Are there more cold deaths than heat deaths?

Non-optimal temperatures are now considered among the leading risk factors of mortality worldwide.[1] A global analysis showed that 9·4% of all deaths can be attributed to both cold and hot non-optimal temperatures, corresponding to about 5 million deaths.[2] In most epidemiological studies, excess cold deaths far outnumber heat deaths. In that same global analysis, of the 9·4% attributable temperature-related deaths, 8·5% (range 6·2–10·5%) were cold-related and only 0·9% (range 0·6–1·4%) were heat-related,[2] which corresponds to approximately 4·6 million deaths from cold and about 489 000 from heat, a ratio of roughly 9:1 of cold versus heat. This pattern is also consistent in regional studies.[3–5] In this Comment we summarise why this pattern emerges and address what this implies for future temperatures and related mortality under climate change.

The pattern of higher cold-related deaths is primarily due to the specific form of the exposure–response relationship. For temperature and mortality, this relationship is non-linear, often described as U-shaped or J-shaped, indicating that both temperatures that are too cold and too hot increase mortality risk, separated by a comfortable or optimal temperature. In epidemiological studies, this optimal temperature is referred to as the minimum mortality temperature—ie, the point where deaths are lowest. From an epidemiological point of view, anything above this optimal temperature can be considered hot for a given location, whereas those lower are considered cold, which differs from people's everyday sense of what constitutes a hot or cold day. For example, the optimal temperature often sits quite high within a location's annual temperature range, meaning that days classified as cold in epidemiological terms could feel mild or even warm to some people. Research shows, however, that an accumulation of even moderately cold days can constitute a physiological stress for the most at-risk people.[6] At the population level, accumulated cold days translates into a slight increase in excess deaths even for days that would not otherwise be considered as cold snaps.

To illustrate this exposure–response relationship, the figure (appendix p 1) shows the association between 24-h average temperature and cardiovascular deaths in Barcelona, Spain from 2000 to 2018 (detailed methods and data sources are reported by Alahmad and colleagues).[7] In Barcelona, the optimal temperature was 23·6°C with the risk increasing steadily for mildly cold days and sharply for hot days. Over 19 years, these risk curves translate to 10 772 cardiovascular excess deaths linked to cold and 556 to heat.

One explanation for why cold deaths were higher than heat deaths is mathematical: the area under the curve for heat is only a third of the total area (appendix p 1). Using numerical integration, the area under the curve was 2·745 for temperatures higher than 23·6°C and 5·287 for temperatures lower than 23·6°C. This finding partly explains why cold-related deaths are higher than hot-related deaths; however, it does not give the whole picture.

Looking at each day from 2000 to 2018 (6940 days) in Barcelona, most days had temperatures lower than the optimal temperature. When rounding temperatures to full digits, we see that the frequency of cold days (<23·6°C) far exceeds hot ones (>23·6°C; appendix p 1). Put another way, the figure (appendix p 1) shows that the contribution of cold days on attributable mortality is much larger than the contribution of a much more modest count of hot days.

However, what about the influence of temperature on the actual risk of death on a given day irrespective of how often it happens? We can assess the relative risk compared with the optimal temperature. During the study period in Barcelona, the coldest day had an average temperature of 1·4°C. On this day, the risk of cardiovascular death increased by 50% (relative risk 1·5) compared with the optimal temperature. Conversely, the hottest day had an average temperature of 32·1°C, which was associated with a 240% increase in cardiovascular death risk (relative risk 2·4). Such a day, however, was very rare, occurring only once in 19 years in Barcelona. Although the relative risk of death was higher on the hottest day, such extreme heat days were so infrequent that the attributable or excess deaths from heat remained much lower than those from more frequent cold. If very hot days were to occur more frequently, the excess deaths related to heat would be considerably higher.

See Online for appendix

This pattern shows that policies aiming at attenuating risks during extreme heat events can potentially achieve a great reduction in deaths. Furthermore, unmitigated climate change will not only introduce new unobserved hotter temperatures that stretch the exposure–response curve to new areas where the risk is higher (appendix p 1), but also increase the frequency of current extreme heat events, compounding the mortality burden. For instance, when comparing the summer of 2022 to the summers from 2018 to 2020, Spain saw triple the number of extreme hot days, leading to nearly five times more heat-attributable deaths.[8] To estimate the future burden of temperature-related mortality under climate change scenarios, projection studies should make assumptions about how future hotter temperatures might increase the mortality burden and also extrapolate the exposure–response curve to new temperature ranges.[9]

A shift in the temperature distribution that is expected with continued climate change, will cause a higher occurrence of temperatures in the heat part of the range and a lower occurrence in the cold part. However, given the shape of the exposure–response relationship and the steeper risk on the right-hand side, such shifts can be expected to be associated with a much higher increase in heat-related deaths than for cold. In fact, a recent health impact projection study in more than 800 cities in Europe showed that a future reduction of cold deaths is unlikely to offset the projected increase in heat deaths.[10]

The bottom line, however, is not whether heat or cold is more dangerous, but how we can save the most lives, especially as the climate continues to change. Nowadays, given the current climate trends and limited success in climate mitigation, the current epidemiological literature strongly suggests that an urgent focus on heat-related deaths is well justified.

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