Office for National Statistics

Article

Climate-related mortality, England and Wales: 1988 to 2022

Relative risk of death associated with temperature for England and Wales from 1988 to 2022.

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Notice

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Following the Health and Social Care Statistical Outputs consultation commissioned by the Health and Social Care Statistics Leadership Forum, we are improving some of our statistical products, so they are more coherent and efficient. Additionally, we are ensuring that our resources are deployed in producing statistics for maximum possible benefit.

Full details of changes to this product, and our other health and social care products, are available in the Health and Social Care Statistical Outputs Consultation Response. We welcome user feedback on our releases. Please use the contact details on individual publication web pages to share feedback.

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1 . Main points

- Both very low and very high temperatures had higher mortality risk, with temperatures below negative 5 and above 25 degrees Celsius representing the greatest risk across England and Wales.
- The highest mortality risk was in London for temperatures exceeding 29 degrees Celsius, where mortality risk was 3 times the risk at optimal temperatures; all regions showed increased mortality risk for temperatures greater than 22 degrees Celsius.
- An estimated 51,670 deaths (95% confidence interval: 37,740 to 64,382) in England, and 2,186 deaths (95% confidence interval: 965 to 3,406) in Wales, were associated with the hottest days over the 35 years from 1988 to 2022.
- There was some indication that heat-related deaths have increased over recent years; in 2022 an estimated 4,507 deaths (95% confidence interval: 3,363 to 5,587) were associated with the hottest days in England.
- An estimated 199,298 deaths (95% confidence interval: 179,111 to 221,233) in England and 16,474 deaths (95% confidence interval: 14,367 to 18,535) in Wales were associated with the coldest days over the 35 years from 1988 to 2022.

These are Experimental Statistics. The methods are under development, which means estimates may change. We advise caution when using the data. Results in this publication also cannot be compared with our previously published analysis on Climate-related mortality and hospital admissions, England and Wales: 2001 to 2020. This is because this release contains updated data and is based on improved methods.

2 . Temperature-related mortality

In this bulletin, we present analysis of temperature-related mortality for English regions, England and Wales, using climate and mortality data from 1988 to 2022.

Deaths occurring over the 35-year period from 1988 to 2022, were combined with climate information from the Centre for Environmental Data Analysis (CEDA) archive. A statistical method was developed to understand the impact of temperature on mortality risk, while adjusting for other factors influencing mortality. Optimal temperature ranges are presented as part of this analysis, to highlight temperatures at which mortality risk was lowest.

Further details of our data sources and methods, can be found in Section 7: Data sources and quality.

Analysis of age groups in England is included in our accompanying dataset.

England and Wales

In England, the lowest mortality risk was observed for temperatures between 9 and 22 degrees Celsius. In Wales, temperatures between 8 and 20 degrees Celsius had the lowest mortality risk. These temperature ranges were considered optimal because of the relatively low mortality risk. Regional differences in optimal temperatures are shown in the next section.

Figure 1: Higher mortality risk for temperatures above 22 degrees and below 8 degrees Celsius

Temperature related relative mortality risk, England and Wales, using data from 1988 to 2022

Notes:

1. The shaded area in Figure 1 shows the optimal temperature range, where mortality risk is lowest. These ranges correspond to temperatures where the relative mortality risk is between 1 and 1.1. Although the mortality risk is relatively low for these optimal temperature ranges, there may still be a substantial proportion of associated temperature related deaths. This is because even a small increase in relative risk can contribute a substantial number of deaths when many days are spent within this temperature range.

2. A relative risk indicates the likelihood of an individual dying during, or shortly after, exposure to a certain temperature. When a temperature has a relative risk of one, this means there is neither an increase nor a decrease in the likelihood of the individual dying during, or shortly after, exposure to that temperature compared to a reference temperature. A relative risk of 1.1 denotes a 10% increase in mortality risk compared to the reference temperature.

3. These estimates are based on observed temperatures from 1988 to 2022. Over this time, there was limited data available for average temperatures below -6 degrees and greater than 30 degrees Celsius. These temperatures have therefore not been included in Figure 1.

Download the data

.xlsx

Regions of England

The highest mortality risk was in London for temperatures exceeding 29 degrees Celsius, where mortality risk was three times the risk at optimal temperatures.

All regions showed increased mortality risk for temperatures greater than 22 degrees Celsius. The greatest source of variability across regions of England was the tolerance for colder temperatures.

Mortality risk remained relatively low across a broad range of temperatures in Yorkshire and the Humber, the East Midlands and the West Midlands, between approximately 7 and 21 degrees Celsius.

Figure 2: Higher mortality risk for temperatures above 22 degrees Celsius

Temperature related relative mortality risk, English regions, using data from 1988 to 2022

Notes:

1. The shaded area in Figure 2 shows the optimal temperature range, where mortality risk is lowest. These ranges correspond to temperatures where the relative mortality risk is between 1 and 1.1. Although the mortality risk is relatively low for these optimal temperature ranges, there may still be a substantial proportion of temperature related deaths. This is because even a small increase in relative risk can contribute a substantial number of deaths when many days are spent within this temperature range.

2. A relative risk indicates the likelihood of an individual dying during, or shortly after, exposure to a certain temperature. When a temperature has a relative risk of one, this means there is neither an increase nor a decrease in the likelihood of the individual dying during, or shortly after, exposure to that temperature compared to a reference temperature. A relative risk of 1.1 denotes a 10% increase in mortality risk compared to the reference temperature.

3. These estimates are based on observed temperatures from 1988 to 2022. Over this time, there was limited data available for average temperatures below -6 degrees and greater than 30 degrees Celsius. These temperatures have therefore not been included in Figure 2.

Download the data

.xlsx

3 . Deaths associated with the hottest and coldest days

In this analysis we considered the highest and lowest temperatures in England, by taking the hottest and coldest 5% of days over the entire period from 1988 to 2022. These extremes corresponded to temperatures below 2 degrees Celsius for the coldest days, and above 18 degrees Celsius for the hottest days, in England overall.

We calculated the deaths attributable to these temperatures to understand the potential deaths that could be avoided by limiting exposure to very high or very low temperatures.

Figure 3 shows the number of deaths associated with the hottest and coldest days in England over time. Our analysis indicates that, for England, historically a greater number of deaths were associated with extreme cold, although over recent years heat-related deaths have increased.

These are Experimental Statistics. The methods are under development, which means estimates may change. We advise caution when using the data.

Figure 3: Deaths related to the hottest and coldest days in England

Estimated temperature related deaths, England, 1988 to 2022

Notes:

1. These numbers are based on temperatures experienced from 1988 to 2022, and any change in climate towards more extreme temperatures would likely lead to an increase in attributable deaths. For example, temperatures exceeding 25 degrees where mortality risk is very high, were only experienced on relatively few days over the study period, and therefore contributed relatively few deaths.

2. We included all occurrences of deaths that were registered up until the end of 2022. Due to registration delay, some deaths that occurred in 2022 are not included in our analysis. This will affect the later months of 2022 most; therefore, the estimated cold-related deaths for 2022 are likely to be underestimated and have been excluded from Figure 3.

3. There is considerable uncertainty and variability in these estimates. Caution should be taken when interpreting yearly increases or decreases.

4. The direct causes of death vary on very hot days compared to very cold days.

Download the data

.xlsx

The regional breakdown of deaths associated with the coldest and hottest days over the most recent five-year period from 2018 to 2022 is available below.

Table 1: Deaths related to the hottest and coldest days across English regions, 2018 to 2022

English Region	Estimated cold-related deaths	Cold Related Deaths per 100,000	Estimated heat-related deaths	Heat Related Deaths per 100,000
East of England	2,900	9	1,600	5
East Midlands	1,800	7	900	4
London	3,000	7	2,200	5
North East	1,200	9	700	5
North West	3,200	9	800	2
South East	3,800	8	1,900	4
South West	2,800	10	1,100	4
West Midlands	2,400	8	1,200	4
Yorkshire & the Humber	1,800	7	900	3

Source: Office for National Statistics

Notes

1. The results shown in table 1 are for the period from 2018 to 2022.

2. Estimated deaths have been rounded to the nearest 100.

3. The estimated deaths per 100,000 have been rounded to the nearest whole number.

4. Regional population totals at the mid-point of each year from 2018 to 2021 were used to estimate the deaths per 100,000 people. For 2022, population totals were not yet available therefore the population estimates for 2021 have been used.

5. We included occurrences of deaths that were registered up until the end of 2022. Because of registration delay, some deaths that occurred in 2022 are not included in our analysis. This will affect the later months of 2022 most; therefore, the estimated cold-related deaths may be underestimated.

6. These numbers are based on temperatures experienced from 2018 to 2022, and any change in climate towards more extreme temperatures would likely lead to an increase in attributable deaths. For example, temperatures exceeding 25 degrees Celsius where mortality risk is very high, were experienced relatively infrequently over this period, and therefore contributed relatively few deaths.

7. The direct causes of death vary on very hot days compared with very cold days.

4 . Climate-related mortality data

Climate-related mortality, England and Wales
Dataset | Released 22 September 2023
Relative risk of death associated with temperature for England and Wales from 1988 to 2022.

5 . Collaboration

Our climate-related mortality analysis was produced by the Office for National Statistics (ONS) in collaboration with our research partners at the London School of Hygiene and Tropical Medicine, the Department of Health and Social Care (DHSC) and Wellcome Trust. Of particular note is Antonio Gasparrini from the London School of Hygiene and Tropical Medicine, Department of Public Health, Environments and Society: Professor of Biostatistics and Epidemiology.

This work was supported by the Wellcome Trust (grant reference: 224682/Z/21/Z).

6 . Glossary

Confidence interval

A confidence interval gives an indication of the degree of uncertainty of an estimate, showing the precision of an estimate. The 95% confidence intervals are calculated so that if we repeated the study many times, 95% of the time the true unknown value would lie between the lower and upper confidence limits. A wider interval indicates more uncertainty in the estimate. Overlapping confidence intervals indicate that there is little or no evidence of a true difference between two estimates, at that level of confidence.

Relative risk

A relative risk indicates the likelihood of an individual dying during, or shortly after, exposure to a certain temperature. When a temperature has a relative risk of 1, this means there is neither an increase nor a decrease in the likelihood of the individual dying during, or shortly after, exposure to that temperature. A relative risk greater than 1 indicates an increased likelihood of death compared with the reference temperature. A relative risk less than 1 indicates a decreased likelihood of death compared with the reference temperature.

7 . Data sources and quality

Statistical methods

This analysis is based on the statistical methods detailed in the article, Mortality risk attributable to high and low ambient temperature: a multicountry observational study, published in the Lancet in May 2015 (PDF, 360KB). We used a quasi-Poisson regression model to understand the association between temperature and mortality, while controlling for other factors that may influence mortality risk. We adjusted for seasonal and long-term trends in deaths, as well as weekday effects in death occurrences. We also adjusted for climate factors, such as humidity and wind speed (using monthly averages), and daily air pollution. We included lagged temperature variables to allow for delayed effects of heat and cold.

Regional estimates were combined to create overall estimates for England, using a pooling technique outlined in the article, Reducing and meta-analysing estimates from distributed lag non-linear models, published on the Biomedcentral website.

Experimental statistics

Experimental Statistics are those that are in the testing phase, are not yet fully developed and have not been submitted for assessment to the UK Statistics Authority. They are published to involve customers and stakeholders in their development, and to develop quality from an early stage. These climate-related mortality statistics are designated as Experimental Statistics.

Further information on Experimental Statistics can be found on our website.

Climate data

Climate data from the Centre for Environmental Data Analysis (CEDA) archive have been used for this analysis. CEDA works in collaboration with the Met Office to produce regional estimates of climate data from meteorological measuring stations across the UK. Daily estimates of temperature, and monthly estimates of humidity and wind speed were used for this analysis. Average temperatures are used throughout this analysis, so there will be days where more extreme temperatures were recorded in specific locations, or at specific times.

Air pollution

We used the Daily Air Quality Index (DAQI) produced by the Department for Environment Food and Rural Affairs (DEFRA) to adjust for pollution effects on mortality risk. DAQI is a summary measure, graded from 1 to 10, of the highest level of pollution across five pollutants:

- nitrogen dioxide
- sulphur dioxide
- ozone
- particles less than 2.5 micrometres (PM2.5)
- particles less than 10 micrometres (PM10)

Mortality data

When a death is registered, a copy of the death certificate is sent from the General Register Office (GRO) to the Office for National Statistics (ONS) and UK Health Security Agency (UKHSA) where the information is processed, quality assured and analysed.

Our analysis is based on deaths by date of occurrence because this allows us to understand associations between deaths and weather patterns at, or around, the time of death.

We included all occurrences of deaths that were registered up until the end of 2022. Because of registration delay, some deaths that occurred in 2022 are not included in our analysis. This will affect the later months of 2022 most; therefore, the estimated cold-related deaths for 2022 are likely to be underestimated. December 2022 especially saw a large number of deaths registered in early 2023. This can be seen by comparing the number of death occurrences in December 2022 between our December 2022 Monthly Mortality Analysis bulletin and our most recent Monthly Mortality Analysis bulletin. Moreover, only death records with complete information for date of death and residential postcode upon death were included in our analysis.

For more information on our mortality data please refer to our User guide to mortality statistics.

We used all death in England and Wales, between 1988 and 2022, to produce information about the number of deaths, and when they occurred, over time. This allows us to understand associations between deaths and weather patterns at, or around, the time of death.

8 . Strengths and limitations

This analysis focuses on temperatures at or around the time of death. Extreme weather can influence mortality risk in other ways, for example through flooding, where temperatures may be within the normal range. This analysis does not offer a complete view of all deaths caused by direct and indirect effects of temperature.

This analysis also does not consider potential future changes in temperature. For example, a shift towards more extreme temperatures would likely lead to an increase in attributable deaths. Our analysis focuses on temperatures observed from 1988 to 2022 and does not consider more recent temperature data.

We have adjusted for other factors influencing mortality, such as pollution, where possible. However, it is important to note that the Daily Air Quality Index (DAQI) is a summary measure and does not capture all the variations in pollutants over the study period, across England and Wales.

9 . Future developments

This analysis focusses on temperature effects on mortality, but further work is needed to understand broader health implications, for example temperature effects on existing conditions and hospital admissions.

The direct causes of death can vary in different temperatures, further work is needed to understand causes of death associated with extreme heat compared with extreme cold, for example.

10 . Related links

Deaths registered weekly in England and Wales
Bulletin | Released weekly
Provisional counts of the number of deaths registered in England and Wales, including deaths involving coronavirus (COVID-19), in the latest weeks for which data are available.

Excess mortality during heat-periods: 1 June to 31 August 2022
Article | Released 7 October 2022
Joint analytical article between the Office for National Statistics (ONS) and UK Health Security Agency (UKHSA) on deaths during heat-periods in 2022.

Winter mortality in England and Wales: 2021 to 2022 (provisional) and 2020 to 2021 (final)
Bulletin | Released 19 January 2023
Winter mortality compares the number of deaths that occurred in the winter period (December to March) with the average of the non-winter periods (the preceding August to November and following April to July). We present data by sex, age, cause of death, region and place of death.

11 . Cite this statistical bulletin

Office for National Statistics (ONS), released 22 September 2023, ONS website, statistical bulletin, Climate-related mortality, England and Wales: 1988 to 2022