The impact of climate change on future mortality in the UK

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Key Takeaways

RGA conducted a thorough review of the academic literature to assess the possible impact climate change could have on future mortality in the UK in 2050 under two scenarios: a “middle of the road” emissions scenario and an “unconstrained growth and energy use” high-emissions scenario.

For those physical risks where the impact could be estimated, two key risks were identified:

1. Increasing average temperatures could reduce mortality by 0.4%-0.5%, depending on the scenario
2. Reduced air pollution could reduce mortality by 1.3%.

The impact of climate change on mortality linked to food insecurity could be material, but it was not possible to quantify. All other physical risks are expected to have a relatively immaterial mortality impact.

The overall impact of quantifiable physical risks on mortality in the UK is anticipated to be relatively modest, with annual population deaths potentially reduced by 1.5%-1.6% in 2050, depending on the scenario, before allowing for adaptation measures.

However, transition policies could have a significant impact. The transition to a lower-carbon economy could have economic consequences that positively or negatively impact mortality, but it is not possible to quantify this because of the significant uncertainties involved. Transition policies could also have a significant positive impact on diet and active travel, leading to improved health and lower mortality, although this could be difficult to achieve, as it would require widespread behavioural change and significant infrastructure investment.

The relatively modest positive mortality impact from currently quantifiable physical risks may be counter to expectations of a negative impact on mortality. However, some risks that are currently too uncertain to be quantified could have a materially negative impact on mortality.

Importantly, these findings do not absolve societies from taking action – both in the UK and globally – to limit greenhouse gas emissions and future climate change impacts.

Introduction

Estimates from the World Economic Forum (WEF), made in collaboration with Oliver Wyman, suggest climate change could lead to an extra 14.5 million deaths worldwide by 2050 under a "middle of the road" greenhouse gas emissions scenario, driven by floods, droughts, heatwaves, and tropical storms.[1]

To a first-order approximation, the WEF/Oliver Wyman estimates imply that annual average global mortality rates could increase by around 1% by 2050.

Vulnerability to these climate change risks varies by region; thus, if the average impact is 1%, some regions may see a significantly higher increase in mortality rates.

RGA reviewed academic literature to assess the possible impact climate change could have on future mortality in the UK by 2050 under two scenarios:

1. The SSP2-4.5 "middle of the road" emissions scenario
2. The SSP5-8.5 "unconstrained growth and energy use" high-emissions scenario

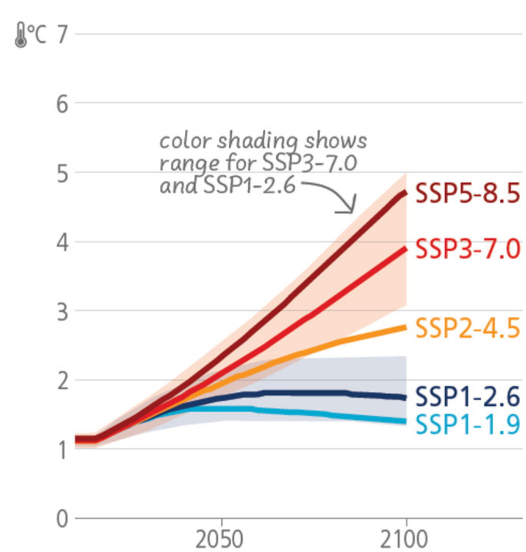
These are two of five scenarios used in the Intergovernmental Panel on Climate Change's Sixth Assessment Report (IPCC AR6) to illustrate potential climate futures.

The "middle of the road" emissions scenario reflects the SSP2 shared socioeconomic pathway, under which there are medium challenges to climate mitigation and adaptation. In this scenario, social, economic, and technological trends do not shift markedly from historical patterns.[2]

The "unconstrained growth and energy use" high-emissions scenario reflects the SSP5 shared socioeconomic pathway, under which there are high challenges to climate mitigation but low challenges to climate adaptation. In this scenario, abundant fossil fuel resources are exploited, and resource- and energy-intensive lifestyles are adopted globally, but local environmental problems such as air pollution are successfully managed through innovation and technological progress.

Figure 1 shows average global surface temperatures relative to the pre-industrial (1850-1900) average. In 2050, global surface temperatures are projected to be around 1.9°C and 2.3°C warmer than the pre-industrial period under the SSP2-4.5 and SSP5-8.5 scenarios, respectively. However, warming scenarios often refer to 20-year averages, and the increase in the 20-year average by 2050 under these scenarios is lower relative to the pre-industrial period at 1.7°C and 2.0°C, respectively.

Figure 1: Global average surface temperature change relative to 1850-1900



IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, 184 pp., doi: 10.59327/IPCC/AR6-9789291691647. Short extracts from this publication may be reproduced without authorization provided that complete source is clearly indicated.

The physical risks considered in this report that could impact future mortality are:

- Average temperatures
- Noncompensable heat stress
- Air pollution
- Droughts
- Floods (extreme rainfall)
- Food security
- Vector-borne diseases
- Storms, storm surges (coastal flooding), and sea level rise

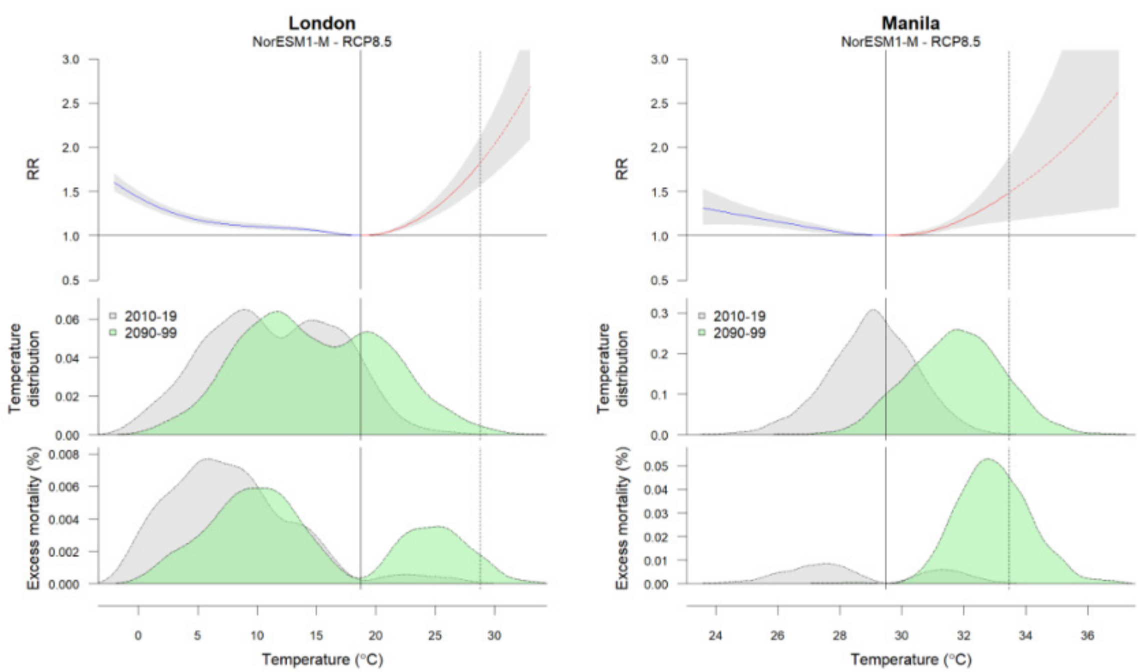
We will also consider the potential mortality impact associated with transition policies that could affect the economy or improve diet and active travel.

Average temperatures

Figure 2 illustrates the general U-shaped temperature-mortality relationship now well established in the academic literature. Relative mortality risk is minimised at a location-specific optimum temperature. When temperatures fall below the optimum level, relative mortality risk increases. These are referred to as 'cold-related' deaths. When temperatures rise above the optimum level, mortality risk increases. These are referred to as 'heat-related' deaths.

The optimum temperature varies by location. It is generally higher in warm regions and lower in cold regions because populations acclimatise to local temperatures.

Figure 2: Temperature and excess mortality in different climates, illustrated using estimates for London and Manila; see Gasparrini et al. (2017) for a full description



Extracted from Gasparrini et al. (2017), available under CC BY 4.0. No changes have been made.

The top graphs illustrate the temperature-mortality relationship in each city, with the solid vertical line indicating the temperature at which mortality risk is minimised. The middle row of graphs shows the temperature distribution for the period 2010-19 (in grey) and projected over 2090-99 (green). The bottom graphs show the resulting distribution of excess mortality arising from non-optimal temperatures relative to the minimum risk temperature.

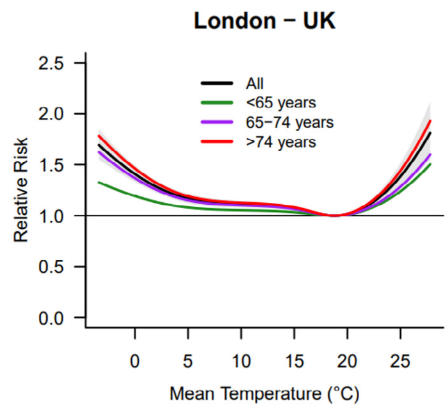
With rising temperatures, the number of cold-related deaths is expected to decline, while heat-related deaths increase.

Chen et al. (2024) have estimated the temperature-mortality relationship for 112 UK cities based on data over the period 1995-2014. The relationship for London is illustrated by the black line in Figure 3.

Figure 3 also shows the relationship between temperature and all-cause mortality for different age groups. With increasing age comes increasing risk of both cold- and heat-related mortality.

Gasparrini et al. (2017) estimate that for the period 2010-19 approximately 7.6% of the total mortality burden of the UK was related to non-optimal temperatures. This breaks down as approximately 7.3% cold-related mortality and 0.3% heat-related mortality.

Figure 3: Temperature-mortality relationships in London; see Chen et al. (2024) for a full description



Extracted from Chen et al. (2024), available under CC BY 4.0. No changes have been made.

Chen et al. (2024) assessed the impact of climate change and population aging on future temperature-related excess mortality in the UK. They examined different levels of global warming under the SSP5-8.5 scenario. Their 'climate only' results are shown in Tables 1 and 2. We show 'climate only' results as actuaries are usually most interested in projections of age-specific mortality rates. However, it is important to note the interaction between an aging population and the impact of climate change when considering the overall mortality burden, particularly in areas such as healthcare strain.

Table 1: Change in cold-related mortality at different levels of warming under SSP5-8.5 compared with cold-related mortality from 1995-2014

Warming level (20-year average)	1.5°C	1.7°C	2°C	3°C
Change in cold-related mortality (%)	-0.5	-0.7	-1.0	-1.6

Source: Results for 1.5°C, 2°C, and 3°C of warming above pre-industrial levels (1850-1900) are from Chen et al. (2024). Results for 1.7°C have been estimated by interpolation.

Based on data from IPCC AR6, the 20-year average of the increase in mean surface temperature (relative to 1850-1900) under SSP2-4.5 in year 2050 is 1.7°C. We have included estimated results at 1.7°C of warming in Table 1, derived by simple interpolation.

In what follows, we will use the 2°C warming results from Chen et al. (2024) as an estimate of the impact under SSP5-8.5 in 2050.

The results from Table 1 indicate that the net impact of warming (reducing cold-related mortality) is expected to lead to a reduction in age-specific mortality rates.

Table 2: Change in heat-related mortality at different levels of warming under SSP5-8.5 compared with heat-related mortality from 1995-2014

Warming level (20-year average)	1.5°C	1.7°C	2°C	3°C
Change in heat-related mortality (%)	0.2	0.3	0.5	1.2

Source: Results for 1.5°C, 2°C, and 3°C of warming above pre-industrial levels (1850-1900) are from Chen et al. (2024). Results for 1.7°C have been estimated by interpolation.

The results from Table 2 indicate that the net impact of warming (increasing heat-related mortality) is expected to lead to an increase in age-specific mortality rates and population heat-related deaths.

We can calculate the net impact of the cold- and heat-related mortality from the 'climate only' results of Chen et al. (2024) as follows:

- For the 1.7°C scenario, around a 0.4% reduction (based on the interpolated results)
- For the SSP5-8.5 scenario, around a 0.5% reduction

Therefore, average warming anticipated by 2050 is expected to reduce age-specific mortality rates.

Table 3 summarises the temperature-related impacts assumed for this report.

Table 3: Estimated current population mortality impact from non-optimal temperatures and how this may change by 2050

Physical Risk	**Estimated Current Population Impact** Current annual population deaths estimated to be attributable to risk	**Potential Change by 2050 under SSP2-4.5** Increase/(decrease) in annual deaths estimated to be attributable to risk	**Potential Change by 2050 under SSP5-8.5** Increase/(decrease) in annual deaths estimated to be attributable to risk
Average temperatures • Cold-related • Heat-related • Net impact	 • 7.3% • 0.3% • 7.6%	 • (0.7%) • 0.3% • (0.4%)	 • (1.0%) • 0.5% • (0.5%)

One of the limitations acknowledged by Chen et al. (2024) is that their analysis did not consider potential population adaptation to heat, which can be achieved through:

- **Acclimatisation** - Through repeated exposure to heat, individuals develop a more efficient and effective cooling response, leading to improved thermal comfort.
- **Aerobic training** - The cooling response can strain the cardiovascular system. Improved fitness achieved through aerobic training can help individuals cope with this.
- **Adjusting behaviours** - The impact of periods of extreme heat can be mitigated by reducing physical activity, increasing water intake, and seeking refuge in cool places.
- **Technology** - External cooling can be achieved using air conditioning or electric fans.

Table 4 illustrates the estimated number of heat-related deaths averted by air conditioning (AC) in several countries or regions in 2019.

Table 4: Estimates by country or region of AC- and heat-related mortality in 2019

Country or Region	Households with AC	Heat-related deaths	Heat-related deaths averted by AC	AC-related PM2.5 deaths
Japan	93%	12,400	30,415	162
South Korea	89%	2,500*	5,416	89
China	65%	72,000	69,476	5,027
ASEAN	24%	11,840*	2,678	560
USA	92%	20,500	47,807	557
UK	3%	5,600*	126	46

Data source: 2021 report of The Lancet Countdown. *Indicates average over 2014-2019.

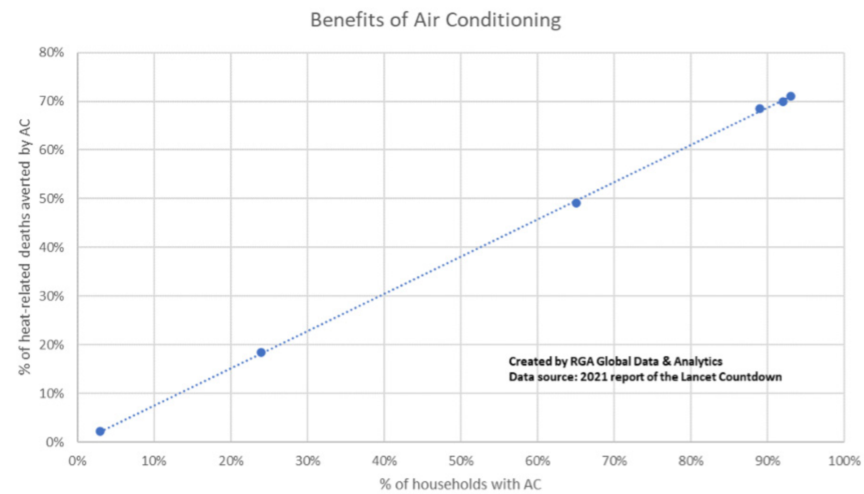
Figure 4 shows a plot of this data with:

- The estimated % of households with AC (x-axis)
- The estimated % of heat-related deaths averted by AC (y-axis)

The data points lie on a line with gradient 75%, implying that AC reduces heat-related deaths by around 75%.

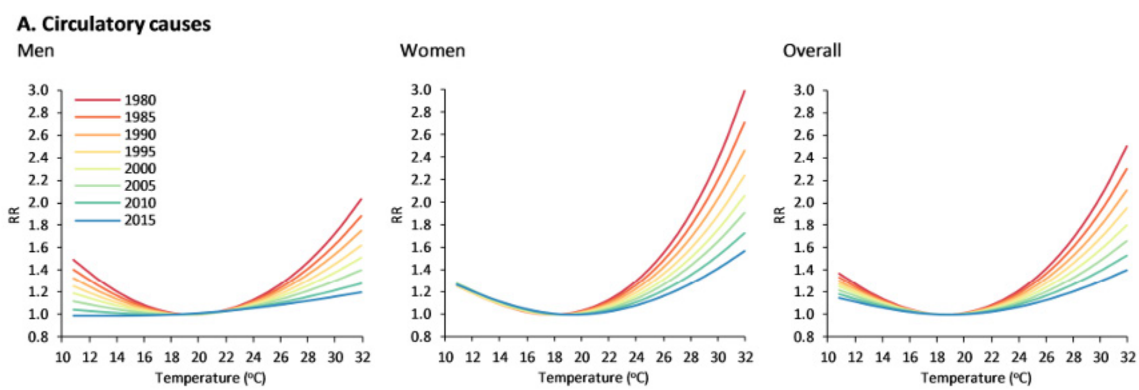
The Lancet estimate of heat-related deaths is approximately 3 times the Gasparrini et al. (2017) estimate quoted earlier, highlighting the uncertainty associated with these estimates. If the analysis included in the 2021 Lancet Countdown report is correct, there is significant scope to increase AC usage in the UK, which would reduce heat-related mortality by nearly 75%.

Figure 4: Plot of data from Table 4 and best-fit line



To illustrate the potential impact of adaptation over time, Figure 5 shows results from Achebak et al. (2018) for how the modelled temperature-mortality relationship for circulatory causes of death changed from 1980-2015 in Spain (data for the UK is not available). Although average temperatures increased over this period, the temperature-mortality risk relationship has reduced for both cold- and heat-related mortality due to adaptation.

Figure 5: Estimated temperature-mortality relationships by calendar year for circulatory causes of death; see Acheback et al. (2018) for a full description



Extracted from Achebak et al. (2018), available under CC BY 4.0. No changes have been made.

Noncompensable heat stress

As temperatures rise, we can expect an increase in periods of extreme temperatures not often seen in the historical record.

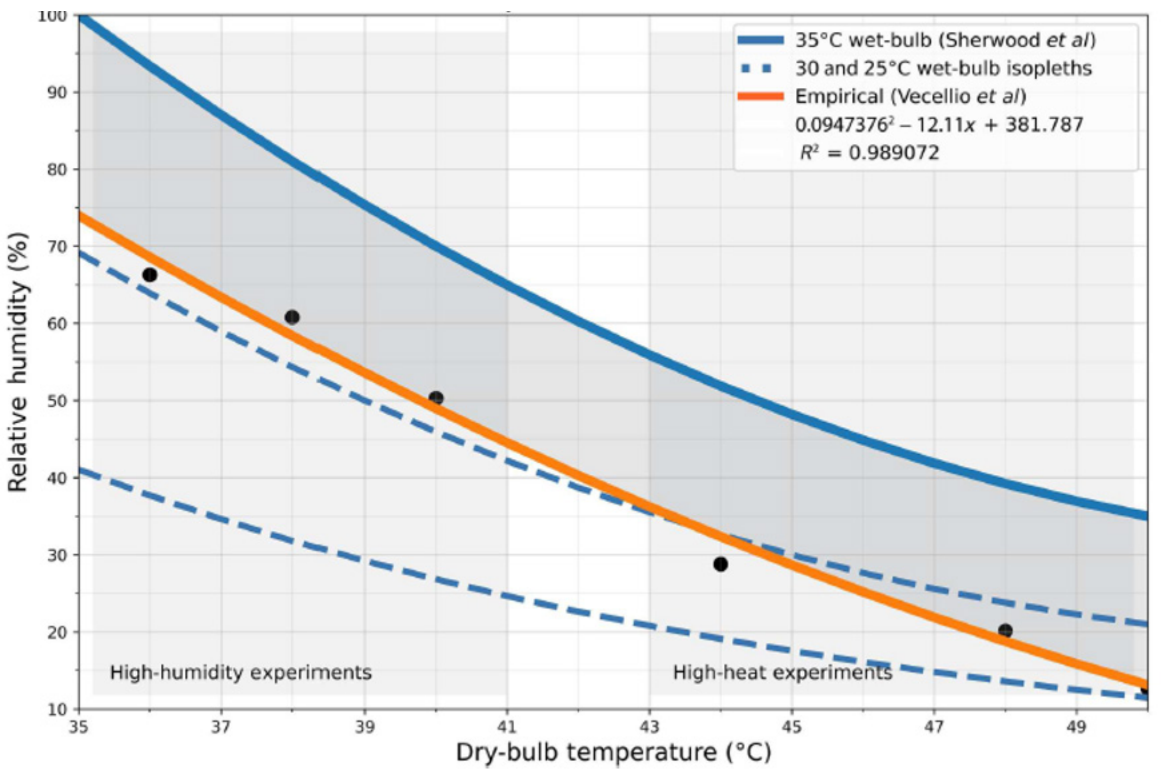
A healthy human core body temperature is 36°C - 37°C. If the temperature reaches 43°C, there is a high risk of death.

Noncompensable heat stress refers to environmental conditions of temperature and humidity under which a healthy human can no longer maintain a stable core body temperature without the assistance of external cooling.

In such conditions, the core body temperature rises by around 1°C per hour. Therefore, six hours of exposure to such conditions will increase core body temperature to a dangerous 43°C.

Noncompensable heat stress conditions are represented by the orange line in Figure 6.

Figure 6: Noncompensable heat stress. Noncompensable heat stress occurs in environments where the combination of dry-bulb temperature and relative humidity lies above the orange line. See Powis et al. (2023) for a full description.

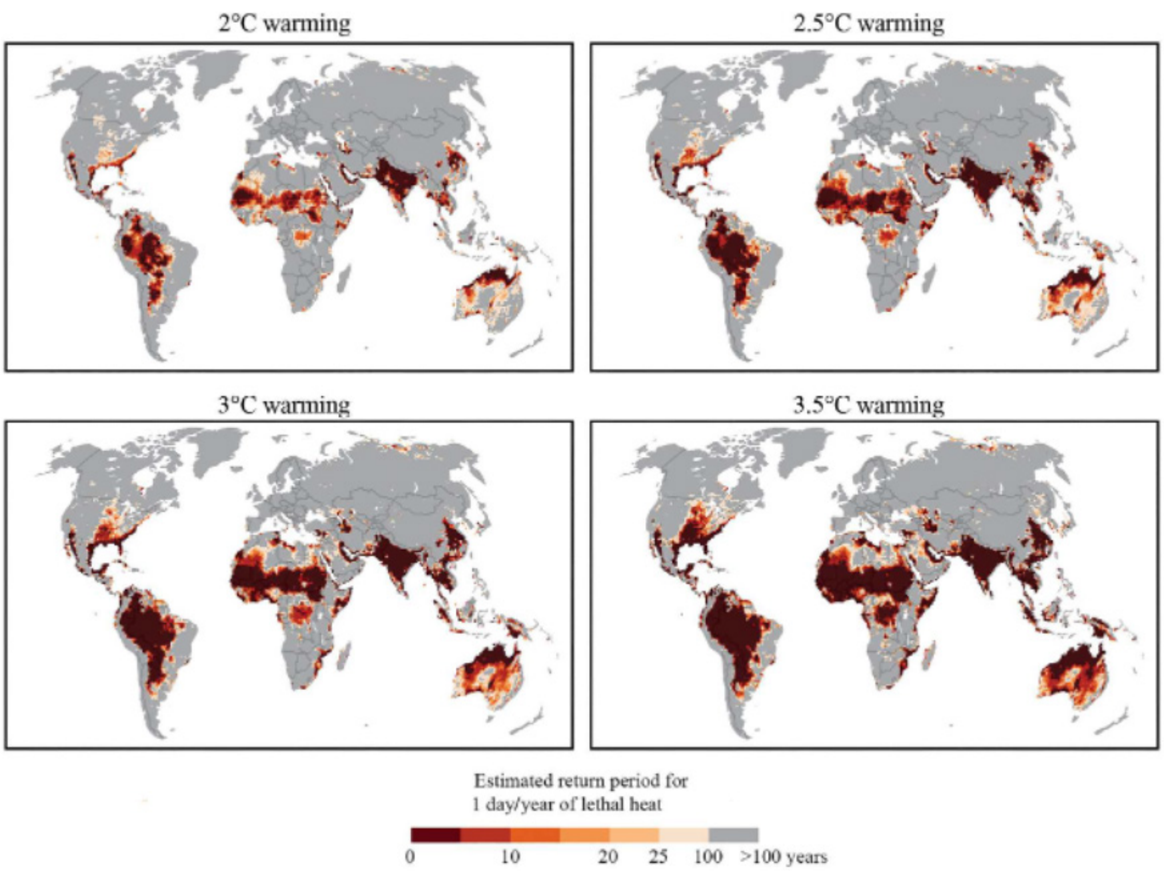


For example, if the dry-bulb temperature – the temperature on a thermometer held in the air – showed 45°C and the environment's relative humidity was 30% or higher, this combination of conditions would be in the noncompensable heat stress danger zone.

Powis et al. (2023) estimated which regions of the world are expected to experience days that include six hours of continuous noncompensable heat stress conditions, together with the expected period between such days, under different scenarios of global warming.

Their results are shown in Figure 7. Darker shades of orange and red indicate areas that would see shorter periods between days experiencing six hours of continuous noncompensable heat stress conditions.

Figure 7: Estimated return periods between days with at least six hours of continuous noncompensable heat stress in a given year; see Powis et al. (2023) for full description. Panels contain results for different global average temperatures above preindustrial levels.



Extracted from Powis et al. (2023), available under CC BY 4.0. No changes have been made, although results for 1°C and 1.5°C warming have been omitted.

Zooming in on the UK, the image in Figure 7 shows that even in the scenario of 2.5°C warming relative to pre-industrial average temperatures (a higher level of warming than expected by 2050 under either the SSP2-4.5 and SSP5-8.5 scenarios) the return period between days with six hours of noncompensable heat stress is more than 100 years.

Therefore, while noncompensable heat stress could be a significant issue for regions such as India, northern Australia, or areas of South America, it is not expected to be a significant issue for the UK by 2050 under the SSP2-4.5 and SSP5-8.5 scenarios.

Air pollution

In this section, we consider:

- The bidirectional link between climate change and air pollution
- The mortality impacts of air pollution
- Air pollution levels in the UK
- UK air pollution and mortality projections in 2050

The bidirectional link between climate change and air pollution

Climate change may impact air pollution in several ways:

- Changes in atmospheric composition due to greenhouse gases can impact ozone produced from the oxidation of methane.
- Changes in temperature, humidity, light, and precipitation can have an impact on the photochemical production and destruction of air pollutants.
- Changes in circulation and weather patterns can alter the accumulation and dispersion of pollutants.
- Changes in climate can affect the natural emissions from soils, vegetation, wildfires, and lightning.

IPCC AR6 states there is "medium confidence" in only a small effect of climate change on the global burden of particulate matter air pollution.

While air pollution may not be a significant direct physical risk of climate change, they are deeply interconnected because air pollutants are frequently emitted alongside greenhouse gases, such as through wildfires or the burning of fossil fuels. Efforts to reduce greenhouse gas emissions are likely to lead to improvements in air quality.

Alternatively, air pollutants such as particulate matter (PM) may have a significant cooling or warming impact on the climate.[3] Dark-coloured particles, such as black carbon, absorb sunlight and have a warming effect. Light-coloured particles, such as sea salt, reflect sunlight and have a cooling effect.

The mortality impacts of air pollution

Key sources of air pollution in relation to its impact on mortality are particulate matter with a diameter less than 2.5 micrometres (PM2.5), nitrogen dioxide (NO2), and ozone. Considering each source in isolation, mortality risk increases by around:

- 8% per 10 microgram per cubic metre increase in long-term exposure to PM2.5[4]
- 2.3% per 10 micrograms per cubic metre increase in long-term exposure to NO2[5]
- 0.2% per 10 microgram per cubic metre increase in short-term exposure to ozone[6]

Mitsakou et al. (2022) estimate that between 29,000 and 43,000 deaths in the UK were attributable to long-term exposure to air pollution in 2019 – approximately 5%-7% of annual deaths.

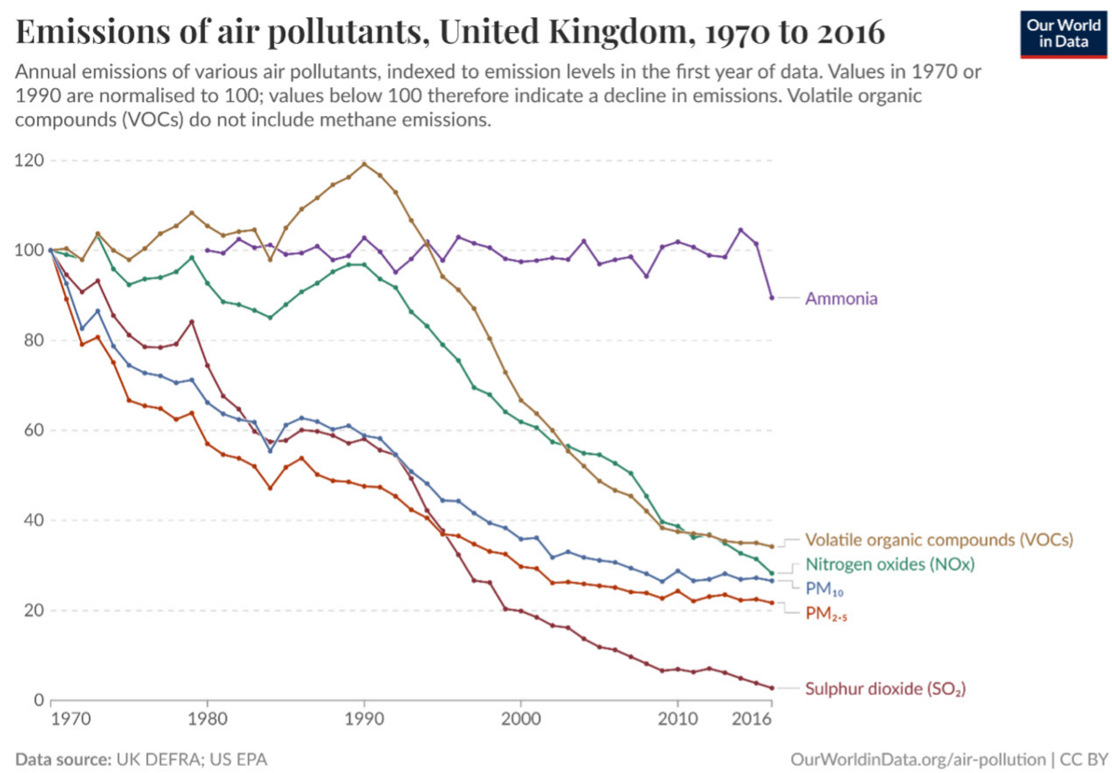
This overall estimate is not split between deaths attributable to different sources of air pollution, but based on the relative size of estimated deaths attributed to individual sources in isolation, around two-thirds of the overall estimate, or some 24,000 taking the mid-point of the range, might be attributed to PM2.5.

Research by Marais et al. (2023) found deaths due to PM2.5 could be more than 48,000, suggesting considerable uncertainty in deaths attributed to air pollution.

Air pollution levels in the UK

Figure 8 shows how emissions of various air pollutants have changed between 1970 and 2016 in the UK.

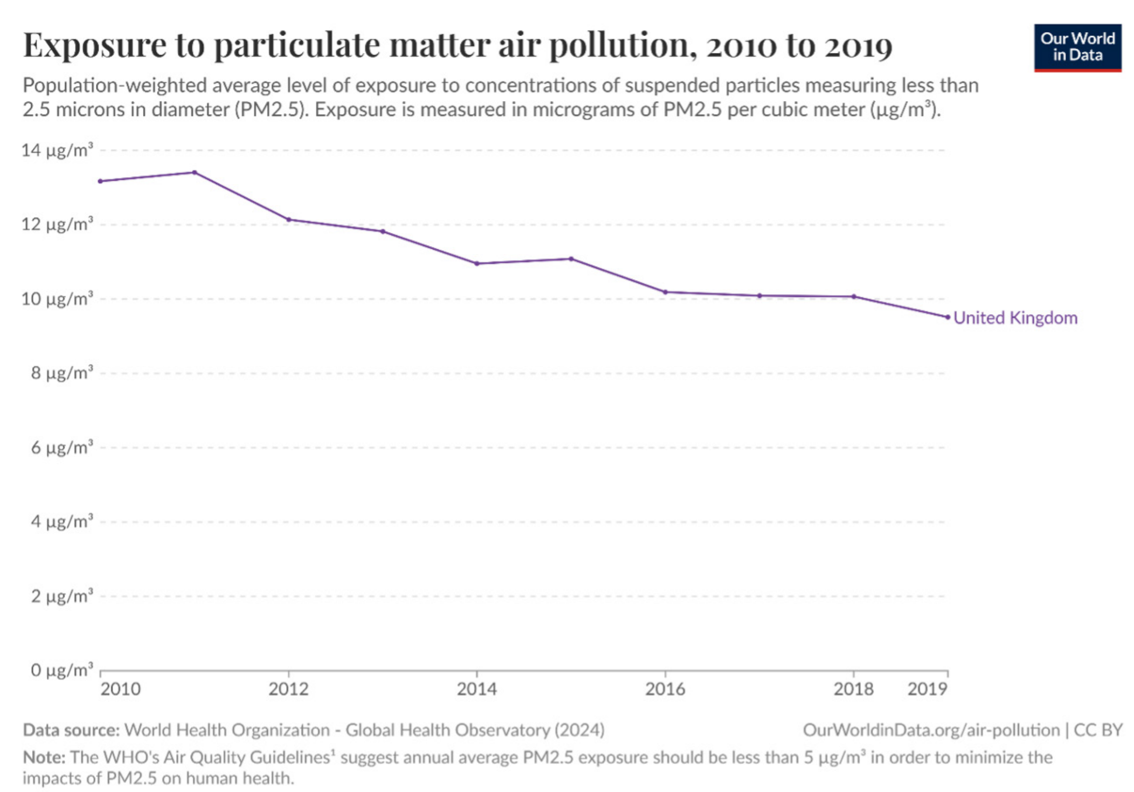
Figure 8: Emissions of air pollutants, United Kingdom, 1970-2016



Source: Our World in Data, available under CC BY 4.0. No changes have been made.

Figure 9 shows the population-weighted average level of exposure to PM2.5 levels from 2010 to 2019.

Figure 9: Exposure to particulate matter air pollution, 2010-2019



Source: Our World in Data, available under CC BY 4.0. No changes have been made.

The UK government estimates that a three-year average of population exposure to PM2.5 has reduced from 10.09 micrograms per cubic meter in 2018 to 7.86 in 2023, a reduction of 22%.[7]

The World Health Organization (WHO) air quality guidelines (AQG) introduced in 2021[8] set an annual average target of 5 micrograms per cubic meter for PM2.5. Although PM2.5 levels have reduced over time, they remain above the WHO's recommended AQG levels, indicating scope for further reduction.

Projecting UK air pollution and mortality in 2050

IPCC AR6 projected reductions in PM2.5 air pollution are relatively modest. Projections under SSP2-4.5 suggest that Europe will see average PM2.5 levels decline by around 1.9 micrograms per cubic meter by 2050 compared to 2015. Under SSP5-8.5, the reduction is around 1.6 micrograms per cubic meter. This would be around a 13% reduction under SSP2-4.5 and around an 11% reduction under SSP5-8.5, based on current population-weighted average exposure of around 15 micrograms per cubic meter for Europe. These figures are broadly similar because SSP5 not only reflects an energy-intensive high emissions future but also assumes that innovation and technology will successfully address issues such as air pollution.

However, per the UKHSA report 'Health effects of climate change (HECC) in the UK: 2023 report' (the HECC 2023 report), future air quality in the UK will be determined by recent policy announcements and new legislation.

In 2019, the UK government published its Clean Air Strategy[9], establishing how it would address all sources of air pollution. Under this strategy, actions to reduce air pollution include impacts from transitioning to a lower-carbon economy. For example:

- Reducing emissions from transport, such as ending the sale of new conventional petrol and diesel cars and vans
- Reducing emissions at home, such as prohibiting the sale of the most polluting fuels
- Reducing emissions from industry, including from energy generation

For our purposes, we anticipate the projected reduction in PM2.5 levels based on recent policy announcements and new legislation, rather than only allowing for the IPCC projections under SSP2-4.5 and SSP5-8.5, because many of these are linked to the transition to a lower-carbon economy.

Table 5: Estimated annual mortality burden associated with long-term effects of exposure to both PM2.5 and NO2

Emission year	Annual mortality long-term, UK total: no population change	Annual mortality long-term, UK total: with population change	Mid value of the range: no population change	Mid value of the range: with population change	% change from 2018: no population change	% change from 2018: with population change
2018	26,287 to 42,442	—	34,365	—	—	—
2030	17,449 to 29,879	18,887 to 32,342	23,664	25,615	−31.1%	−25.5%
2040	16,321 to 28,104	18,384 to 31,657	22,213	25,021	−35.4%	−27.2%
2050	16,010 to 27,539	18,732 to 32,220	21,775	25,476	−36.6%	−25.9%

Source: UK Health Security Agency, HECC 2023 report, available under the Open Government Licence v3.0.

Table 5 is an extract from the HECC 2023 report. The 'with population change' estimates in Table 5 reflect an increased and ageing UK population by 2050. We will adopt the 'no population change' results, as actuaries are usually most interested in projecting changes to age-specific mortality rates.

The analysis set out in Table 5 is from research carried out by Macintyre et al. (2023), which suggests that by 2050:

- Exposure to PM2.5 will decrease between 28% and 36% relative to 2018 levels
- Exposure to NO2 will decrease between 35% and 49%
- Mortality attributable to the effects of long-term exposure to PM2.5 and NO2 will decrease roughly between 25% and 37% compared with a 2018 baseline, depending on future demographic change

However, as noted earlier, UK air quality improved between 2018 and 2023 (the latest year for which air quality data is available), so some of this mortality benefit has already been achieved. We assume around half of the eventual mortality benefit derived from air quality improvements between 2018 and 2023 were experienced by 2023, with the other half still to come.

We further assume that:

- Around 5.5% of annual population deaths in 2018 were due to air pollution.
- Based on reductions in PM2.5 air pollution between 2018 and 2023, this will have decreased to around 5% of annual population deaths by 2023. We will use this as our estimate of the current impact of air pollution.
- Based on the analysis set out in the HECC 2023 report, mortality due to air pollution (without population change) will reduce by around one-third by 2050 relative to 2018 levels.

This implies the population impact will be around 3.7% by 2050, a reduction of around 1.3% from the estimated current impact.

Table 6: Estimated current population mortality impact from air pollution and how this may change by 2050

Physical Risk	**Estimated Current Population Impact** Current annual population deaths estimated to be attributable to risk	**Potential Change by 2050** Increase/(decrease) in annual deaths estimated to be attributable to risk
Air pollution	5%	(1.3%)

Droughts

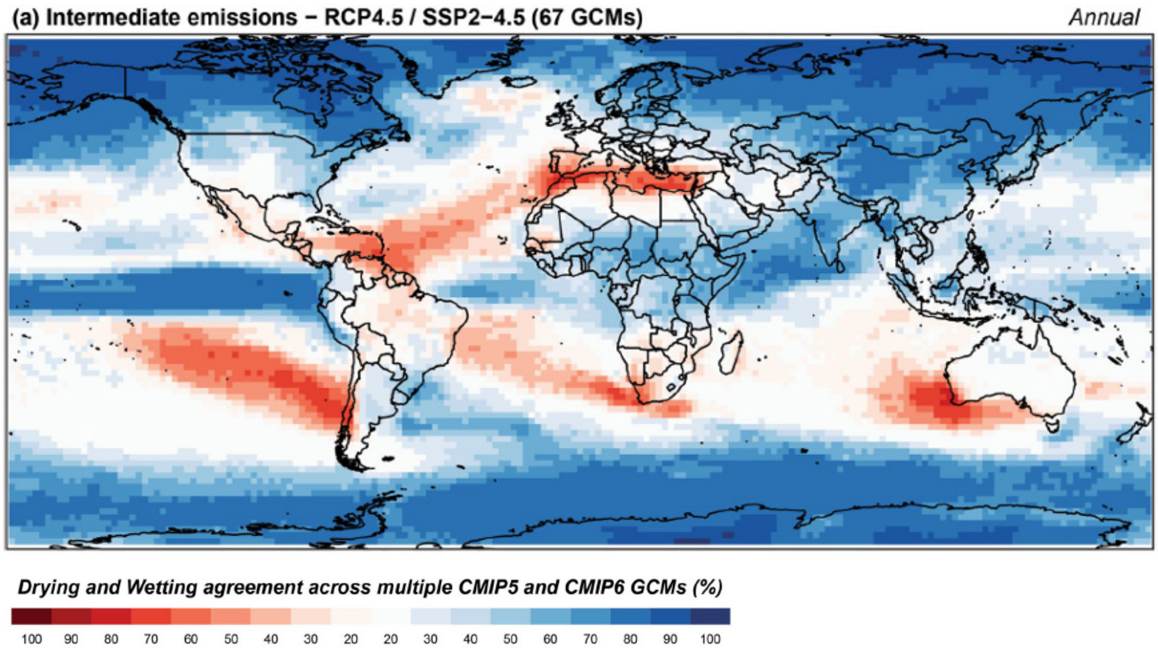
The UK is vulnerable to multi-season, longer-duration hydrological droughts, normally associated with a precipitation deficit that causes surface and subsurface water supplies to become low.[10] Different areas of the UK are vulnerable to different types of droughts: The northwest is vulnerable to shorter, heatwave-driven droughts, whilst the southeast is more vulnerable to multi-year groundwater droughts. Recharging of groundwater and reservoirs usually takes place from November to April, so successive dry winters prevent replenishment and cause significant water resource issues.

According to the HECC 2023 report:

- The UK is increasingly vulnerable to droughts, although they are still relatively rare occurrences.
- There is no clear evidence of an increase in drought severity, extent, or duration due to climate change.
- Droughts typically have a slow onset, and many of the associated health impacts — such as decreased mental health — are indirect. This makes it difficult to quantitatively attribute morbidity and mortality specifically to drought.
- There is limited evidence regarding current UK-specific health impacts of droughts, making it difficult to estimate future risk.
- Evidence indicates that drought risk is likely to increase in the UK.
- Although not a major health risk, droughts should continue to be included in climate-health risk assessments as a potentially emerging risk that may occur concurrently with other hazards, such as heatwaves and wildfires.

The risk of future droughts depends on future precipitation levels, and projecting such levels is difficult. Global climate models (GCM) do not necessarily agree whether large areas of the world will be wetter or drier in the future. This is illustrated in Figure 10 for the SSP2-4.5 scenario. Darker colours indicate a greater level of agreement.

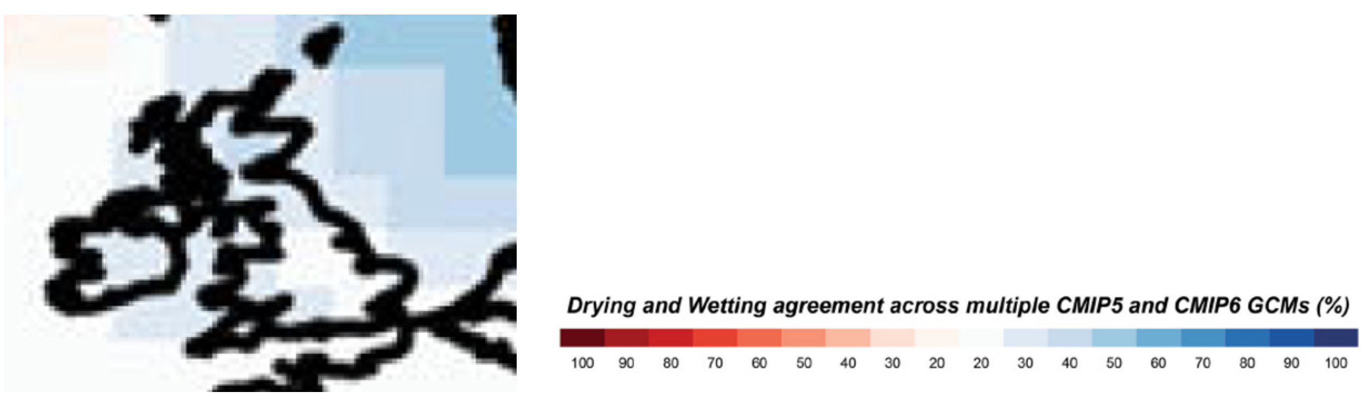
Figure 10: Spatial distribution of drying and wetting multi-model agreement under the SSP2-4.5 scenario



The colours of this map indicate the level of agreement among 67 global climate models as to whether the future will be dryer (red) or wetter (blue). See Trancoso et al. (2024) for a full description. Extracted from Trancoso et al. (2024), available under CC BY 4.0. No changes have been made.

Zooming in on the UK, there is only limited agreement among the models for a wetter future under the SSP2-4.5 scenario (Figure 11).

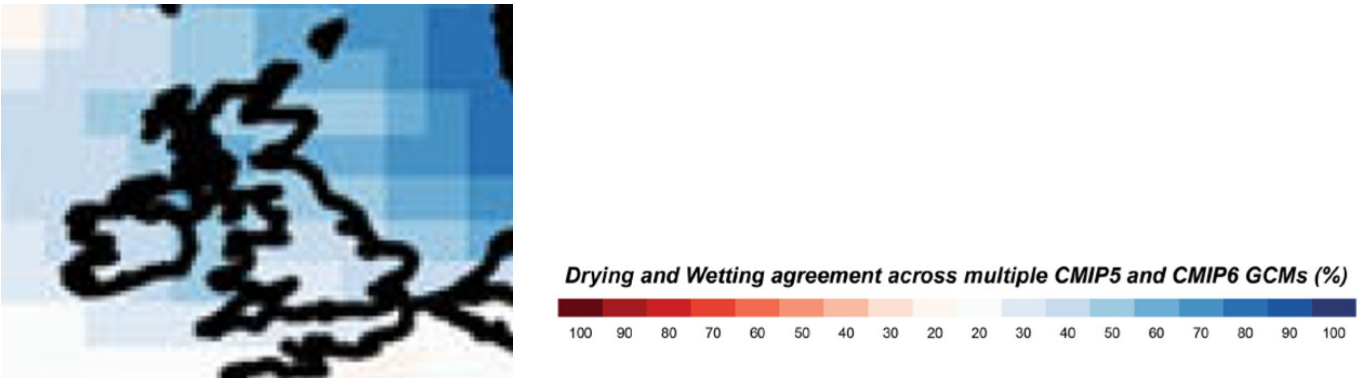
Figure 11: Spatial distribution of drying and wetting multi-model agreement for the UK under the SSP2-4.5 scenario



The colours of this map indicate the level of agreement among 67 global climate models as to whether the future will be drier (red) or wetter (blue) for the UK under the SSP2-4.5 scenario. See Trancoso et al. (2024) for a full description. Extracted from Trancoso et al. (2024), available under CC BY 4.0. No changes have been made.

There is more agreement among the models that the UK may see a wetter future under the SSP5-8.5 scenario, as shown in Figure 12.

Figure 12: Spatial distribution of drying and wetting multi-model agreement for the UK under the SSP5-8.5 scenario

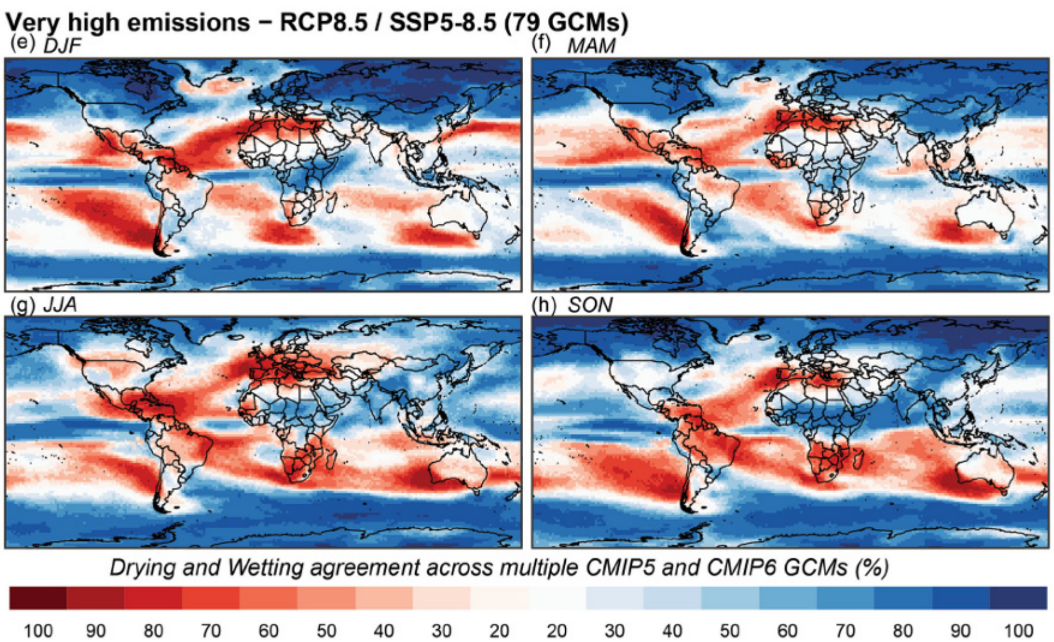


The colours of this map indicate the level of agreement among 79 global climate models as to whether the future will be drier (red) or wetter (blue) for the UK under the SSP5-8.5 scenario. See Trancoso et al. (2024) for a full description. Extracted from Trancoso et al. (2024), available under CC BY 4.0. No changes have been made.

Looking at the seasonal results behind the SSP5-8.5 scenario, as shown in Figure 13, there is significant agreement under a high-emissions scenario that the UK could expect a wetter winter ("DJF" – December, January, and February) and a drier summer ("JJA" – June, July, and August).

Seasonal results for the SSP2-4.5 scenario show little agreement among the models that any season will be either wetter or drier.

Figure 13: Spatial distribution of drying and wetting multi-model agreement by season under the SSP5-8.5 scenario



The colours of this map indicate the level of agreement among 79 global climate models as to whether the future will be drier(red) or wetter (blue) under the SSP5-8.5 scenario. See Trancoso et al. (2024) for a full description. Extracted from Trancoso et al. (2024), available under CC BY 4.0. No changes have been made.

With no recent significant drought mortality events in the UK, some limited agreement among climate models that the future will be wetter under SSP2-4.5, and more agreement for a potentially wetter future overall under SSP5-8.5, we assume that droughts related to climate change will not be a significant driver of mortality in the UK under either scenario.

Floods (extreme rain)

There are three main types of flood events:

1. River flooding (also called fluvial flooding) - when rivers overflow their banks due to excessive rainfall
2. Coastal flooding, including storm surges
3. Surface water flooding (also called pluvial flooding) - when rainwater cannot drain away quickly enough and instead accumulates on the ground surface

In this section, we consider river and surface flooding. Coastal flooding, including storm surges, is examined in a later section.

River flooding has been the dominant source for the current burden of health and social costs, but a greater number of properties are at risk from surface water flooding.[11]

The HECC 2023 report noted that flooding during June and July 2007 was linked to the deaths of 13 people. The total annual impact of floods on UK deaths is uncertain, as data is not routinely reported in health or vital registration data systems, but it has been estimated that flood events since 2007 have resulted in fewer than five deaths per incident.

In the UK, a storm is named when it has the potential to cause disruption or damage, usually from strong winds but also from rain if it could lead to flooding.[12] Table 7 shows the number of named storms over 2015-16 to 2024-25.

Even if each of these named storms were associated with flooding events that led to 10 deaths (twice the HECC 2023 report estimate for deaths per incident since 2007), that would be fewer than 100 deaths per year, on average.

Yang et al. (2023) considered the link between floods and mortality, looking at direct deaths, such as drowning, and indirect deaths caused by food and water contamination. Counterintuitively, they found that all-cause mortality risk in the UK reduced by 4% during the period up to 60 days after exposure to floods. They provided two possible reasons:

- Evacuation led some people's deaths to go unregistered at their usual place of residence.
- Exposure to flood raised the level of attention to personal health and health services.

Later research carried out by Wu et al. (2024) using data from the UK Biobank study found that every unit of increase in an index of flood exposure (measured as the product of the flood duration and severity) was associated with a 6.7% increase in all-cause mortality

Table 7: Number of named storms in the UK, 2015-16 to 2024-25

UK storm season	Number of named storms
2015-16	11
2016-17	5
2017-18	10
2018-19	8
2019-20	7
2020-21	7
2021-22	7
2022-23	4
2023-24	12
2024-25	6

Data source: Met Office

risk over the following six years. The median (mean) of the flood index distribution was 1.8 (4.4), suggesting around a 12% (30%) increase in all-cause mortality at that level. Interestingly, they found that individuals with higher socioeconomic status tend to have an increased risk of flood-related mortality from chronic diseases (e.g., cardiovascular, respiratory, and neurodegenerative diseases) but decreased risk of flood-related mortality from suicide.

Kovats and Brisley (2021) report that 578,000 people are at significant risk of river flooding in the UK today, while 1.185 million are at significant risk of surface water flooding. Risk for this purpose is at a one-in-75-year level, so this group includes people who might be expected to experience flooding every year, every other year, once every three years, up to once every 75 years.

If we assume three things ...

1. 20% of the 1.8 million people exposed to river or surface water floods experienced a flood in any given year;
2. Their demographic profile was broadly representative of the population overall;
3. As a result of flood exposure, their mortality risk was increased by 30%

... then the estimated annual population deaths attributable to the direct and indirect impacts of floods would be around 0.2%. We will use this as our estimate of the current population impact, although there is significant uncertainty associated with it.

As shown in Figures 11 and 12, there is limited agreement among global climate models that the UK could see a wetter future that would increase flooding risk.

According to the HECC 2023 report, by 2050 the populations at risk of river or surface water flooding could increase by 38% and 57%, respectively, under a 2°C warming scenario with low population growth.

For our purposes, we assume that estimated annual population deaths attributable to floods could increase by around 50% by 2050 under both scenarios, giving an increase of 0.1% relative to the current estimated impact.

Table 8: Estimated current population mortality impact from floods due to extreme rainfall and how this may change by 2050

Physical Risk	**Estimated Current Population Impact** Current annual population deaths estimated to be attributable to risk	**Potential Change by 2050** Increase/(decrease) in annual deaths estimated to be attributable to risk
Floods (extreme rain)	0.2%	0.1%

Food security

Food security refers to having access to sufficient, nutritious food for a healthy life. Factors include:

- Global food availability
- Food accessibility through domestic production and imports
- Food supply resiliency to shocks
- Healthy food affordability

As shown in Figure 14, the UK government estimated that 90% of UK households were classified as food secure – defined as either 'high' or 'marginal' food security – in 2022-23.

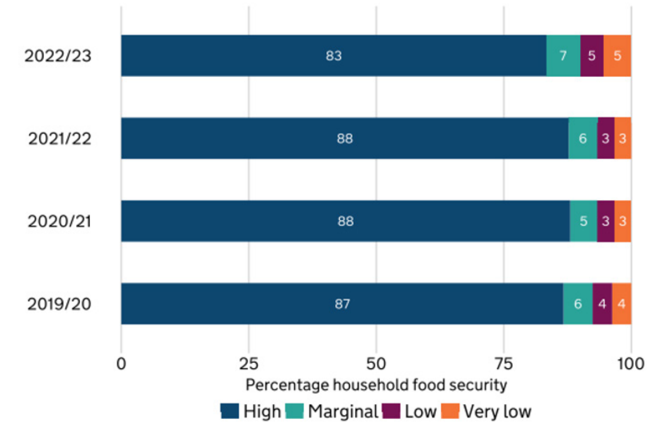
Food insecurity increases mortality risk, as shown in Table 9, which is based on research from Ma et al. (2024) using data for the US.

Climate change physical risks – such as increasing temperatures, droughts, floods, and storms – are expected to negatively affect food production, which could worsen food insecurity. Extreme weather events continue to have a significant effect on domestic production in the UK, particularly arable crops, fruits, and vegetables.[13]

Data on deaths attributable to food insecurity in the UK is not readily available.

As shown in Figure 15, the Institute for Health Metrics and Evaluation (IHME) estimated UK deaths in 2021 by risk factor, some of which could partially relate to food insecurity because they are tied to diet and weight. Note that risk factors are not mutually exclusive, and the sum of deaths attributed to each risk factor may exceed the total number of deaths.

Figure 14: Household food security status of all households in the UK, 2019-20 to 2022-23



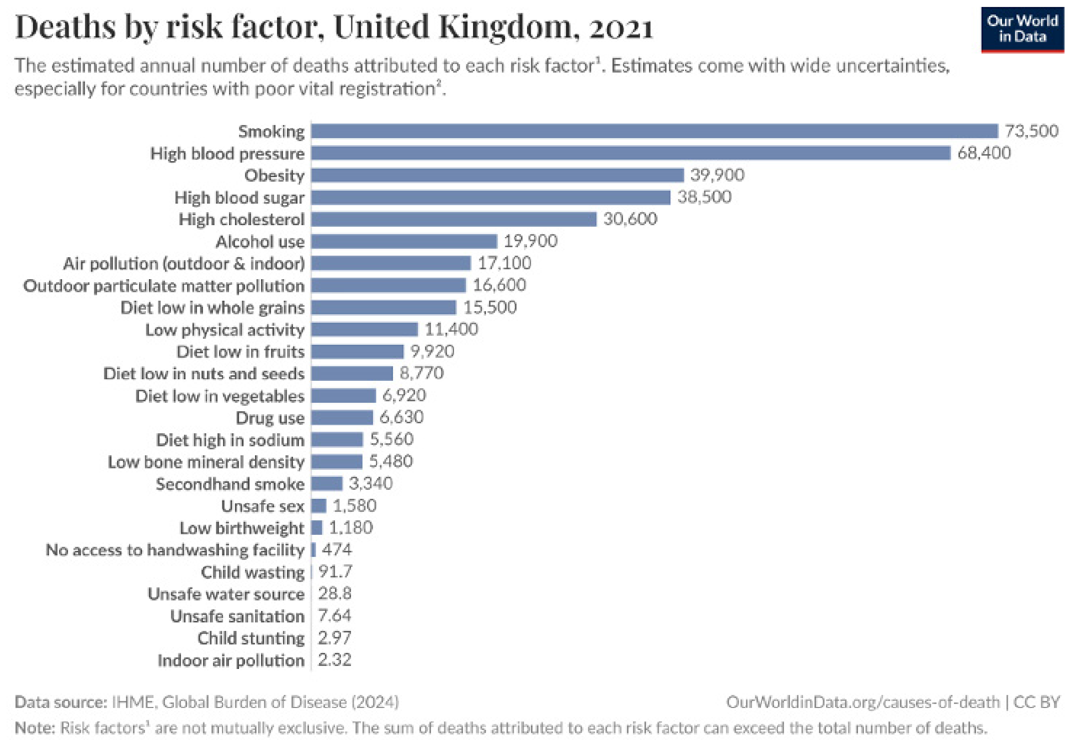
Source: Department for Environment, Food & Rural Affairs, UK Food Security Report 2024, available under the Open Government Licence v3.0.

Table 9: Hazard ratios for categories of food security and premature mortality; see Ma et al. (2024) for a full description

Hazard ratio	Full food security (Reference)	Marginal food security	Low food security	Very low food security
All	1.00	1.26	1.19	1.35
Women	1.00	1.34	1.24	1.61
Men	1.00	1.23	1.15	1.14

Data source: Ma et al. (2024)

Figure 15: Deaths by risk factor, UK, 2021



Source: Our World in Data, available under CC BY 4.0. No changes have been made.

Not all of these diet- or weight-related deaths are due to food insecurity. Many may be related to individuals who choose to eat in a manner that is sub-optimal for mortality despite coming from food-secure households.

If 10% of the UK population had 25% higher mortality risk due to food insecurity, which is reasonable based on results from Ma et al. (2024), this equals around 2.5% of UK population deaths annually linked to food insecurity.

Given there is no way to validate this estimate, we consider the estimated impact unknown, but it should be recognised as a potentially significant driver of population mortality relative to other climate risks.

Because food insecurity is linked to poverty, it may have less impact on insured groups, which are generally of higher socioeconomic status than the general population.

Table 10: Estimated current population mortality impact from food insecurity and how this may change by 2050

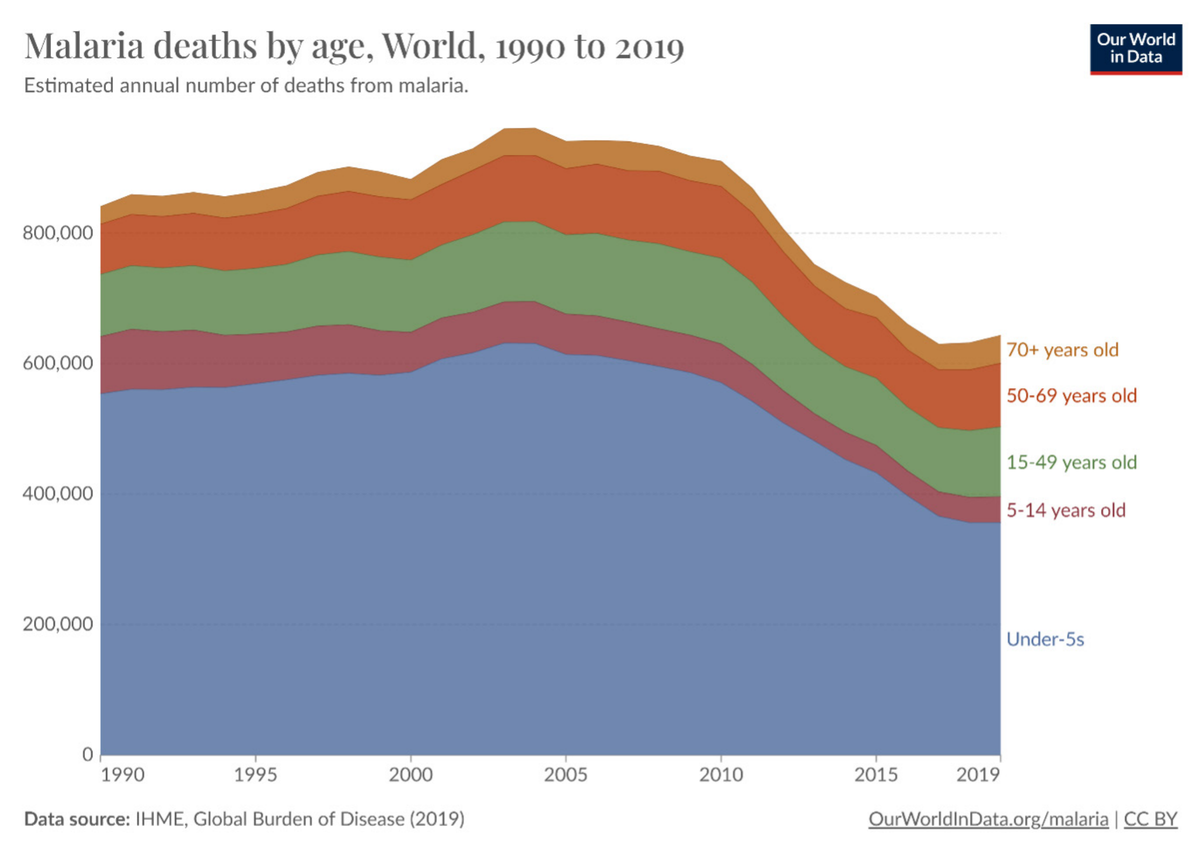
Physical Risk	**Estimated Current Population Impact** Current annual population deaths estimated to be attributable to risk	**Potential Change by 2050** Increase/(decrease) in annual deaths estimated to be attributable to risk
Food insecurity	unknown	unknown

Vector-borne diseases

Vector-borne diseases, e.g., Zika and Lyme, are transmitted by vectors such as mosquitoes, ticks, and flies. The two key vector-borne diseases in mortality impact are malaria and dengue; of those, malaria has the biggest global impact.

As shown in Figure 16, IHME estimates that more than 600,000 people died of malaria in 2019 globally, driven by those younger than age 5.

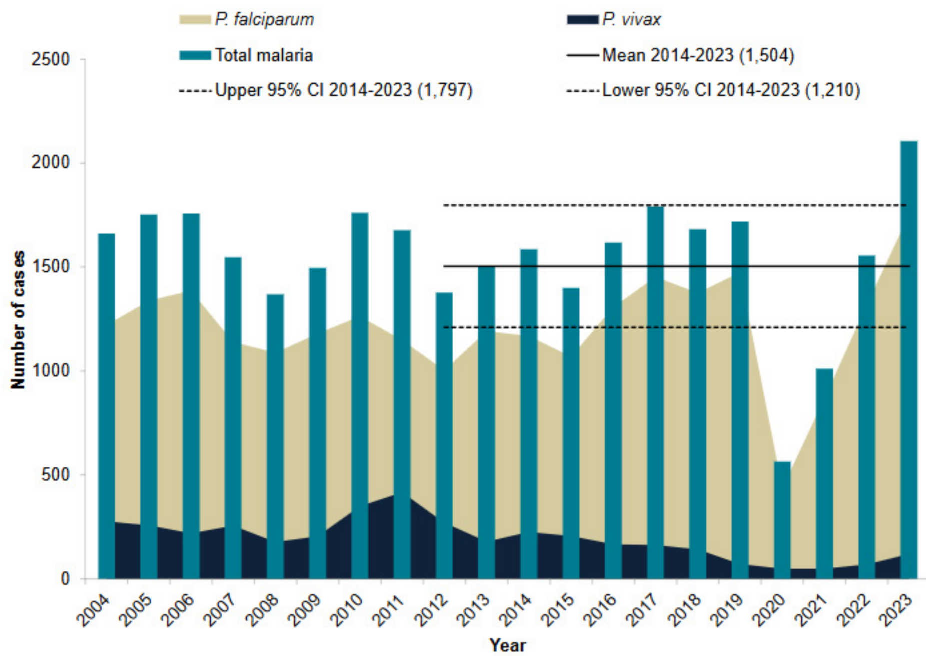
Figure 16: Malaria death by age, World, 1990-2019



Source: Our World in Data, available under CC BY 4.0. No changes have been made.

Malaria is not currently transmitted in the UK, but travel-associated cases occur in those who have returned to or arrived in the UK from malaria-endemic areas. Figure 17 shows the number of cases of malaria in the UK from 2004 to 2023. There were 2,106 cases reported in the UK in 2023, leading to six deaths.[14] On average, there were six malaria deaths each year from 2014 to 2023.

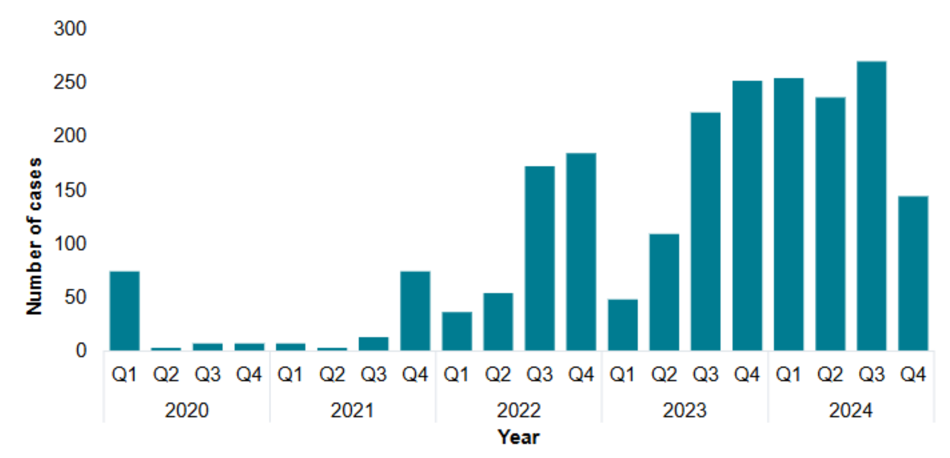
Figure 17: Cases of malaria in the UK, 2004-2023



Source: UK Health Security Agency, report 'Malaria imported into the UK: 2023', available under the [Open Government Licence v3.0](#).

Dengue fever does not occur in the UK[15], although, like malaria, there are reported cases acquired from travel to endemic areas. Figure 18 shows dengue cases by quarter, Q1 2020 to Q4 2024.

Figure 18: Number of dengue cases by quarter, Q1 2020 to Q4 2024

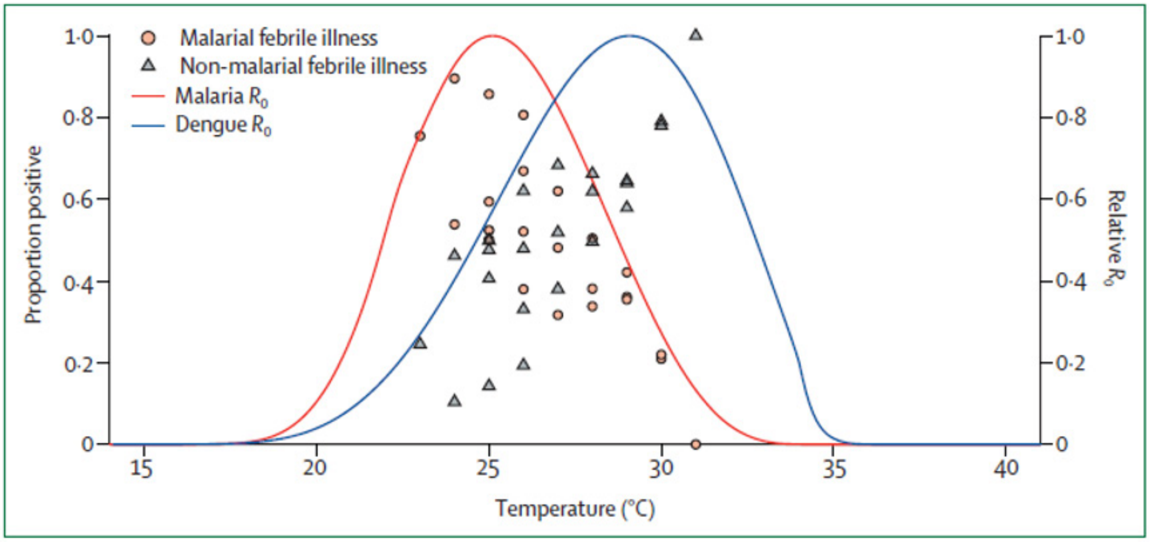


Source: UK Health Security Agency, report 'Travel-associated infections in England, Wales and Northern Ireland: 2024, available under the [Open Government Licence v3.0](#).

Data on dengue deaths in the UK is not available, but in 2023, the global case fatality rate for dengue was around 0.1% (6,800 deaths out of 6.5 million cases)[16], so the number of dengue cases shown in Figure 19 would not be expected to lead to significant deaths.

Temperature has a significant effect on malaria and dengue transmission. The red line in Figure 19, from Mordecai et al. (2020), shows how malaria transmission varies with temperature, with a peak in transmission at around 25°C. The blue line shows how dengue transmission varies with temperature, with a peak at just under 30°C. With increasing average temperatures, many regions of the world could see malaria transmission decrease while dengue transmission increases.

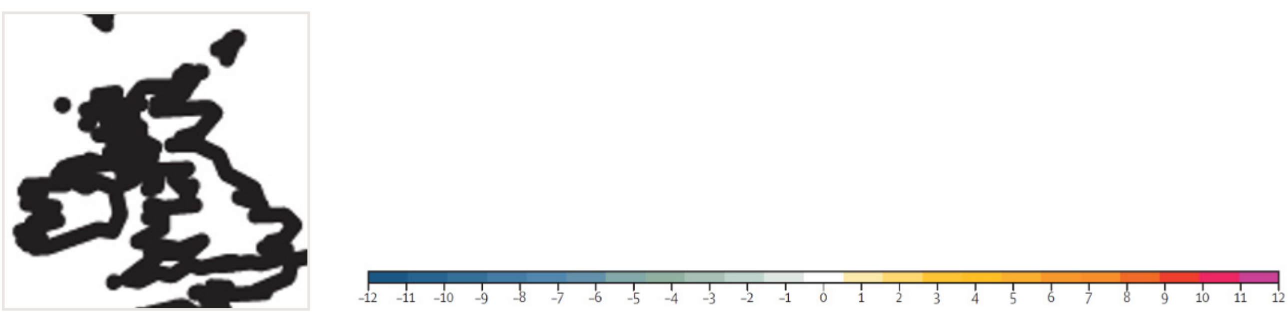
Figure 19: How temperature affects malaria and dengue relative transmission; see Mordecai et al. (2020) for a full description



Extracted from Mordecai et al. (2020), available under CC BY 4.0. No changes have been made.

Colon-Gonzalez et al. (2021) have estimated that over the 100-year period to 2070-2099, the UK would not see an increase to the transmission season for malaria under either the SSP2-4.5 or SSP5-8.5 scenarios (see Figure 20).

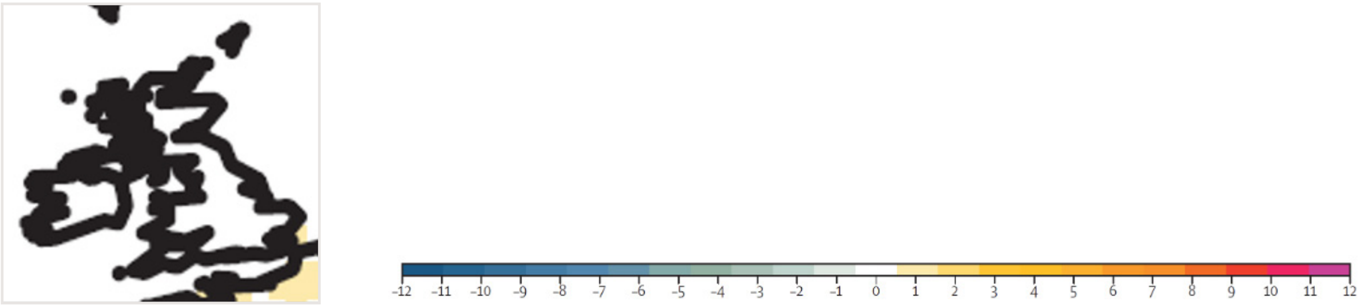
Figure 20: Simulated change in length of transmission season (LTS) for malaria under RCP8.5-SSP5; see Colon-Gonzalez et al. (2021) for full description



Extracted from Colon-Gonzalez et al. (2021), available under CC BY 4.0. No changes have been made.

Colon-Gonzalez et al. (2021) also project no increase in the dengue transmission season in the UK under the SSP2-4.5 scenario, although under the more extreme SSP5-8.5 scenario, they project a one-month increase in the far southeast of the UK.

Figure 21: Simulated change in length of transmission season (LTS) for dengue under RCP8.5-SSP2; see Colon-Gonzalez et al. (2021) for full description



Even if climate change significantly increases deaths from vector-borne diseases by 2050, we assume deaths that year will still be less than 0.1% of annual population deaths.

Table 11: Estimated current population mortality impact from vector-borne diseases and how this may change by 2050

Physical Risk	Estimated Current Population Impact Current annual population deaths estimated to be attributable to risk	Potential Change in Population Impact by 2050 Increase/(decrease) in annual deaths estimated to be attributable to risk
Vector-borne diseases	<0.1%	<0.1%

Storms, storm surges (coastal flooding), and sea level rise

Storms

As shown in Table 7, over the period 2015-16 to 2024-25, the UK has seen fewer than 10 named storms per year on average. As a reminder, a storm is named when it has the potential to cause disruption or damage.

Mortality linked to UK storms is relatively low. On 18 February 2022, record-breaking Storm Eunice caused widespread travel disruption and school closures and left around 200,000 homes without power. Recorded wind speeds reached 122 mph, a new record for England. Four people died from the storm – three by falling trees and one by debris hitting a vehicle.[17]

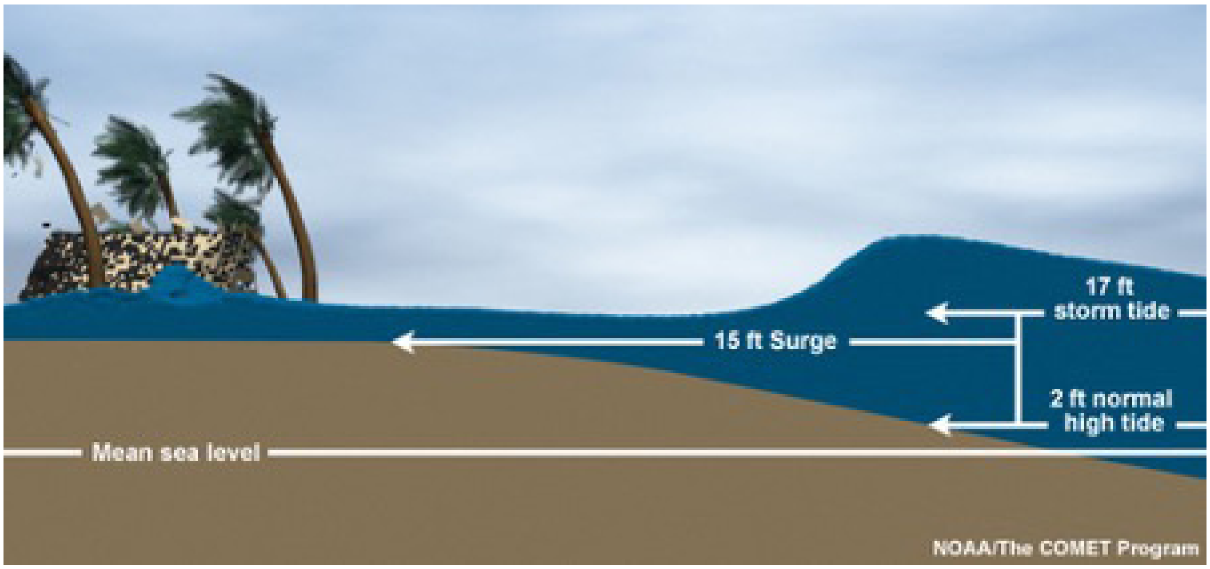
Storm surges (coastal flooding)

Storm surges that cause coastal flooding present perhaps the greatest mortality hazard associated with storms.[18]

Storm surges occur when strong storm winds push sea water toward the coast, causing sea levels to bulge. Associated low pressure that pulls up the sea level also adds a small contribution to the surge.

As Figure 22 shows, storm surges can raise the water level by 15 feet. This can happen on top of a normal high tide, causing a storm tide to surge 17 feet, or around five metres.

Figure 22: Storm surge vs storm tide



Source: National Weather Service (NWS)/National Oceanic and Atmospheric Administration (NOAA); use of this material does not imply endorsement by the NWS/NOAA.

Perhaps the deadliest UK storm surge event occurred in 1953 when around 160,000 hectares (more than 600 square miles) of eastern England were flooded and 307 people died.[19] While this storm was among the worst the UK has seen, the main reason for the deaths was the lack of warning; wind damaged telephone lines in Lincolnshire and Norfolk, and southern counties did not receive warning of the storm's severity until it was too late.

This led to the establishment of an official service to forecast coastal flooding and the creation of the Thames Barrier, which have prevented subsequent major flooding events and loss of life.

Kovats and Brisley (2021) reported that around 126,000 people in the UK currently are at significant risk of coastal flooding. Risk for this purpose is at a one-in-75-year level, so this group includes people who might be expected to experience flooding every year, every other year, once every three years, up to once every 75 years.

UK mortality linked to coastal flooding and storm surges is relatively low partly due to this low level of population exposure. During 5-6 December 2013, Storm Xaver led large areas of England's East Coast to experience some of the worst coastal flooding since 1953.[20] By 7 December 2013, 15 people had died across northwest Europe, but there were no reported fatalities from coastal flooding. More than 10,000 people were evacuated along England's East Coast, and approximately 800,000 properties were reported to have been protected by flood defences along 2,800 kilometres of UK coastline.

Sea level rise

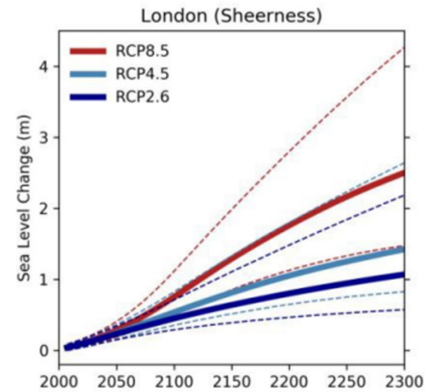
According to the Met Office, sea level rise is the primary mechanism expected to change UK coastal flood risk.[21]

Figure 23 shows the projected sea level rise estimated by the Met Office under different scenarios. These are based on the IPCC's Fifth Assessment Report rather than IPCC AR6. Still, these assessments have been shown to have relatively good agreement with their median regional projections.[22]

By 2050, sea-level rise is projected to be around 0.2-0.3m under RCP4.5 (broadly equivalent to SSP2-4.5) and RCP8.5 (broadly equivalent to SSP5-8.5).

According to the HECC 2023 report, the population at risk of coastal flooding could increase by 200% by 2050 under a 2°C warming scenario with low population growth.

Figure 23: Sea-level rise projections under a range of emission scenarios for London



Source: HECC 2023 Report, available under the Open Government Licence v3.0.

Taken together, annual UK deaths linked to storms, including storm surges, are low. Even if they increase 200% from heightened storm intensity and sea level rise, we assume annual deaths linked to storms will remain below 0.1% of annual population deaths in 2050.

Summary of physical risk impacts

Table 12 summarises how the physical risks of climate change that we are able to estimate might impact UK mortality by 2050.

Table 12: Estimated current population mortality impact from physical risks associated with climate change and how this may change by 2050

Physical Risk	Estimated Current Population Impact	Potential Change by 2050 under SSP2-4.5	Potential Change by 2050 under SSP5-8.5
	Current annual population deaths estimated to be attributable to risk	Increase/(decrease) in annual deaths estimated to be attributable to risk	Increase/(decrease) in annual deaths estimated to be attributable to risk
Average temperatures	7.6%	(0.4%)	(0.5%)
Air pollution	5%	(1.3%)	(1.3%)
Droughts	n/a		
Floods (extreme rain)	0.2%	0.1%	0.1%
Food insecurity	unknown	unknown	unknown
Vector-borne disease	<0.1%	<0.1%	<0.1%
Storms, storm surges (coastal floods), and sea level rise	<0.1%	<0.1%	<0.1%
Overall		**(1.5%)**	**(1.6%)**

These results do not include the effect of population aging and, thus, reflect the impact of physical risks on the overall mortality rate of the population assuming its demographic profile remains unchanged. We are unable to quantify the potential change in relation to the impact of food insecurity, which we might expect to increase annual population deaths.

Transition risks

Transition risks are those associated with the transition to a lower-carbon economy. Examples include:

- Policy and legal - Risks associated with regulatory change, including the costs of compliance, such as carbon taxes or climate-related disclosures
- Technology - Innovations that make existing technologies obsolete
- Market - Unanticipated changes in the supply and demand for goods and services
- Reputational - Shifts in consumer sentiment and the potential negative consequences of not meeting demand for climate-friendly products

We are going to consider three ways transition risks may potentially impact mortality:

- Economic
- Diet
- Active travel

Economic impact and mortality

Economic impacts on mortality could be significant. Health and social care funding, public health initiatives, employment status, income levels, food price inflation, funding for education, medical research funding, and many other mortality drivers are linked to the state of the economy.

The potential economic impacts of climate change and transition policies on mortality are highly uncertain.

- Uncertainty surrounds the actions of governments and society transitioning to a lower-carbon economy.
- Climate science and our understanding of how climate will respond to our actions also is uncertain.
- How transition policy actions and physical risks associated with climate change will impact the global economy also remains unclear.
- And we are uncertain how those economic impacts may affect mortality outcomes.

We have already touched on the first two uncertainties on the potential mortality impacts of physical risks under different future climate scenarios.

Economic impact of transition policies and climate change

Economic models used over the past 30 years to consider how transition policies and physical risks may impact the global economy are relatively simple and reflect only a small number of the full range of potential physical impacts of climate change.

As an example, the NGFS Phase V climate scenarios published in November 2024 reflect a 'damage function' that captures GDP losses from physical risks that is taken from the now retracted paper by Kotz et al. (2024). This damage function allows for the estimated GDP impacts from temperature (mean and variability) and precipitation (annual level, number of wet days, and extreme daily rainfall). However, it does not allow for the GDP impact of other important risks, such as from heatwaves, sea-level rise, tropical cyclones, tipping points, damage to ecosystems, and the economic impacts of the health effects of physical risks.

In addition, the economic model of the now retracted paper by Kotz et al. (2024) assumes that the economic impacts of physical risks on a country occur only in that country and do not affect other countries.

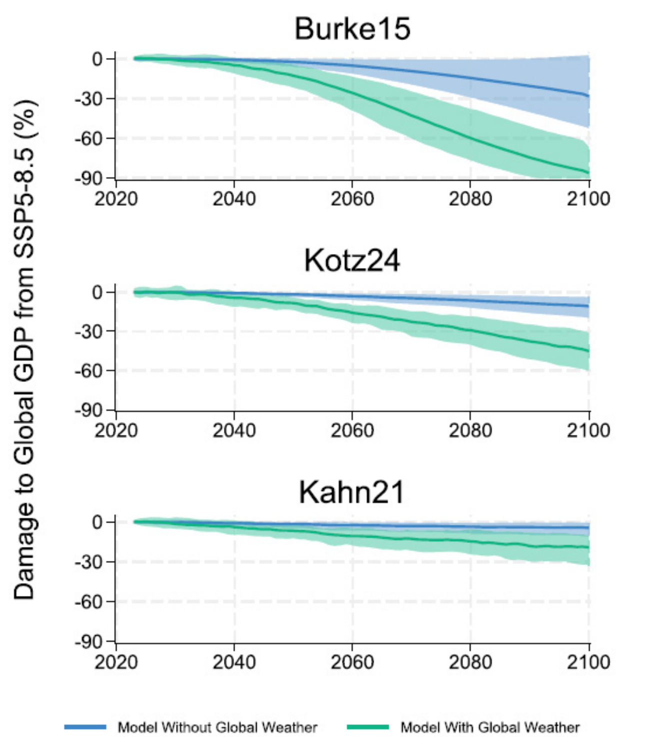
To illustrate the additional uncertainty associated with this assumption, consider Figure 24 taken from Neal et al. (2025).

The three panels in Figure 24 show the projected GDP loss in percentage terms in three different economic models over time in a high-emission scenario (SSP5-8.5) relative to a lower-emission scenario (SSP1-2.6). The panel labelled 'Kotz24' is Neal et al. (2025)'s implementation of the model from the now retracted paper by Kotz et al. (2024). The blue line in each panel shows the projection assuming each country's economy is only affected by changes to the weather in that country – the assumption made in the retracted paper by Kotz et al. (2024) and underlying the damage function used in the NGFS Phase V climate scenarios. The green line recognises the interconnectedness of the global economy – through global supply chains, for example – and allows for a country's economy to be affected by weather changes in other countries.

The difference between the blue and green lines in each panel illustrates the uncertainty associated with this one assumption for a given economic model. For the Kotz24 model, the blue line shows a median loss of 11% by 2100, whereas the green line shows a median loss of 40% – nearly 4 times worse.

The variances among the panels illustrate the uncertainty associated with using different economic models. The green line in the Kahn21 model shows a loss of 19% by 2100, whereas the Burke15 model shows an 86% loss.

Figure 24: Projections of GDP loss in a higher-emission scenario (SSP5-8.5) relative to a lower-emission scenario (SSP1-2.6) for three economic models; see Neal et al. (2025) for a full description



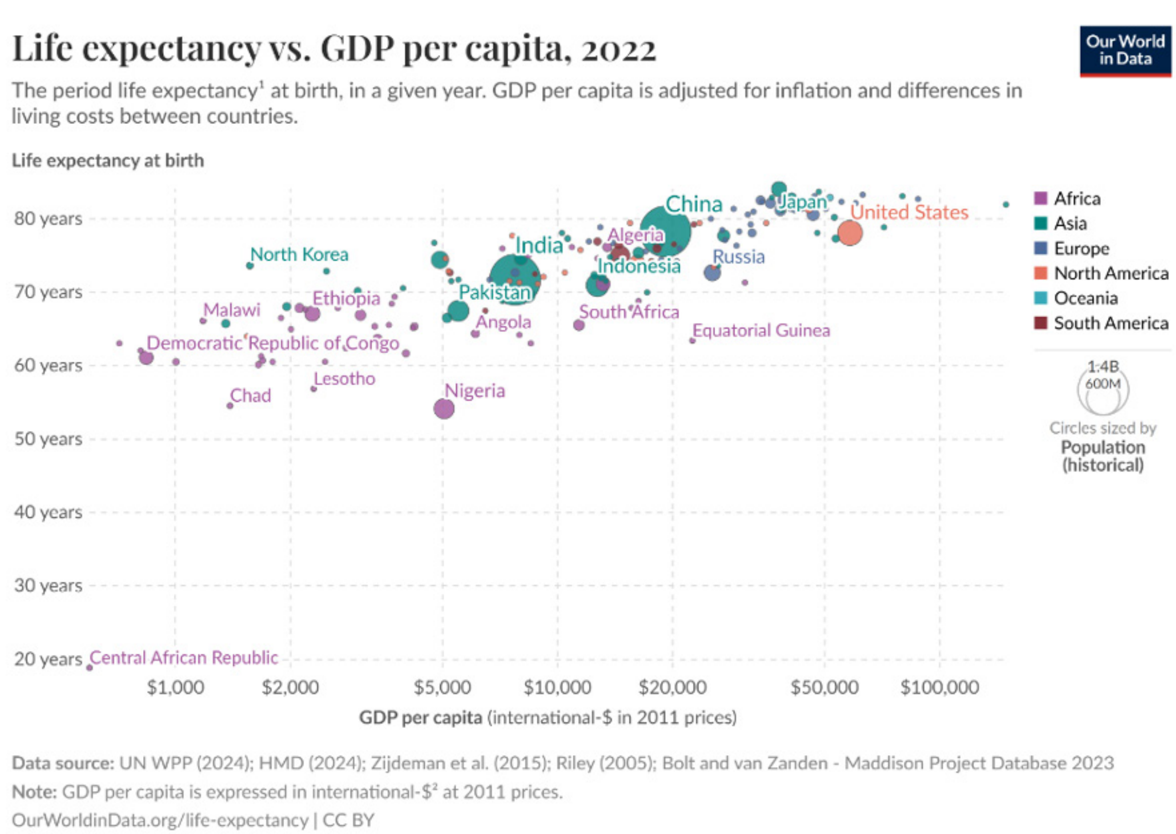
For further discussion regarding damage functions and economic impacts, see 'The Emperor's New Climate Scenarios' by Trust et al. (2023) and Professor Steve Keen's presentation to the Institute and Faculty of Actuaries, 'How to (and not to) extrapolate damages from global warming'.[23]

How economic impacts may affect mortality outcomes

Research on how the economy may impact mortality outcomes paints a complex picture.

As shown in Figure 25, there is a positive correlation between long-term economic development (measured as GDP per capita) and life expectancy.

Figure 25: Life expectancy vs GDP per capita, 2022



Source: Our World in Data, available under CC BY 4.0. No changes have been made.

Dadgar and Norström (2022) found that, over the long term, across 21 OECD countries spanning 1960-2018, a 'one-unit' increase in GDP (corresponding to an increase of 3.3%) was associated with a reduction in total mortality of 3.8%.

A substantial body of literature shows population-level mortality is 'pro-cyclical' over the short term for developed countries; when economic conditions deteriorate, population-level mortality tends to decrease, and when economic conditions improve, population-level mortality tends to increase. For developing countries, the relationship is mixed.

To give an indication of the potential size of this effect:

- Granados and Ionides (2017) found that a 1 percentage point increase in the national unemployment rate was associated with a reduction of 0.5% in the rate of age-adjusted mortality.[24]
- Dadgar and Norström (2022) found an increase in the unemployment rate of 1 percentage point decreased total mortality by 0.3%.

At the individual level, however, a wealth of research shows people with higher incomes tend to live longer and indicates a strong association between low income and unemployment and increased mortality, as individuals who fall into unemployment when the economy deteriorates are likely to see their health suffer.

An explanation for these seemingly counterintuitive results could be that while those who fall into unemployment are likely to suffer worse health, this effect is more than compensated for by improvements in the average health of the rest of the population via improved dietary habits and a reduction in lifestyle habits detrimental to health. When the economy slows, people tend to reduce smoking, drinking, and excessive eating, while they increase the time devoted to physical activity, sleep, and medical care.

Lower economic activity may lead to other benefits:

- Less frequent driving may result in fewer traffic accidents.
- An increase in part-time working may lead to more free time to provide informal social care, thereby reducing mortality at older ages.

Recent research by Salinari and Benassi (2022), looking at the relationship between life expectancy and unemployment levels during the Great Recession after the 2008 global financial crisis, found that these short-term effects may continue over the long term. They also found that, at least for the Great Recession, the impact may be asymmetric, as life expectancy responded quickly to the increase to unemployment but not to the subsequent decrease in unemployment.

To the extent that lower GDP results in less funding for health and social care, education, or medical research, we would expect this to have a negative impact on mortality over the long term.

The complex ways that economic impacts may influence mortality outcomes increase the uncertainty of how climate-related impacts on the economy may affect future mortality.

Potential mortality benefits of transition policies

Depending on how transition policies are implemented, they have the potential to improve health in the following scenarios:

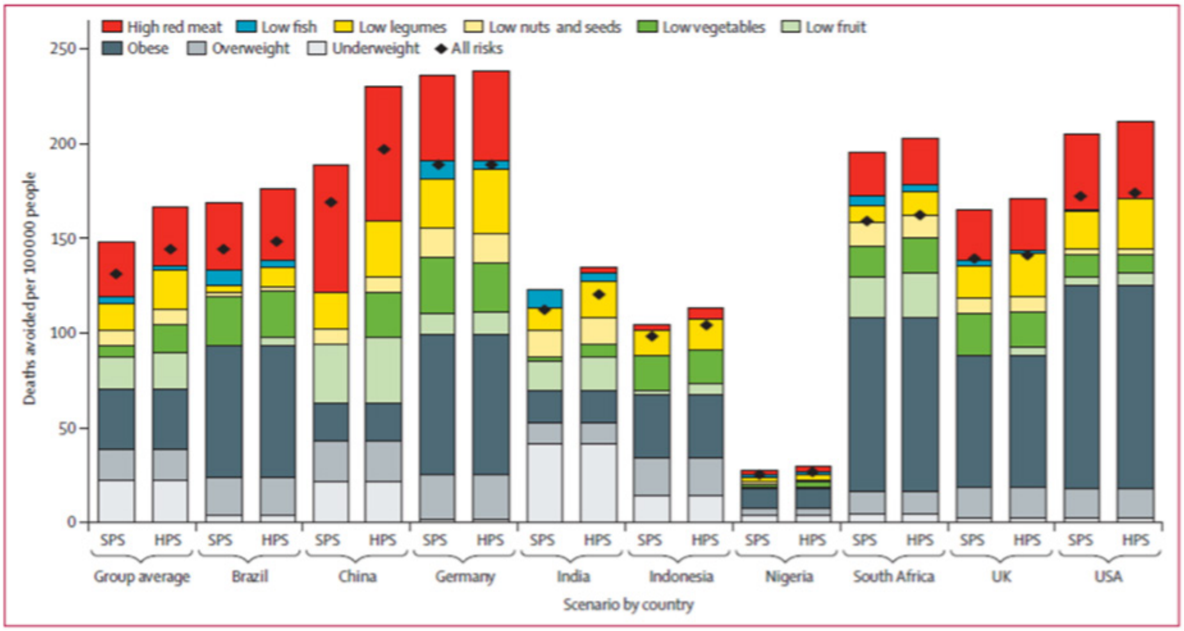
- Sustainable food and agriculture policies may, if designed and implemented appropriately, encourage people to eat a calorie-balanced diet high in plant-based nutrition.
- Sustainable travel and transport policies may encourage people to walk or cycle instead of using their cars.

Hamilton et al. (2021) estimated the potential deaths that could be avoided if these health benefits could be achieved.

Figure 26 shows diet-related deaths that could be avoided. The x-axis shows two scenarios for various countries: a sustainable pathway scenario (SPS) broadly equivalent to the 2015 Paris Agreement; and a more optimistic 'health in all climate policies' scenario (HPS). Each bar shows the deaths avoided per 100,000 population, colour-coded to represent the key dietary risks. As individuals may be subject to more than one risk, the overall total deaths avoided per 100,000 population is shown by the black diamond toward the top of each bar.

For the UK, in the SPS scenario, Hamilton et al. (2021) estimate around 139 deaths per 100,000 population could be avoided. If the UK were to achieve this level, around 96,000 deaths would be avoided based on a population of 69 million.[25]

Figure 26: Number of deaths avoided attributable to dietary risks in the year 2040, relative to the current pathway scenario, per 100,000 population, by scenario and country; see Hamilton et al. (2021) for full a description



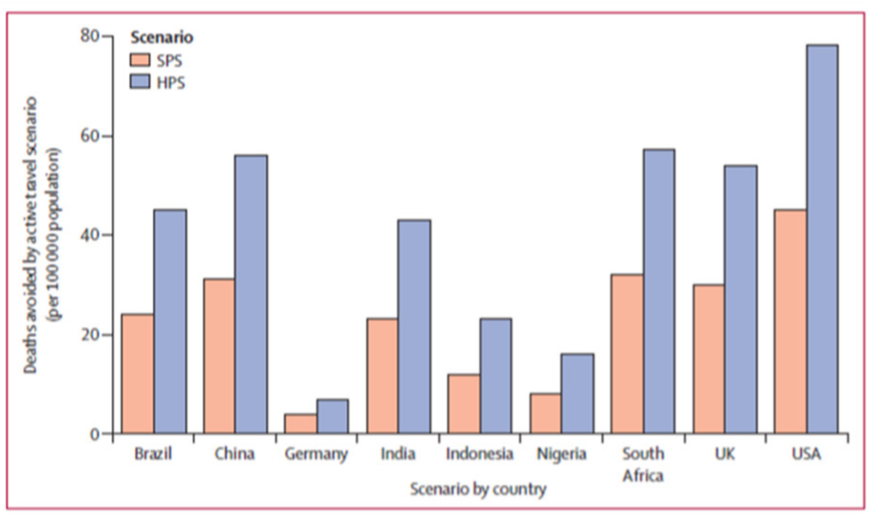
Extracted from Hamilton et al. (2021), available under CC BY 4.0. No changes have been made.

Figure 27 shows the deaths that could be avoided if active travel (walking and cycling) increased. Again, the x-axis shows the two SPS and HPS scenarios for various countries. The bars show the deaths that could be avoided per 100,000 population in each scenario.

For the UK, in the SPS scenario, Hamilton et al. (2021) estimate that around 30 deaths per 100,000 population could be avoided. If the UK could achieve this level, it would equal round 21,000 avoided deaths for a population of 69 million.[25]

Hamilton et al. (2021) showed that transition risks have the potential for a much larger positive impact compared to the relatively modest negative impact from physical risks. However, it must be recognised that these potential positive impacts are extremely difficult to achieve, given they require significant behaviour change within the general population, plus potentially significant investment in infrastructure (to make cycling more attractive, for example).

Figure 27: Number of deaths avoided in the year 2040 under the SPS and the HPS per 100,000 population, relative to the current pathway scenario; see Hamilton et al. (2021) for a full description



Extracted from Hamilton et al. (2021), available under CC BY 4.0. No changes have been made.

Caveats and other considerations

Climate science has improved significantly over recent decades, but uncertainty remains.

We must also acknowledge that some risks are too unclear to quantify given the research currently available, and these could have a significant impact.

Most research about the impact of climate change on mortality does not allow for the adaptation we will likely see as society works to lessen the impact of these negative risks. An example of this would be the rollout of new malaria vaccines,[26] which could reduce the impact of climate change on the spread of vector-borne malaria. Note that scope for adaptation against climate-related physical risks is generally greatest for higher socioeconomic groups.

This paper has concentrated on the direct mortality impacts of physical risks, but these risks could cause new-onset morbidity, and there could be negative mortality impacts from this in the future. An example would be the negative mental health consequences of extreme weather events for those who lose their homes or livelihoods and are displaced.

Even if the impact of climate change on future mortality were relatively modest for the UK, other countries may see greater impacts, which may lead to inward migration to the UK, placing a strain on public services such as healthcare.

We have considered emissions scenarios up to 2050. Over longer periods, the mortality impact could be greater, particularly in high-emission scenarios.

We have considered each physical risk in isolation, but reality is more complex, and interactions between risks increases uncertainty. There is also the risk of reaching climate tipping points, which could lead to a self-reinforcing cycle of increased greenhouse gas emissions and warming.

Some of the actions that have led to climate change, such as deforestation, bring humans and animals closer into contact, which increases the risk of zoonotic disease transmission and future pandemics.

Conclusion

This paper delves into the academic literature to assess the possible impact climate change could have on future mortality in the UK by 2050 under the SSP2-4.5 'middle of the road' emissions scenario and the SSP5-8.5 high-emissions scenario.

For those physical risks whose impact could be estimated, two key risks were identified:

1. Increasing average temperatures could reduce mortality by 0.4%-0.5%, depending on the scenario.
2. Reducing air pollution could decrease mortality by 1.3%.

The impact of climate change on mortality linked to food insecurity could be material, but it was not possible to quantify this. All other physical risks are expected to have a relatively immaterial mortality impact.

The overall impact of quantifiable climate change physical risks on mortality in the UK is anticipated to be relatively modest, with annual population deaths potentially reducing by 1.5%-1.6% in 2050, depending on the scenario, before allowing for adaptation measures. This result may be counter to expectations of a negative impact on mortality, although we need to recognise the uncertainties involved.

Transition policies could have a significant impact. Transition to a lower-carbon economy could have economic consequences that positively or negatively impact mortality; however, given the significant uncertainties involved, it is not possible to quantify this. Transition policies could also have a significant positive impact on diet and active travel, leading to improved health and lower mortality, although this could be difficult to achieve because it would require widespread behavioural change and significant infrastructure investment.

The modest positive mortality impact from quantifiable physical risks in the UK outlined in this paper does not absolve society from taking action to limit greenhouse gas emissions and future climate change impacts. Climate change remains a significant risk factor and a priority issue that must be addressed through collective action at the governmental, corporate, and individual levels. The insurance industry has an opportunity to play a leadership role in combatting the climate crisis by promoting awareness, providing education, and inspiring, motivating, and incentivizing populations to modify behaviours in ways that will benefit their health as well as the planet's.

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Limitations

The information provided in this paper is intended for general discussion and education purposes only and should not be relied upon for making specific decisions. The potential change in annual population deaths in 2050 is based on the assumptions specified, and different assumptions would give rise to different results.

RGA has made all reasonable efforts to ensure that the information provided in this publication is accurate at the time of inclusion and accepts no liability for any inaccuracies or omissions.

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