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Extreme heat-related mortality avoided under Paris Agreement goals

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ABSTRACT

In key European cities, stabilising climate at 1.5°C would decrease extreme heat-related mortality by 15-22% per summer compared with stabilisation at 2°C.

The first goal of the Paris Agreement is to "[hold] the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change"[1]. As there is a current paucity in the study of risks between a 1.5°C and 2°C world[2], the question to the scientific community is 'what are the impacts avoided by stabilising climate at 1.5°C instead of 2°C?'. Research has started to emerge for global changes in some specific sectors to address this question, e.g. the crop and water sectors[3] but very little has emerged for regional impacts, and nothing specifically from the health sector.

Increased heat-related mortality has already been attributed to long-term climate change[4], and to the climate change enhancement of specific heat waves[5]. These mortality effects are not only limited to locations unaccustomed to high-temperature, but are likely ubiquitous around the globe[6]. Locations that have recorded particularly extreme heat waves, such as Chicago in 1995, and Europe in 2003, have, in general, put into place robust emergency response plans that help mitigate the impacts of high temperatures on health[7]. In such events, it has been reported that the mortality comes mainly from the elderly generation, and this is a trend that is projected to hold into the future[8].

Given that global annual mean temperature is already 1°C above pre-industrial temperatures and fast approaching 1.5°C[9], there is an urgency to understand the risks avoided by stabilizing climate at 1.5°C. It is well known that land-areas are warming faster than ocean areas, and even more so at high northern latitudes, meaning climate change signals over populated regions often warm more than the global mean.

Detection of heat-related mortality in the past

Detectable changes have already been found for specific historical heat waves in terms of changing climate[10] and epidemiology[5]. It is easier to detect significant changes in the climate component of a heat wave because climate data is far more readily available than epidemiological data and the heat-mortality relationship varies strongly across regions and even between cities within the same country[11]. However, ref[5] was able to examine heat-related mortality in two of the most data-rich cities in the world, London and Paris. The record breaking heat-mortality event in the region of those cities was the 2003 summer heatwave[10], which saw 35,000-70,000 excess deaths[12] (i.e. deaths which would not have occurred without the heat wave). It was shown that the risk of heat-related mortality increased by 70% in Paris, and 20% in London for 2003 climate conditions compared with pre-industrial climate conditions, highlighting how present day climate change has already impacted some sectors of society.

Avoided heat-related mortality in the future

But how might a heat wave like that of 2003 impact society in the future? Given the change in direction of policy relevant science due to the Paris Agreement climate goals being more ambitious than expected, we consider if a detectable change in heat-related mortality can be inferred for future heat waves. We perform the exact same analysis as in ref[5] (and readers are referred to that paper for methodological details), but instead of projecting heat-related mortality into the past, we project it into 1.5°C or 2°C worlds using climate projection data taken from the Half a degree Additional warming, Prognosis and Projected Impacts (HAPPI) project[2]. The HAPPI project employs thousands of initial condition ensemble members that allow for a comprehensive sampling of the climate space under three climate scenarios; the Current-, 1.5°C- and 2.0°C- decade scenarios. This allows for heat extremes with potential severe health impacts to be examined.

Specifically, we ask the question 'if the societal conditions associated with 2003 were the same in future years, how would the mortality attributable to extreme heat change?'. Framing the question in this way means the experiments do not take into consideration estimated future changes in, for example, increased populations or adaptation to rising temperatures and increased urbanisation, the latter of which can scale non-linearly with climate change[13]. These considerations are less relevant in the context of the question we are asking because our concern is about how increased future temperatures alter mortality, but the considerations are important to the overall question regarding how cities should plan for future heat emergency events.

A significant increase in heat-related mortality under the future scenarios consistent with the Paris Goals is found compared with present climate conditions (Fig. 1). The observed 2003 heat event resulted in ∼735 excess deaths for Paris and ∼315 for London (black dashed lines), i.e. significantly more deaths per capita in Paris (population 2,126,000) than in London (population 7,154,000). The excess mortality numbers for each city change depending on how you define the city populations, we follow the population values from ref[14]. In both cities, the observed mortality event is in the tail of the Current decade experiment (blue), emphasizing how extreme this event was. As expected, the 1.5°C (orange) and 2.0°C (red) experiments show increased mortality in both cities, with a 22% and 15% increase in extreme mortality (i.e. mortality above the 2003 threshold) if climate is stabilized at 2°C rather than 1.5°C, for London and Paris, respectively. Expressed as a change in relative risk (see Methods), if climate is stabilized at 1.5C over 2C, the 2003 mortality event is made 2.4 times less likely in London, and 1.6 times less likely in Paris.

For London, currently ∼10% of summers result in zero heat-related deaths (Figure 1, left, blue line). This percentage drops to ∼4% and ∼2% of summers for the 1.5°C to the 2°C experiments, respectively. The change in the average number of heat-related deaths is 75±7 between the 2°C and 1.5°C decade experiments (left, orange and red lines). In Paris, summers without any heat-related deaths are already rare (<1%, right, blue line), and the mean change in mortality between the 2°C and 1.5°C experiments is 87±9 deaths (right, orange and red lines). Individual models show very similar patterns to the multi-model mean (not shown), although the MIROC5 model shows a larger change between the Current- and 1.5°C-experiments, than between the 1.5°C and 2°C experiments.

Future outlook and recommendations

This analysis presents a quantitative assessment of the mortality risk if current temperature extremes were projected into the future under scenarios consistent with the Paris Agreement, assuming no future change in population vulnerability or exposure through, for example, adaptation policies which may be implemented in the coming years. These mortality changes may be amplified with high, more urbanised populations in the future, but could be mitigated with adequate adaptation. The number of deaths presented here for London and Paris should be interpreted as the number of future deaths we need to avoid through adaptation measures, in order to keep heat-related health impacts at current conditions. Cities that are potentially at higher risk than London and Paris are those that have not recorded a large heat-mortality event over the recent decades, or that lack adequate resources for planning or implementation, and so may have inadequate or out of date emergency response plans. In such cases local governments should review their procedures and plan ahead, investigating the viability of heat early warming systems in their region, and perhaps engaging with the ongoing Loss and Damage policy discussions[15] to help to build a international resilience to city-level heat risks.

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Author contributions statement

D.M. designed and wrote the paper. D.M., C.H. performed the analysis. All authors contributed to the discussion and writing of the paper.

Additional information

The authors declare no competing financial interests.

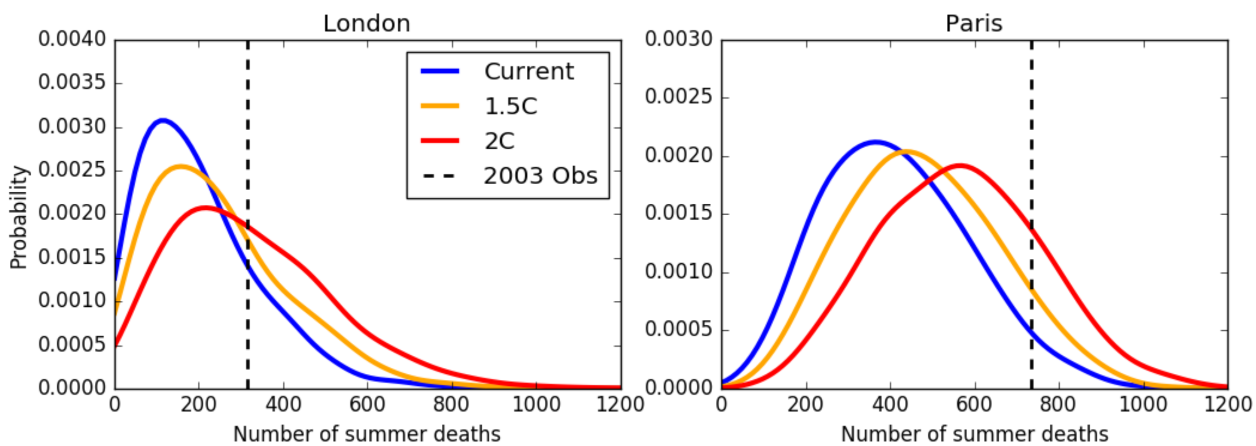

Figure 1. Distributions of summer mortality in the Current, 1.5°C and 2°C decade experiments. Cumulative summer mortality in (left) London and (right) Paris using the method from[5] but applied to the HAPPI data. Blue, orange and red show the Current, 1.5°C and 2°C experiments, respectively. The dashed black line shows observed 2003 values. The full distributions of data for all ensemble members of all models are shown in each case.