Office for National Statistics

Article

# Climate-related mortality and hospital admissions, England and Wales: 2001 to 2020

Counts and rates of deaths and hospital admissions associated with temperature for England and Wales from 2001 to 2020.

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## Correction

### 18 February 2022 15:00

We have corrected errors in section 5. Changes in deaths from conditions associated with warmer and colder days in Table 1, Table 2, Figure 3 and their in-text references. The previous version included causes of death that were not statistically significant. It should have only included statistically significant causes.

We have corrected an error in section 5 under the heading changes in deaths from conditions associated with warmer and colder days in Figure 1. The previous version included data from Wales for Annual - deaths related to climate and Annual - all cause deaths. It should have included data from England and Wales. This happened because of a human error.

# Notice

## 11 May 2022

Please note an error has been identified in calculating the number of "fewer cold days" in the period 2001 to 2020. This has resulted in a significant overestimate in the number of fewer cold day deaths. This happened because of human error.

We are also working to improve the methodology used to estimate "Climate-related mortality and hospital admissions" in response to external reviews. We are working on an update and will publish further information as soon as we are assured of the data quality and methods used.

In the meantime, we advise not to use any of the content in this publication, including accompanying datasets, while we improve the quality of this analysis. This is an Experimental Statistic, and we are still developing our understanding of this topic by working with other experts to improve our methodology.

Please contact climate.health@ons.gov.uk for more information.

# Table of contents

# 1 . Overview

This article estimates the change in deaths and hospital admissions associated with rising average temperatures in England and Wales in 2001 to 2020; the trends are relevant to climate change but may also reflect other factors such as improved healthcare and housing.

These experimental statistics are a step towards regular, transparent Office for National Statistics (ONS) estimates of climate-health impacts, which are diagnosis-specific and inform policy-makers and the public. Our methods will develop over time and should be read alongside important government reports and the scientific literature on climate risk.

We found relatively little increase in deaths caused by warmer weather and a reduction in deaths caused by cold winters, leading to a net decrease in deaths; in contrast, there was a net increase in hospital admissions linked to warmer weather, especially from injuries.

Previous research has linked warmer weather to injuries from outdoor activities, increased violence and mental health problems; direct harm from extreme heat is still less common but this is likely to change over time.

Our findings are consistent with previous research and confirm that the warming trajectory predicted by climate scientists is already affecting health in England and Wales; however, in the UK's cool-to-temperate climate, the mortality impact is limited and appropriate policy and behaviour changes could mitigate much of the health risk from increasing temperatures.

This analysis is retrospective and does not indicate future impacts of climate on health in the UK; as average temperatures increase, more heatwaves and extreme weather events are expected, which is likely to cause greater harm to health.

These statistics are designated as Experimental Statistics and are not directly comparable with publications on excess winter mortality or the effects of heatwaves in future. For further information please see the Data sources and quality section.

# 2 . Climate change and its effects on health

Climate change is a substantial threat to human health in the UK and globally through direct and indirect mechanisms. Heatwaves, wildfires, droughts, floods and severe storms – accepted to be linked to climate change – have increased globally in recent years.

The UK has a temperate climate, but average temperatures have risen over time. The Met Office found that the period 1991 to 2020 was 0.9 degrees Celsius warmer than the 1961 to 1990 average, while the 10 warmest years recorded occurred since 2002. You can explore these data on the Climate Change Statistics Portal.

Direct measurement of associations between temperature and health is difficult, because of distinct effects of warm versus cold temperatures and mediating factors affecting individual exposure to harms. Attribution of harms specifically to climate change resulting from human activity is not straightforward but methods are increasingly being developed.

Research has identified associations between heatwaves, extreme weather, and health conditions and causes of death including cardiovascular and respiratory conditions. Effects have also been observed on maternal and infant health, violent behaviour and suicide.

Mental health is a growing concern linked to climate change with the risk of death for patients with mental illnesses increasing by approximately 5% for every 1 degree Celsius increase in temperature. Certain medications may increase the relative risk of death by 7% to 8% per 1 degree Celsius increase in temperature above 18 degrees Celsius and people with mental health conditions may be unable to self-care appropriately in extreme weather.

The effects of climate change include increased extreme weather potentially associated with cold temperatures or rainfall, and longer-term health hazards such as sea-level rise. Historical associations between colder weather and mortality are well-known and monitored annually in the UK, and many vulnerable people have similar health conditions to those affected by heat. Numbers of deaths and injuries caused directly by storms and floods in the UK are small. Research on potentially differing trends of health impacts of cold and adverse weather because of simultaneously rising average temperatures and increasing extreme events is inconclusive.

# 3 . What’s included in these estimates

We looked at numbers and rates of deaths in England and Wales associated with changing numbers of warm and cold days over a 20-year period, 2001 to 2020.

We calculated the average number of deaths over the 20-year period on warm days (over 13.8 degrees Celsius) and cold days (under 6.4 degrees Celsius) (thresholds calculated from the central England average daily maximum and minimum temperature 1990 to 2000). These temperature thresholds were then applied to the average daily maximum and minimum temperatures in the period 2001 to 2020. We derived the mean difference over the 20-year period in the number of events per health condition per day associated with higher or lower than average temperature, and the change from the period 1990 to 2000.

We analysed hospital admissions in England using a similar approach, covering accident and emergency attendances and non-scheduled in-patient admissions between 2010 to 2018.

Only diagnoses whose outcome has a known association with temperature are included. A health condition was included if identified as relevant in the scientific literature and showing a statistically significant difference between warm or cold and other days. Statistical associations do not indicate a direct health effect of heat or cold. An indirect method of estimation was used based on the measured statistical association of each cause of death or hospitalisation with days warmer or colder than average and change in number of those days each year compared with the baseline.

For a list of health conditions and more details on methods see Data sources and quality.

For comparison with previous research looking at effects of heat, we also carried out analysis restricted to warm days, over 15.4 degrees Celsius (central England average daily mean temperature) in the four warmest months of the year (June to September). This was to clarify whether increased temperatures in the summer months are associated with increased mortality.

# 4 . What’s not included in these estimates

We did not estimate changes based on "all cause" deaths or admissions, instead focusing on health conditions with a known association with warm or cold temperatures. Therefore, we may not capture all temperature-related health events.

Some health conditions linked to temperature in the scientific literature showed no statistically significant association in our data so were excluded from analysis. For mortality analysis, exclusions were homicide and violence, and natural forces (cold and warm 12-month analysis) and falls, natural forces, homicide and violence, mental health, dehydration and dementia (four warmest months analysis). For hospital admissions, exclusions were Alzheimer's disease and cardiovascular conditions (cold analysis), Parkinson's and cardiovascular conditions (warm analysis), homicide and violence, natural forces, respiratory conditions, and those with less well-defined reasons (four warmest months).

Air pollution is known to be harmful and associated with long-term health issues and there are potential links with climate change. However, there is currently no accepted method to determine what proportion of annual deaths associated with air pollution is contributed by increasing temperatures.

International reports have identified a range of mostly indirect health impacts of climate change, which have been identified as potential future risks to the UK. These include vector-borne diseases, food security issues, effects of salination and land use change because of sea level rise, and wildfires. Deaths and hospital admissions reflect only the most acute impacts, and it will be important in future to develop more sensitive measures of the health impacts, for instance on mental health and chronic illnesses.

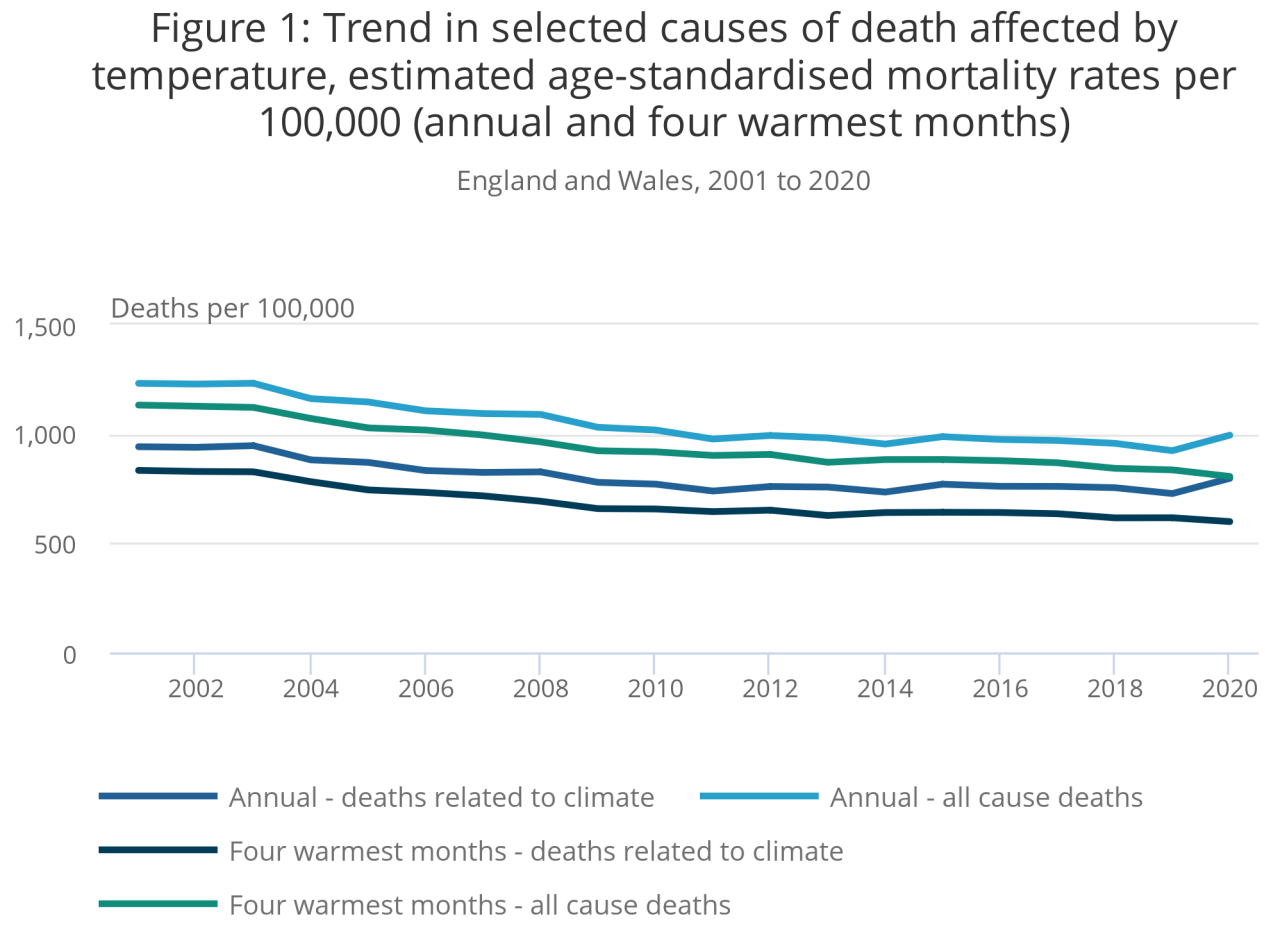
# 5 . Changes in deaths from conditions associated with warmer and colder days

A general decline over the years 2001 to 2020 in the rate of deaths involving causes associated with warm or cold temperatures is shown in Figure 1.

Figures for 2020 should be treated with caution because of coronavirus (COVID-19). This is broadly consistent with the long-term decline in the ONS's annual measure of excess winter mortality, which also showed a rise in 2020 to 2021. The trend when only the four warmest months (June to September) are considered has also been decreasing for England and Wales, although this decline slowed since 2009.

**Figure 1: Trend in selected causes of death affected by temperature, estimated age-standardised mortality rates per 100,000 (annual and four warmest months)**

**England and Wales, 2001 to 2020**




**Source: Office for National Statistics – Death registration data for England and Wales**

**Notes:**

1. Mortality rates per 100,000 population standardised to the 2013 European Standard Population. Age-standardised rates are used for comparison between populations which may contain different proportions of people of different ages.

2. Figures are for deaths occurring rather than deaths registered each year.

3. Figures exclude deaths of non-residents.

4. Rates for the four warmest months have been annualised to be comparable with the annual rates.

Over a 20-year period the estimated change in deaths associated with warm or cold temperature was a net decrease of 555,094, an average of 27,755 deaths per year (Table 1). A decrease in deaths from outcomes associated with cold temperature greatly outnumbers deaths associated with warm temperature.

Warmer weather in the UK rarely reaches temperatures that cause direct heat-related harms. While the reduction in deaths may relate to climate change, some evidence also suggests the population has reduced vulnerability to cold, see more detail in the Discussion section.

Figures for England and Wales separately are included in the Datasets.

Table 1: Total change in selected causes of death affected by temperature, estimated counts
England and Wales, 2001 to 2020

| | 2001 to 2020 | | | Average per year | | |
|---|---|---|---|---|---|---|
| | Change in deaths | Minimum | Maximum | Change in deaths | Minimum | Maximum |
| **More warm days** | -45,538 | -47,820 | -43,257 | -2,277 | -2,391 | -2,163 |
| **Fewer cold days** | -509,556 | -537,670 | -481,441 | -25,478 | -26,884 | -24,072 |
| **Net change** | -555,094 | -585,490 | -524,698 | -27,755 | -29,275 | -26,235 |

Source: Office for National Statistics – Death registration data for England and Wales

Notes

1. See Figure 1 notes 2 and 3.
2. Causes of death included are detailed in Table 5.
3. Warm days are defined as above 13.8 degrees Celsius and cold days below 6.4 degrees Celsius.

An analysis restricted to warm days in the four warmest months of the year showed an increase of 1,643 deaths, an average of 82 per year (Table 2). Excess deaths because of heat are expected to rise in future with accelerating climate change as mentioned in the Discussion.

Table 2: Total change in selected causes of death affected by temperature in the four warmest months, estimated counts
England and Wales, 2001 to 2020

| | 2001-2020 | | | Average per year | | |
|---|---|---|---|---|---|---|
| | Change in deaths | Minimum | Maximum | Change in deaths | Minimum | Maximum |
| **More warm days** | 1643 | 1011 | 2275 | 82 | 51 | 114 |

Source: Office for National Statistics – Death registration data for England and Wales

Notes

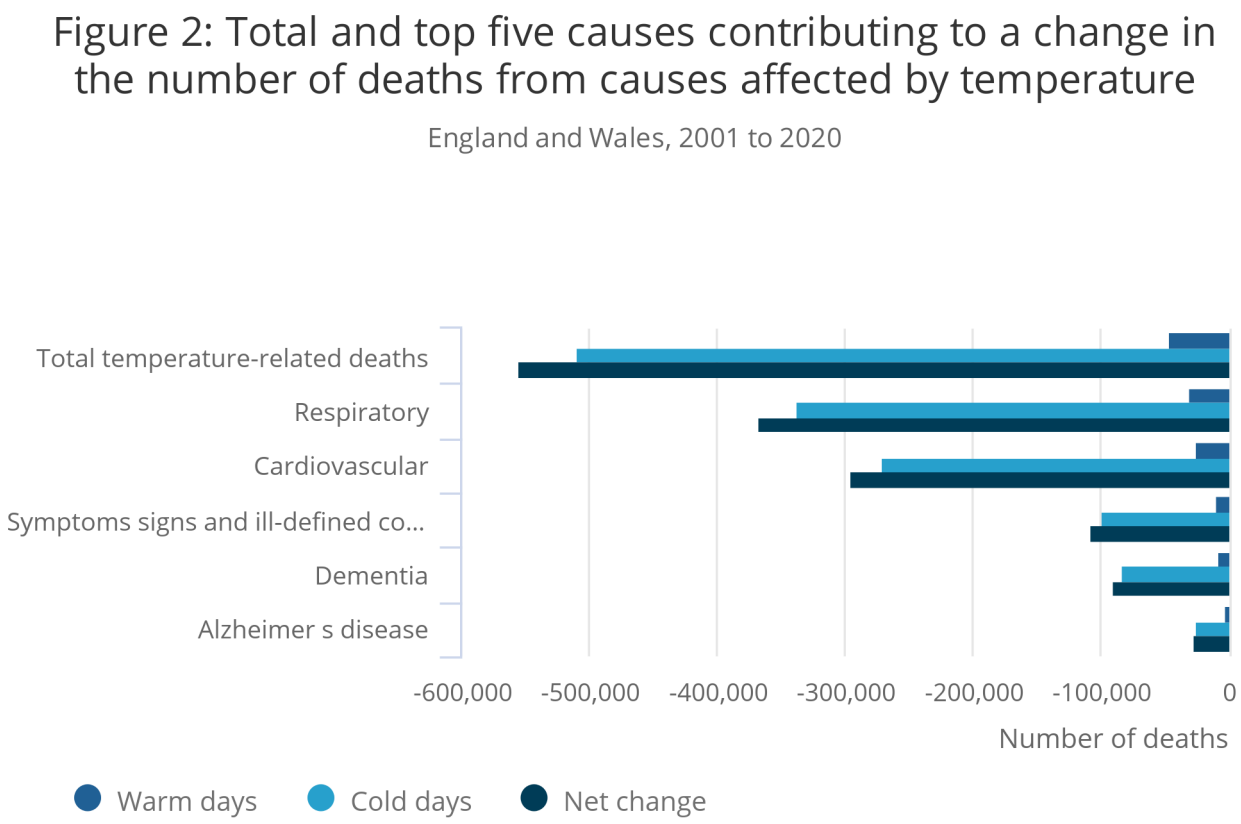
1. For footnotes see Table 1.
2. Warm days for this analysis are defined those with an average above 15.4 degrees Celsius.

The change in the number of deaths by conditions mentioned on the death certificate (there can be more than one mention per death) is shown in Figure 2. For "total temperature-related deaths" each death was counted once, even if multiple conditions were mentioned.

More warm days and fewer cold days reduced the number of deaths. Fewer cold days (warmer winters) has a relationship with reducing deaths, however, attributing causality is complex and expanded on in the Discussion.

**Figure 2: Total and top five causes contributing to a change in the number of deaths from causes affected by temperature**

**England and Wales, 2001 to 2020**




**Source: Office for National Statistics – Death registration data for England and Wales**

**Notes:**

1. See Figure 1, notes 2 and 3 and Table 1, notes 2 and 3.

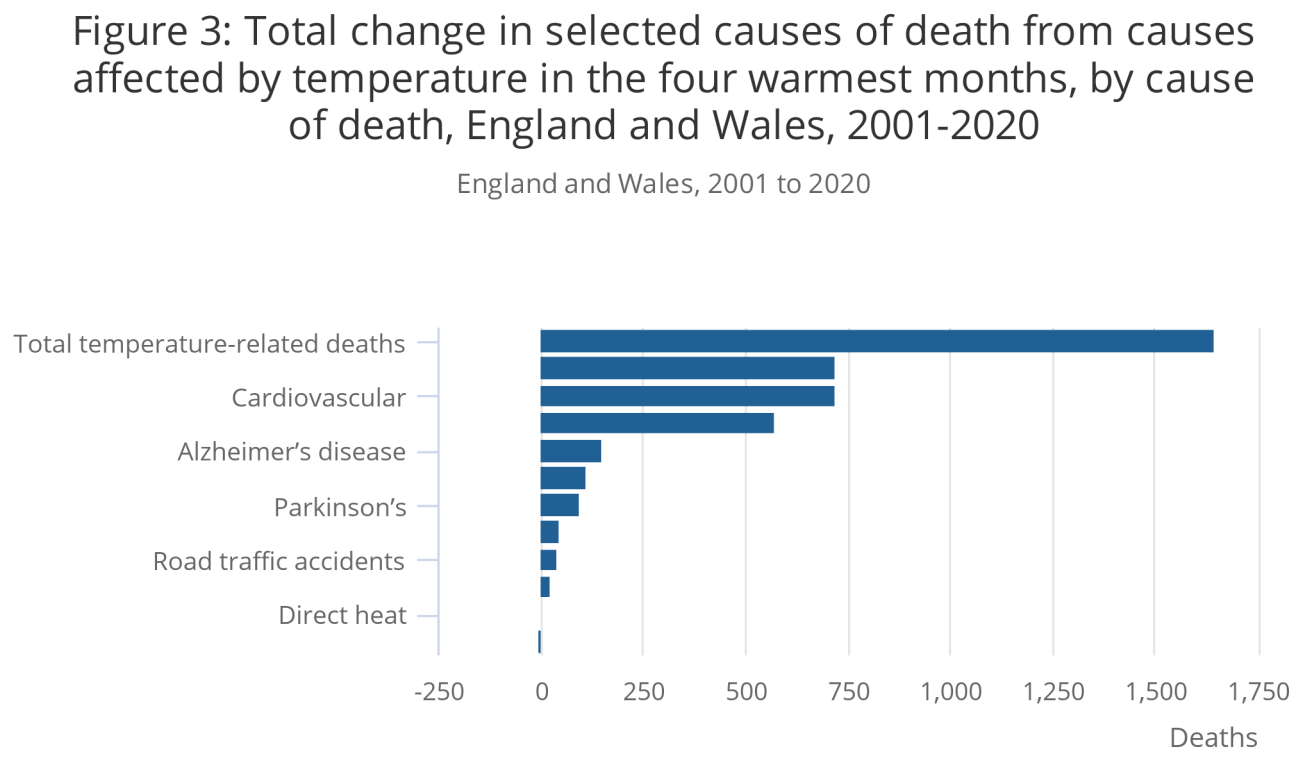
2. For "total temperature-related deaths" each death was counted only once even if more than one relevant condition was mentioned.

3. Counts are the average over the period 2001 to 2020.

Analysis for the four warmest months of the year is shown in Figure 3. This shows an increase in the number of deaths associated with increased warm days. Cardiovascular and respiratory related deaths were the biggest contributors (43.7% and 43.8% respectively).

**Figure 3: Total change in selected causes of death from causes affected by temperature in the four warmest months, by cause of death, England and Wales, 2001-2020**

**England and Wales, 2001 to 2020**




**Source: Office for National Statistics – Death registration data for England and Wales**

**Notes:**

1. See Figure 2.
2. This analysis is for warm days, which are above 15.4 Celsius.
3. Counts are the average over the period 2001 to 2020.

# 6 . Changes in hospital admissions from conditions associated with warmer and colder days

Analysis for hospital admissions covers nine years (England only).

There were 108,722 extra hospitalisations (episodes) associated with warm days compared with the baseline (12,086 per year). After considering a decrease in episodes associated with cold days (Table 3), the net increase was 72,121 (8,013 per year).

Analysis for the four warmest months of the year highlights admissions affected by increasing temperatures. This showed 16,020 more episodes in the period 2010 to 2018 associated with warmer days than the baseline (1,780 per year) (Table 4).

Table 3: Total change in selected reasons for hospital admission affected by temperature, estimated counts England, 2010 to 2018

| | 2010 to 2018 | | | Average per year | | |
|---|---|---|---|---|---|---|
| | **Extra admissions** | **Minimum** | **Maximum** | **Extra admissions** | **Minimum** | **Maximum** |
| **More warm days** | 108,772 | 74,768 | 142,676 | 12,086 | 8,308 | 15,853 |
| **Fewer cold days** | -36,601 | -24,902 | -48,300 | -4,067 | -2,767 | -5,367 |
| **Net change** | 72,121 | 49,866 | 94,375 | 8,013 | 5,541 | 10,486 |

Source: Office for National Statistics – Daily admissions and first episodes in Hospital Episode Statistics (HES) data

Notes

1. Figures are based on diagnoses given during an admission or first episode.
2. Diagnoses included are detailed in Table 5.
3. Warm days are those where the average maximum was above 13.8 degrees Celsius and cold days where average minimum was below 6.4 degrees Celsius.

Table 4: Total change in selected reasons for hospital admission affected by temperature in the four warmest months, estimated counts
England, 2010 to 2018

| | 2010 to 2018 | | | Average per year | | |
|---|---|---|---|---|---|---|
| | **Extra admissions** | **Minimum** | **Maximum** | **Extra admissions** | **Minimum** | **Maximum** |
| **More warm days** | 16,020 | 4,593 | 27,448 | 1,780 | 510 | 3,050 |

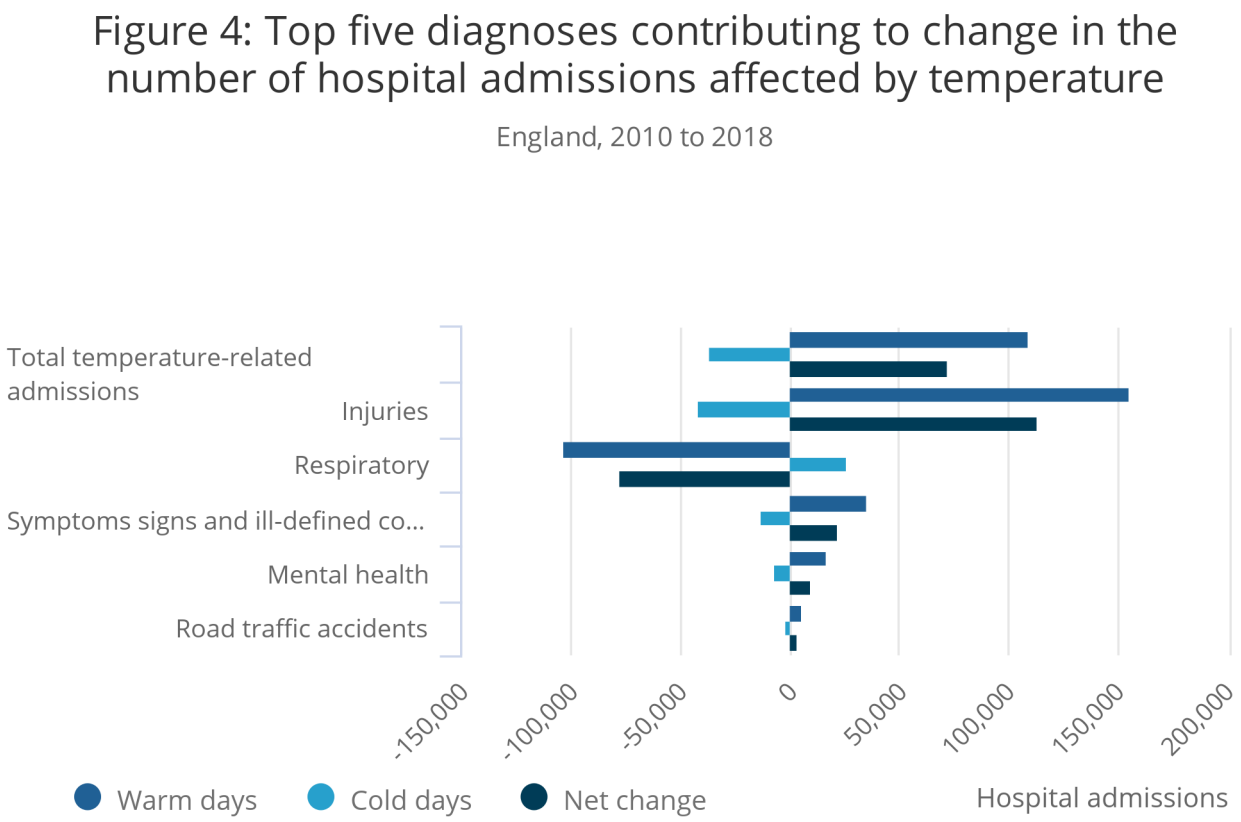
Source: Office for National Statistics – Daily admissions and first episodes in Hospital Episode Statistics (HES) data

Notes

1. For footnotes see Table 3.
2. Warm days for this analysis are those where daily mean was above 15.4 degrees Celsius.
3. Rates are the average over the period 2010 to 2018.

**Figure 4: Top five diagnoses contributing to change in the number of hospital admissions affected by temperature**

**England, 2010 to 2018**




**Source: Office for National Statistics – Daily admissions and first episodes in hospital episode data**

**Notes:**

1. Figures are based on diagnoses given during an admission or first episode.

2. Diagnoses included are detailed in Table 5.

3. Warm days are those where average maximum was above 13.8 degrees Celsius and cold days where average minimum was below 6.4 degrees Celsius.

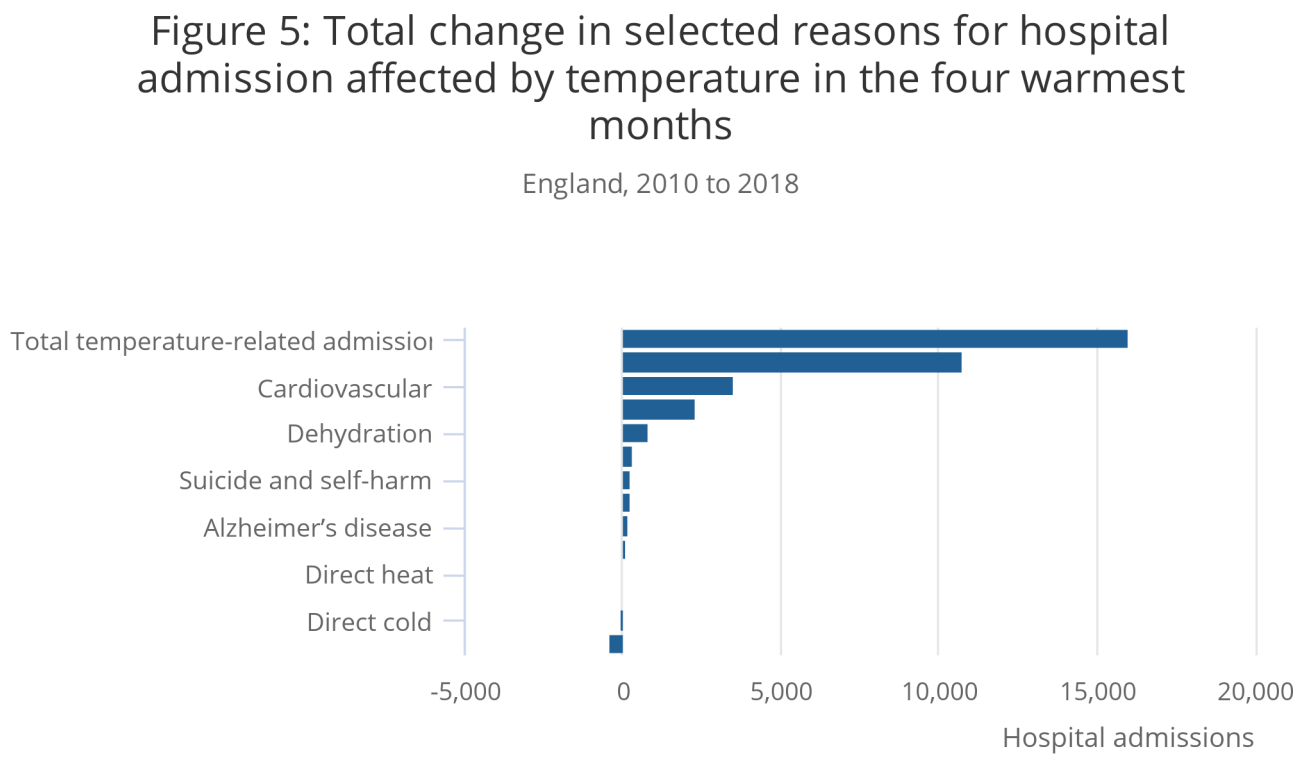
4. For "total temperature-related admissions" each admission was counted only once even if more than one relevant condition was mentioned.

The change in hospital admissions by diagnosis (conditions diagnosed in first episode) is shown in Figure 4. For "total temperature-related admissions" even if multiple conditions were mentioned on an admission, it was only counted once. More warm days have increased admissions, above the number fewer cold days can counteract.

Analysis of the four warmest months of the year is shown in Figure 5. Increasing admissions are associated with increased warm days. Injuries and cardiovascular-related deaths were the biggest contributors.

**Figure 5: Total change in selected reasons for hospital admission affected by temperature in the four warmest months**

**England, 2010 to 2018**




**Source: Office for National Statistics – Daily admissions and first episodes in hospital episode data**

**Notes:**

1. See Figure 4.
2. This analysis only looks at warm days, which for this analysis are those above 15.4 degrees Celsius.

# 7 . Discussion

Globally, human-induced climate change has been estimated to account for 37% of heat-related deaths (1% in the UK.) Initial reductions in deaths because of milder winters have been predicted to be outweighed by increases in heat-related mortality.

Estimates suggest 257% extra heat-related deaths and a 2% decline in cold-related deaths by the 2050s. Our preliminary findings are similar, although we have found greater decreasing cold-related mortality.

Cold-related health impacts have declined over the last century. There is evidence that factors other than climate change may have driven reductions in cold-related mortality. Some evidence suggests that improvements in socioeconomic circumstances, health infrastructure and behavioural adaption have reduced vulnerability to cold, however, the attribution of causality remains complex.

Heat-related respiratory admissions in Europe are estimated to be 26,000 annually between 2021 and 2050 compared with 11,000 between 1981 and 2010. Our findings are similar, with an increase of 108,772 over nine years. Global projections of heat-related deaths because of climate change and our results suggest that climate change will have negative impacts to human health in the UK in the future. It will be important to develop more sensitive measures of the health impacts, for instance on mental health and chronic illnesses.

# 8 . Climate-related mortality and hospital admissions data

Climate-related mortality and hospital admissions, England and Wales
Dataset | Released 17 January 2022
Counts and rates of deaths and hospital admissions because of climate event-related mortality for England and Wales from 2001 to 2020.

# 9 . Glossary

## Age-standardised mortality rates

Age-standardised mortality rates (ASMRs) are used to allow comparisons between populations that may contain different proportions of people of different ages. The 2013 European Standard Population is used to standardise rates. In this article, we have adjusted the weekly ASMRs to allow for comparisons with annual rates.

## Registration delay

Mortality statistics are compiled from information supplied when deaths are certified and registered as part of civil registration, a legal requirement. According to the Births and Deaths Registration Act 1953, a death should be registered within five days unless it is referred to a coroner for investigation. Mortality statistics for a given time period can be based on occurrence (death date) or registration (registration date); registration delay is the difference between date of occurrence and date of registration.

## Statistical significance

The term "significant" refers to statistically significant changes or differences. Significance has been determined using the 95% confidence intervals, where instances of non-overlapping confidence intervals between estimates indicate the difference is unlikely to have arisen from random fluctuation.

### 95% confidence intervals

A confidence interval is a measure of the uncertainty around a specific estimate. If a confidence interval is 95%, it is expected that the interval will contain the true value on 95 occasions if repeated 100 times. As intervals around estimates widen, the level of uncertainty about where the true value lies increases. The size of the interval around the estimate is strongly related to the number of deaths, prevalence of health states and the size of the underlying population. At a national level, the overall level of error will be small compared with the error associated with a local area or a specific age and sex breakdown. More information is available on our uncertainty pages.

## 10 . Data sources and quality

The data used were:

- Daily deaths occurring in years 2001 to 2020 from death registration data for England and Wales
- Daily admissions and first episodes in hospital episode data for England in 2010 to 2018, where:
- A&E attendance was not a planned follow-up
- admitted patient care episode was the first in the series and the admission was not pre-planned
- Mean, minimum and maximum daily temperatures (1990 to 2020) from Met Office Hadley Centre – Central England Temperature Data

A literature search was conducted to identify conditions linked with climate change (temperature) relevant to England and Wales. These were matched to the relevant International Classification of Diseases (ICD-10) codes (Table 5). An event was included where any relevant codes were mentioned on the death certificate or diagnoses.

Table 5: ICD-10 codes used in this article

| Health conditions | ICD-10 codes |
|---|---|
| **Alzheimer Disease** | G30 |
| **Cardiovascular** | I00-I42, I50-I51, I60-I99 |
| **Cold weather** | P80, T33-T35, T68-T69, X31 |
| **Dehydration** | E86, X54 |
| **Dementia** | F01, F03 |
| **Drowning** | W67-W74 |
| **Falls** | W00, W01-W04, W09-W19 |
| **Hot weather** | T670-T679, X30, X32 |
| **Injuries/fractures/broken bones** | S00-S99, T00-T14 |
| **Mental health** | F10-F63, F67-F89, F99 |
| **Natural forces** | T750, X33-X34, X36-X39 |
| **Parkinson Disease** | G20 |
| **Respiratory** | J00-J22, J30, J39, J40-J84, J96-J99 |
| **Road traffic accidents** | V01-V89 |
| **Suicide/self-harm** | X60-X84, Y10-Y34 |
| **Violence** | X85-Y09, U50.9 |

Source: Office for National Statistics

We defined "warm" days as those where the Central England maximum temperature was above 13.8 degrees Celsius and "cold" days as those where the minimum temperature was below 6.4 degrees Celsius. These temperatures were calculated from the average maximum and minimum daily temperature in a baseline period 1990 to 2000.

We took as "expected" the number of warm and cold days per year in 1990 to 2000 and as "observed" the numbers of warm and cold days in 2001 to 2020. The "change in warm or cold days" was the difference between the total observed warm or cold days and the expected days if the average in the baseline period continued. The average difference in deaths per day over the 20 years in the period 2001 to 2020 for each cause of death between warm or cold days and "not warm or cold" days was calculated and multiplied by the change in warm or cold days to give the observed "change in deaths". Confidence intervals were calculated to show the potential minimum and maximum change at a 95% confidence level.

The same method was repeated for the analysis of hospital admissions, years 2010 to 2018.

For the warmest four months, calculations were restricted to days and events in June to September each year. The temperature used to define "warm" days was 15.4 degrees Celsius (calculated from the baseline average mean temperature). Cold days were not analysed separately.

### Experimental Statistics

These statistics are designated as Experimental Statistics: they are in the testing phase and are not yet fully developed nor submitted for assessment to the UK Statistics Authority. We welcome discussion on methods and findings, including suggestions for development, by email to climate.health@ons.gov.uk.

This article is a step towards regular, transparent Office for National Statistics estimates of climate-health impacts, which are diagnosis-specific and inform policy-makers and the public. Our methods will develop over time and should be read alongside main and scientific literature on climate risk.

These experimental statistics are not directly comparable with publications on excess winter mortality or the effects of heatwaves in future. We have used temperature to measure climate over the period 1990 to 2000 and 2001 to 2020.

## 11 . Limitations and future developments

We assumed that:

- in a temperate climate, temperature variation within average bounds is unlikely to have acute clinically significant effects
- outside those bounds, temperature-related effects on health are not limited to extreme events

A conservative approach was taken by including health conditions supported by literature and showing a significant relationship to temperature in our data. This may mean the observed effects are being underestimated. Additionally, different results may have been found by using varying baselines and time periods.

We used published Central England temperatures, so associations between temperature and events are likely to be less clear than with local temperature measurements. We also used a single temperature threshold for all health conditions. Future analyses will address these limitations, relating deaths and admissions to local temperatures and exploring different criteria per health condition. We will also look at disaggregation of the results by sex, age and other available characteristics. We additionally plan to explore parameters that measure the heat gain or loss endured by persons outdoors and dwellings (impacting indirectly persons indoors) such as radiant temperature, wind chill, humidity and evaporation.

The focus was on temperature, but climate change-related events may also be associated with extreme weather that can fall within average temperatures, such as rainfall and flooding. In future we will explore these using rainfall measures and flood reports.

# 12 . Related links

Independent Assessment of UK Climate Risk (CCRA3))
Webpages
Comprehensive assessment of the risks and opportunities facing the UK from climate change.

Understanding the health effects of climate change
Blog | Released 9 November 2021
Blog from Dr Isabel Oliver on the main health challenges to the UK and the UK Health Security Agency's activities to tackle them.

Public Health England heatwave mortality monitoring
Webpages
Reports on the surveillance of excess mortality during periods of heatwave.

Excess winter mortality in England and Wales
Bulletin | Released 26 November 2021
More people die in the winter than the summer. Office for National Statistics data by sex, age, region, cause of death and place of death.