extremes last longer than hot extremes)? Or is there a 'winter mortality effect' separate to the temperature signal? It is challenging to disentangle the possible causes of these seasonal differences.

Addressing the above three issues could lead to further enhancement of heat-event (and cold-event) alerts, leading to improved responses to these events.

Conflict of interest

The author declares no conflicts of interest.

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