Impact of Climate Change on Cold-related Mortality

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The warmer temperatures generated by climate change can adversely affect mortality, with heatwaves being referred to as its silent killer. A related issue, not as often discussed, is the extent to which climate change will reduce the number of cold-related deaths.

The objective of this essay is to explore possible favorable impacts of a reduction in the relatively large number of winter deaths due to winter weather that should be considered in assessing the overall impact of climate change.

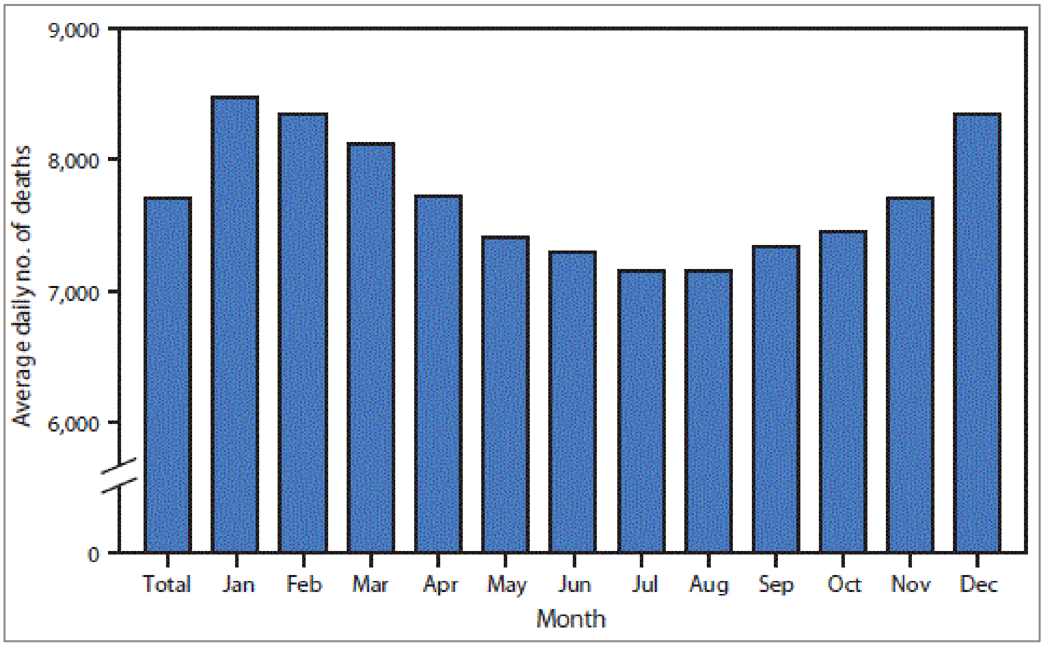
Many countries experience far more deaths in the winter than in the summer. This somewhat contrasts with the broadly U-shaped relationship between temperature and mortality which indicates that both extreme heat and extreme cold can result in greater mortality risk. As overall temperature increases, the extent to which offsetting effects of these patterns on mortality may arise depends on several factors, including exposure to these temperature ranges and the vulnerability and sensitivity of applicable population segments, including their location, population mix, aging, socioeconomic mix, and effectiveness of adaptation measures taken.

Figure 1[1] shows that, in 2017, the average number of deaths per day in winter months in the United States was significantly greater than the number of deaths in summer months – the number of deaths in January was 8,478,

[1] Centers for Disease Control and Prevention (CDC). https://www.cdc.gov/mmwr/volumes/68/wr/mm6826a5.htm

18% greater than 7,157 average daily deaths in July. Over the period between 2014 to 2019, the relative ratios of the number of deaths in the United States were about 107%, 98%, 94%, and 101%, for the first to fourth calendar quarters, respectively.

Figure 1:
THE NUMBER OF U.S. DEATHS BY MONTH IN 2017



Source: Centers for Disease Control and Prevention (CDC).
https://www.cdc.gov/mmwr/volumes/68/wr/mm6826a5.htm

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Underlying Source: QuickStats: Average Daily Number of Deaths, by Month — United States, 2017. MMWR Morb Mortal Wkly Rep 2019;68:593. DOI: http://dx.doi.org/10.15585/mmwr.mm6826a5external icon

Temperature extremes can affect the risk of mortality across a wide range of causes of death. Leading causes that contribute to this seasonality include cardiovascular diseases, lower respiratory diseases, strokes, Alzheimer's disease, diabetes, influenza[2], and kidney diseases. In contrast, deaths due to cancer appear to be relatively uniformly spread throughout the year, while accidents, including falls and firearm-

[2] The number of deaths due to influenza, usually heavily concentrated in the winter, may depend more on the effectiveness of that year's flu vaccinations and living more indoors or in proximity to others than to the specific winter temperature.

related events, as well as suicide, tend to occur more frequently in summer. Excess winter deaths have been more frequent for females than males, partly because there are more females than males at older ages when a person is more vulnerable to winter deaths.

Sensitive to temperature can differ by individual. Nor do they have adequate access to protective equipment (e.g., furnaces in winter, air conditioning in summer, or appropriate clothing when needed) that can moderate the adverse effects of extreme temperature incidents.

In a study of the net effect of climate change on mortality, it is appropriate to consider its effect on both heat-related and cold-related deaths. Some locations with colder climates may see a net mortality benefit from climate change, at least in the short term, because of the lower frequency of extremely cold days.

For example, in a study of 13 countries, more temperature-attributable deaths were caused by cold (7.29%) than by heat (0.42%), with extreme cold and hot temperatures being responsible for 0.86% of total mortality (Gasparrini et al. 2015). However, because this study did not consider the effect of changes in future conditions such as population aging, it may be inappropriate to conclude that global warming will necessarily benefit global mortality.

Between 2000 and 2019, Zhao et al. (2012) reported that, although heat-related deaths[3] constituted about 1% of global deaths (about 0.5 million deaths annually, increasing from 0.91% to 1.04% in the 2016–2019 period), cold-related deaths affected about nine times as many people (but this percentage decreased from about ten times in 2000–2003 to about eight times in 2016–2019). Globally there were about five million hot and cold-related deaths over the twenty-year period: 8.52% of total deaths over the entire period and 8.19% during 2016–2019. As temperatures have risen since 2000, heat-related deaths increased by 0.21% (116,000 deaths) while cold-related deaths declined by 0.51% (283,000 deaths). There was substantial variation geographically, with more than half the total excess deaths occurring in Asia; Eastern Europe had the highest heat-related mortality rate and Sub-Saharan Africa had the highest cold-related mortality rate. Northern America had about 171,000 cold-related deaths (3.73%) and about 20,000 heat-related deaths (4.10%).

Although cold spells are projected to decrease across Europe (Martínez-Solanas et al. 2021), in many cases this decrease will not offset the projected additional heat-related deaths. In addition, climate change may exacerbate cold spells at certain times and locations because of more erratic jet stream behavior, even if winters are on the whole warmer.

Hajat et al. (2014) estimated hot- and cold-related deaths in the United Kingdom during the 2000s, 2020s, 2050s, and 2080s based on a medium emissions scenario and nine climate scenarios. This analysis indicates that in the United Kingdom,

- cold-related deaths are currently far more frequent than heat-related deaths;
- cold-related deaths are expected to decrease because of climate change and more than offset the increase in heat-related deaths (for a constant population);

[3] Using average daily temperatures, with cold and hot temperatures taken at suboptimal levels. The cold and hot temperatures were defined as temperatures either lower or higher than the minimum mortality temperature.

- temperature-related deaths as a proportion of total deaths increase with age, especially after age 75; and
- more than half of temperature-related deaths currently occur at ages 85 and above, an age group that will increase as the population ages.

Countries with temperate climates similar to the United Kingdom also have had proportionately more cold-related deaths than naturally colder countries like Sweden. Among the reasons include (1) many U.K. houses are not suited to colder temperatures because of poor insulation, being difficult and expensive to heat, and (2) individuals may not be as well prepared for cold weather because temperature-related risks were underestimated. Efforts to make homes warmer in winter by making them more airtight may make them hotter in summer. Heat-related deaths are also caused by such factors as a lack of home air conditioning and overheating on London public transport.

U.K. public health officials have reported excess winter deaths in England and Wales using the month of death (Hajat and Gasparrini 2016) rather than attempting to attribute deaths to cold weather–related causes. The definition of excess winter deaths used by the U.K. Office for National Statistics (ONS 2019) is the number of deaths in the period of December to March, less the average of deaths in the prior and subsequent four months. For example, there were 23,000 excess deaths during the winter of 2018–2019, whereas in 2017–2018 there were about 50,000.

The Netherlands is also currently experiencing excess cold-related mortality (Botzen et al. 2020), with the impact on mortality of extreme heat and cold differing by age group, with people at least 80 years of age being more vulnerable and sensitive to hot days (4.6%/degree Celsius) than to cold days (2.1%/degree Celsius). There can be long time lags between exposure under extreme temperatures and consequential deaths (e.g., respiratory diseases peak about 12 days after peak cold, according to Keatinge 2002), especially under cold conditions. Botzen et al. expected climate change to decrease total net mortality in the Netherlands in the immediate future because of the dominant effect of reduced cold-related mortality; however, they expected this relationship to reverse over time under high emission scenarios unless additional adaptation measures are implemented.

Similarly, in a study of 16 European countries based on three different climate scenarios in four climate models, Martinez-Solanas et al. (2021) projected that the heat-attributable fraction of mortality will begin to exceed the reduction of the cold-attributable fraction in the second half of the 21st century, especially in the Mediterranean area and under higher emission scenarios. They found that 7.17% of deaths reported between 1998 and 2012 were attributable to extreme temperatures, with cold being more harmful than heat by a factor of 10: 6.51% versus 0.65%, with large differences across countries.

Nevertheless, Martínez-Solanas et al. asserted that there will no longer be a strong association between the extent of cold temperatures and excess winter deaths over this period because of improvements in housing and health care, higher incomes, and increased awareness of cold weather risks.

The assertion that cold-related mortality will decrease in the next two decades in countries such as the United Kingdom has been contested by the results of several studies (e.g., Ballester et al. 2016), usually based on the distinction between deaths caused by cold temperatures and the number of excess winter deaths. If true, climate change may not significantly decrease the number of cold-related deaths. Supporting this position include:

- Kinney et al. (2015), using daily temperatures and deaths, studied the extent to which cold temperatures are associated with excess winter mortality across and within 36 U.S. cities (1985–2006) and three French cities (1971–2007). They found that excess winter mortality did not depend on corresponding seasonal temperatures. Variability in daily mortality within a city was not strongly influenced by temperature. Although seasonality may be a significant factor, this suggests that the winter temperature may not be the key driver of such excess mortality.
- U.S. and Canadian cities that are generally warmer experience worse mortality from extreme cold events and cold temperatures than do corresponding colder cities. Although deaths directly linked to cold exposure (e.g., hypothermia and falls) are generally limited, the relatively greater mortality during somewhat milder temperatures is thought to be largely due to respiratory infections and cardiovascular impacts (Lee 2014; Gasparrini et al. 2015). Although positively correlated with temperature, this may not be directly caused by the extent of cold temperatures. Nor are they the primary mortality driver of these excess deaths.

Despite global warming trends, mortality during winter may not significantly decrease, partly because of the importance of a range of other medical and non-medical factors that contribute to excess winter mortality. For example, in cities in eastern Canada, the intra-annual distribution of freezing rain events by 2100 may become more frequent from December to February, but less frequent in other months. The net result will depend on location, socioeconomic, occupational, and other non-climatic determinants of health and socioeconomic vulnerability, as well as other climatic factors, such as low humidity, which may be (Barreca 2012) at least as important as temperature.

One should avoid simple aggregate extrapolations when considering changes in the temperature-mortality relationship over time. For example, although heat- and heatwave-related mortality has generally diminished over time, it appears to have stabilized lately (Arbuthnott et al. 2016). This pattern may have partly been due to more effective adaptation measures and increased population density, offset to some extent by population aging and acclimatization. No trend was apparent regarding the impact of cold weather.

Between 1985 and 2012, mortality attributed to cold temperatures increased in the United States and was stable in Canada, despite increasing winter temperatures (Vicedo-Cabrera et al. 2018). Regional differences arise, for example, some reductions in cold-related mortality in the southern United States are projected under climate change, but less so in colder climates in the northeastern United States and Canada.

A common mistake is to think that temperature-related deaths occur only at extreme temperatures. In general, deaths are more frequent when people are not prepared or acclimatized to temperature extremes. Thus, deaths may be more common during cold days in generally warmer regions, as are hot days in generally colder regions. In the case of Mexico, Cohen and Dechezleprêtre (2022) estimated that 26,000 deaths each year are triggered by temperatures from which people with low income are inadequately protected. In Mexico, 92% of weather-related deaths are currently experienced during cold or mildly cold days, with only 2% on extremely hot days.

Mortality has been associated with both seasonal mean values and standard deviations of temperature. For example, among the U.S. Medicare retiree population (those aged 65 and older) in New England during 2000–2008 (Shi et al. 2015), an increase in mean summer temperatures of 1°C was associated with 1.0% greater mortality, and an increase in mean winter temperatures corresponded to 0.6% lower mortality. This suggests that on average mortality may be somewhat more sensitive to the effects of changes in hot temperatures than corresponding changes in cold temperatures.

Whether or the extent mortality related to cold waves will decrease in the coming decades in Europe or the United States is currently unclear (IPCC 2022). Although projected global cold extremes may decrease in frequency and intensity, greater regional climate volatility means that cold waves will remain locally important threats in many areas, including in generally milder regions with larger temperature differences between "normal" winter days and periods with extremely cold conditions, especially where there is less ability or willingness to adapt. Many countries in the global north will likely experience minimal to moderate decreases in cold-related mortality, whereas warm-climate countries in the global south are projected to experience increases in heat-attributable deaths. This will be accentuated in many cities, particularly in Europe and East Asia, by their rapidly aging populations who are vulnerable to cold wave health risks and have failed to take adequate adaptation protective action.

Regarding weather volatility, according to the National Oceanic and Atmospheric Administration (U.S.), scientific opinion is divided between whether there will be a decreasing or even an increasing trend in polar vortices.[4] However, in some areas, they will continue to occur, especially in spurts, no matter how hot global average temperatures get. It is unlikely that cold temperature-driven weather will disappear with global warming.

In summary, although some countries will experience reduced mortality in the aggregate in the short term, experience suggests that this may not continue, because (1) there can be stronger sensitivity to hotter than colder temperatures, especially among the most vulnerable, (2) temperature variability may not significantly reduce cold-related deaths, and (3) adaptation and population composition, particularly by age can make a difference between populations. The IPCC (2022) indicated that, with high confidence, future increases in heat-related deaths globally are expected to outweigh those related to cold.

The relative importance of these factors remains under discussion in the scientific community. In any case, analysis of both hot- and cold-related mortality should be incorporated when assessing the net effect of climate change. It has to be remembered that the impact of a warmer climate is greater than the direct impact of temperature itself. For example, hotter temperatures also contribute to other climate change mortality risks, including those associated with more intense storms, worse air quality including from smoke from wildfires, increased flooding from more intense rainfall, additional infectious diseases from expanded scope of vectors such as mosquitoes, desertification, and sea level rise. In contrast, there are comparatively few indirect cold-related deaths.

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[4] A polar vortex is a band of strong winds that forms in the stratosphere between about 10 and 30 miles above the poles every winter that can result in extremely cold weather as they move farther south.

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