Temperature-related mortality and climate change in Australia

Temperature-related mortality is one of the main measures used to assess the costs and benefits associated with climate change. Some assessments have found a net benefit of climate change due to reduced cold temperature deaths offsetting increases in heat-related deaths.[1–3] Antonio Gasparrini and colleagues[1] and Vicedo-Cabrera and colleagues[3] found a net benefit of climate change for Australia, a surprising outcome given that other regions that experience cooler weather were associated with a net cost of climate change. Examples of the regions that were associated with a net cost of climate change in Gasparrini and colleagues'[1] and Vicedo-Cabrera and colleagues'[3] reports include North America, Central America, central Europe, southeast Asia, South America and southern Europe. In comparison to these regions, why Australia would have a net benefit from climate change is unclear, as it is a country associated with extreme heat rather than extreme cold.

In 2018, I reported that Australian cities were adversely impacted by heat and had little cold-temperature mortality in an article published in *Climatic Change*.[4] The corresponding temperature-mortality relationship is a J-shaped curve, rather than the U-shaped curves reported by Gasparrini and colleagues.[5] This J-curve relationship implies that climate change is likely to increase the number of deaths in Australian cities in the future. A J-shaped curve has been reported before[6–10] and is more appropriate for a country known for having winters that are much milder than those in North America and central Europe.

Although Gasparrini and colleagues[1] used a statistically determined minimum mortality temperature to distinguish between heat-related and cold-related mortality, this reference temperature can be quite warm. For example, the minimum mortality temperature for Melbourne was very high and equal to the 90th percentile (ie, an average daily temperature of 22·4°C compared with the mean average daily temperature of 18·1°C reported for Australia).[1] A high minimum mortality temperature could mean that deaths during average temperatures are associated with cold-related mortality rather than being treated as deaths during moderate (usual) temperatures.

By contrast, in my article[4] I used endogenous threshold regressions and a temperature measure that accounts for acclimatisation to distinguish between heat-related and cold-related mortality. This Excess Heat Index that accounts for acclimatisation (EHI_A) is part of the Excess Heat Factor produced by the Australian Bureau of Meteorology. It is the 3-day average temperature minus the 30-day average temperature. The measure has a mean of 0°C, which is a useful reference temperature that can be compared with 3-day periods that are hotter or colder than the previous 30 days. To distinguish between heat-related and cold-related mortality, I used the thresholds determined by this estimation technique to classify the estimated mortality into the number of deaths during cold temperatures (EHI_A at <–3·51°C), moderate temperatures (EHI_A at ≥–3·51°C and <1·95°C), hot temperatures (EHI_A at ≥1·95°C and <7·26°C), and extreme heat (EHI_A at ≥7·26°C).

Consistent with the thresholds estimated, most temperature-related deaths in Australia were associated with high and extremely high temperature events. In some regressions a negative relationship with cold temperatures was apparent, which is plausible given that winters in Australia are quite mild. My article indicated that the risk from future temperature events in Australian capital cities will be associated with extreme heat and hot temperature events rather than cold temperature events, in contrast to the previous results.[1,3,5] I believe that further analysis is warranted to confirm whether the reference temperatures used to distinguish between heat-related and cold-related mortality are appropriate given the prevailing climate in Australia.

I declare no competing interests.

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Temperature-related mortality and climate change in Australia

Authors' reply

We thank Thomas Longden for his Correspondence, in which he offers insightful comments on some publications from our research team on temperature-related mortality projections under climate change scenarios.[1,2] His letter provides us with the opportunity to discuss some aspects in more detail, and to clarify specific debated issues.

The focus of Longden's Correspondence is on the projected temperature-related impacts for Australia under different climate change scenarios, found in our analyses, which show a different pattern when compared with those in other regions of the world, specifically a net decrease in temperature-related mortality. This difference can be explained by a projected decrease in cold-related deaths that is higher than the increase in heat-related mortality. However, providing a context for correctly interpreting such findings is important. First, some estimates are quite uncertain, and the relatively wide confidence intervals include ranges that are in fact compatible with a net increase (see for instance the right-bottom panel of figure 3 in our Article).[1] Second, as shown in the same graph and in figures 1 and 2 in Vicedo-Cabrera and colleagues' publication,[2] the net change is stronger for milder climate change scenarios, whereas the pattern reverses and the net change is less clear for more extreme warming. Finally, and most importantly, both publications define such scenarios as global temperature trajectories or changes, but they explicitly state that in all of these scenarios, Australia is projected to experience a milder temperature increase if compared with the other regions assessed in these investigations (see table 2 and the figure in the appendix [p 12] of our Article).[1]

Longden then reports results from an article he authored, in which an alternative method based on endogenously determined thresholds was used to estimate cold-related and heat-related deaths in five Australian cities.[3] We value the comparison with other approaches; however, we would like to point out that the analytical framework we applied is the result of an intense methodological development for environmental epidemiological studies that has occurred in the past two decades,[4,5] providing study designs and statistical techniques validated in simulation studies[6,7] and used in hundreds of publications.[8] The results cannot be easily dismissed with a comparison with a newly developed and relatively untested method. Further research and a critical review of the various approaches is needed.

In the first part of his letter, Longden also discusses specific results relating to the shapes of the exposure–response curves and the minimum mortality temperature. Regarding the curves, he states how in his cited analysis the temperature–mortality association resembles a J-shaped curve,[4] more than a U-shaped curve as in a previous Article published in 2015 by our research team.[9] This J-curve association implies a higher risk and excess mortality associated with heat compared with cold. Longden supported his statement by citing five articles. However, we would like to point out that three of these articles involve locations in tropical areas of Vietnam, Kenya, and China, which are not climatologically similar to the three main Australian cities included in our analysis (Melbourne, Sydney, and Brisbane). The other two articles are multilocation analyses reporting results for US cities, in which the estimated curves look more like an inverse J shape (see for instance figure S8 in the cited study by Lee and colleagues[10]). These associations, characterised by a high minimum mortality temperature and a high number of cold-related deaths, are consistent with what we previously found.[9] Regarding the minimum mortality temperature, we reported the estimate of 22·4°C for Melbourne (see the table in the appendix [pp 7–15] of the 2015 Article),[9] but we stress how this value is not uncommon across the other 381 cities included in the analysis, especially those in relatively warm climates. This minimum mortality temperature is higher than the average annual temperature of 18·1°C for Australia (table 1 in the 2015 Article),[9] but also for all the other cities or countries, consistent with findings from other research groups; for instance, the two multicity studies cited in Longden's Correspondence.

In conclusion, we welcome the assessment that Longden has provided on our Article, and we agree that further analyses and comparison with alternative approaches are warranted to complement the evidence on potential health effects of climate change in Australia and other regions of the world.

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