UK Health Security Agency

Adverse Weather and Health Plan

Supporting evidence

2024

Contents

1. Introduction

This document collates the activities and scientific evidence that underpin the UK Health Security Agency's (UKHSA) Adverse Weather and Health Plan (AWHP) on the impacts of adverse weather events and climate change on health and wellbeing. The primary aim is to improve our understanding of the impacts on health caused by extreme and adverse weather events.

This summary presents evidence from which best practice recommendations can be developed. Guidance materials under the AWHP set out detailed, evidence-based recommendations for professionals and the general public to prepare for and respond to different adverse weather hazards to reduce health risks. The AWHP and associated documents (including this supporting evidence) will be updated on a regular basis to ensure that the plan and guidance are supported by a strong and reliable evidence base collected from academia and real-world examples.

Please note:

UKHSA published the fourth Health Effects of Climate Change (HECC) in the UK: state of the evidence report in December 2023 (1). The HECC report compiles up to date evidence on the impacts of climate change on health and effective interventions to protect health. Findings from the HECC report have been considered in the relevant sections of this document.

The 2024 'AWHP Equity Review and Impact Assessment' has been published in parallel with this iteration of the 'AWHP: supporting evidence', with the core aims that:

- the 'AWHP: supporting evidence' summarises the existing evidence-base to improve understanding of health risks from extreme and adverse weather events
- the 'AWHP Equity Review' collates evidence on the impacts of adverse weather on different populations (including those with protected characteristics) and assesses the extent to which the AWHP may contribute to addressing these – it also identifies actions that can be taken to reduce health inequalities and promote equity and inclusion

1.1 Why is an adverse weather and health plan needed?

Climate change is happening now and affects many of the wider determinants of health directly or indirectly by influencing the weather conditions we experience on a day-to-day basis. Indeed, global temperatures are increasing in the UK and across the globe. We are now observing what has been predicted for some time: namely, greater severity and frequency of extreme weather events such as heat episodes, flooding, drought, and wildfires.

As outlined in the HECC report (1), without adaptation, the projected health impacts on heat and cold mortality in the UK are expected to increase as a result of climate change and sociodemographic factors. The proportion of people affected by higher temperatures, flooding and droughts will increase due to the increasing frequency and severity of these events. Cold-related mortality will also increase despite fewer colder days in a warming climate due to the UK's ageing population. The impacts of adverse weather events can affect everyone and can influence many aspects, including health, but there are clear geographical and sociodemographic differences in how climate risks to health will be felt across the UK (1). The extent to which individuals, communities and populations experience the negative health effects of adverse weather will vary based on their capacity to respond and adapt to the stressors imposed by such events. In the UK, as the HECC report (1) highlights, the impact of climate change will be costly to society and the NHS.

1.1.1 Policy and legal context

The UK Health Security Agency (UKHSA) is responsible for protecting every member of every community from the impact of infectious diseases, chemical, biological, radiological and nuclear incidents and other health threats. This includes those arising from human interactions with the environment. It does this by working in partnership at local and national levels, through provision of intellectual, scientific, and operational leadership, including in response to adverse weather events.

The UKHSA launched the Centre for Climate and Health Security (CCHS) in October 2022, to lead efforts to protect health in the context of a changing climate and provide a focus for partnerships and collaborations with academia, local authorities and other public sector organisations.

The CCHS works with all partners, including Devolved Governments (DGs), to offer scientific advice and support to ensure that the impacts of climate change are considered and embedded in the design and delivery of climate change policies across local, national government and with international partners.

The AWHP was one of the first publications from CCHS, demonstrating the Centre's impact in the area of climate and health security.

1.1.1.1 Climate Change Act (2008), Climate Change Risk Assessment (CCRA) and National Adaptation Programme (NAP) for the UK

Under the Climate Change Act (2008) (2) the UK government has a statutory obligation to produce a national Climate Change Risk Assessment (CCRA) every 5 years. The first UK CCRA (CCRA1) was published in 2012 (3), and informed the first UK National Adaptation Programme (NAP) in 2013 (4). The NAP sets out the actions that the UK government, other agencies, public sector bodies and devolved governments will take to adapt to the challenges of climate change in the UK for the next 5 years. The third NAP was published in 2023 and details the government's response to the risks and opportunities identified in the CCRA3 (5).

The Technical Report for CCRA3 (6) presented strong evidence that under warming scenarios of 1.5°C to 2°C, the UK will be subject to a range of significant and costly impacts unless major actions are taken now. It identified 61 climate risks across multiple sectors of our society alongside a wide range of potential climate impacts on health and productivity, affecting households, businesses, and public services. These impacts could range from a deterioration in soil health and agricultural productivity to impacts on water availability and alternative energy supply. Eleven of these risks relate directly to public health and the broader health sector (Table 1) and 7 score the highest urgency (that is, 'More Action Needed') (7). Please note, risks in bold are those risks that are the subject of this supporting evidence document.

Evidence indicates that the costs of climate change to the UK are already high and increasing. For 8 out of the 61 climate risks detailed by CCRA3, the UK-wide economic damages are estimated to exceed £1 billion per annum by 2050 under a 2°C warming scenario.

The CCRA also includes a review of costs and benefits of adaptation policies and concludes that many early adaptation investments are highly effective and deliver high value for money (6). These include early weather warning systems, climate-resilient infrastructure and improving the evidence base for best practices. Adaptation also often leads to important co-benefits: as well as reducing potential losses from climate change, it often generates direct economic gains or leads to social or environmental benefits (7).

1.1.1.2. UKHSA's National Adaptation Plan (NAP) commitments

UKHSA's key commitments under the second NAP (2018 to 2023) (5) was to develop and deliver the AWHP and the HECC report. Both products were published in 2023. UKHSA will provide progress updates on its commitments under the third iteration of the NAP to DEFRA as part of routine monitoring of its commitments (5).

1.1.1.3. National Health Service Act (NHS) 2006

UKHSA has duty to take steps as Secretary of State considers appropriate to protect and improve the health of the public in England, in accordance with Sections 2A and 2B of the act (8). Additionally, UKHSA has the power to conduct, commission or assist research in relation to public health to benefit the NHS.

1.1.1.4. Civil Contingencies Act (CCA) 2004

UKHSA is as a Category 1 responder under the Civil Contingencies Act 2004 (CCA) (9) in respect of emergency planning, the response and resilience functions for public health. For the avoidance of doubt, these duties under the CCA shall be delegated from the Secretary of State to officials in UKHSA who are responsible for emergency planning, resilience and response, such that those officers operate as if UKHSA itself were a Category 1 responder under the CCA.

1.1.1.5. UK National Leadership for Risk Identification, Emergency Preparedness, Response and Recovery 2023

DHSC is the leading governmental department for prevention and resilience, preparation, emergency response and recovery for impacts on health from severe storms and weather (excluding those mentioned separately in the guidance) (10). UKHSA carries these responsibilities on behalf of DHSC for public health impacts from adverse weather events.

1.1.1.6. Equality Act 2010

As a public sector organisation, UKHSA has a legal duty to pay due regard to inequalities between people who share a protected characteristic and those who do not.

The general equality duty that is set out in the Equality Act 2010 (11) requires public authorities, in the exercise of their functions, to have due regard of the need to: eliminate unlawful discrimination, harassment and victimisation and other conduct prohibited by the Act; advance equality of opportunity between people who share a protected characteristic, and those who do not; foster good relations between people who share a protected characteristic, and those who do not.

1.2 What is the Adverse Weather and Health Plan (AWHP)?

The first edition of the Adverse Weather and Health Plan (AWHP) in April 2023 delivered our commitment under the National Adaptation Programme to develop a single plan, bringing together and improving current guidance on weather and health. The Plan brought together and built on the Heatwave Plan for England, first published in 2004, and the Cold Weather Plan for England, first published in 2011.

The AWHP continues to build on existing measures taken by government, its agencies, the NHS England and local authorities, to protect individuals and communities from the health effects of adverse weather and to build community resilience.

This is an ambitious plan which seeks to support local and national organisations to prepare, build and respond to future adverse weather events to protect lives and promote health and wellbeing in order to:

- prevent the increase in years of life lost due to adverse weather events
- prevent mortality due to adverse weather events
- prevent morbidity due to adverse weather events

- reduce the use of healthcare services due to adverse weather events

Achieving these goals will also support actions to reduce wider health inequalities and protecting those most at risk from the impacts of adverse weather and climate change.

The AWHP programme of work is underpinned by:

- the Plan itself
- this support evidence document
- the guidance and support materials
- the Weather Health alerts (heat and cold), developed in collaboration with the Met Office

1.3 Methodology

This section briefly outlines the methodological approach taken to compile this document. This version is based on the first, and previous, Adverse Weather and Health Plan (AWHP): supporting evidence, published in April 2023 which has been updated and reviewed. Gap analysis was undertaken in collaboration and consultation with internal and external partners to systematically identify key evidence needs for this second edition.

To gain the necessary insights and improve understanding of the health effects of extreme and adverse weather events, a mixed methods synthesis has been undertaken, combining:

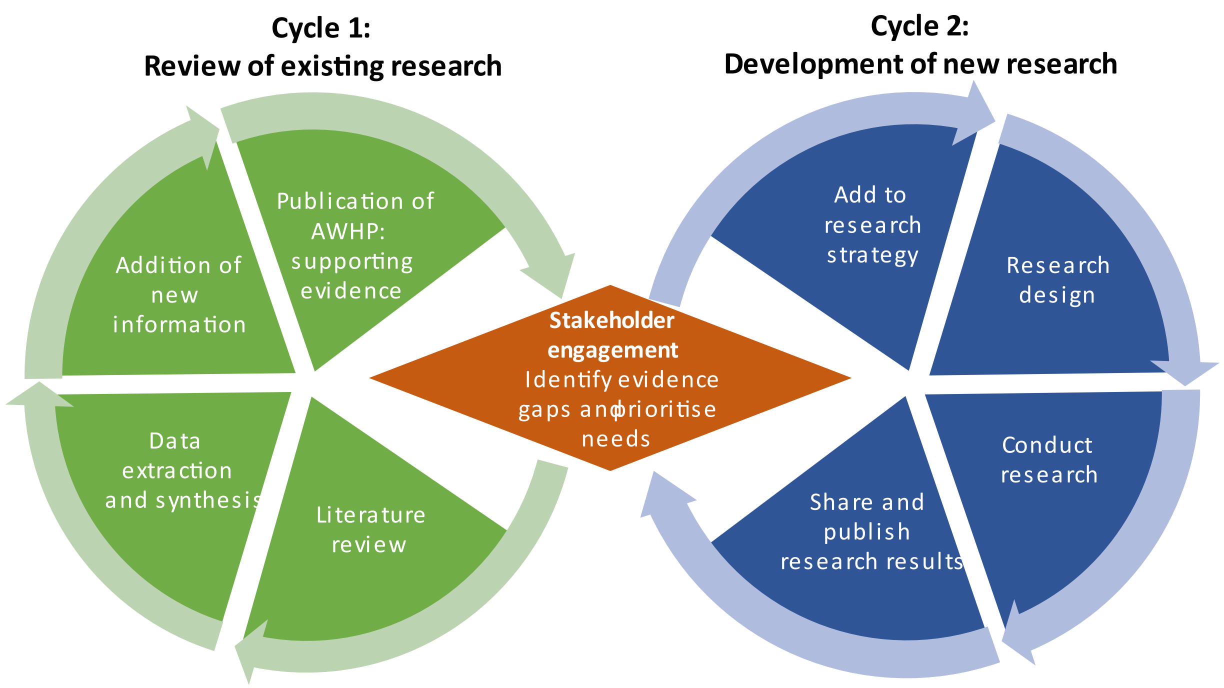
- qualitative and quantitative data collection and analysis from peer-reviewed and grey literature on the health effects of hot and cold weather, drought, flooding, storms, and thunderstorm asthma
- expert consultation and scientific studies that have been conducted by UKHSA and its partners in response to previously identified evidence gaps (including systematic literature reviews (for example, on public health effectiveness of warm spaces during periods of adverse cold weather)
- qualitative research conducted by UKHSA and its partners (for example, focus groups on risk perception and uptake of protective behaviours in response to hot weather by older adults)
- stakeholder engagement activities (for example, with cross-sector stakeholders on the health impacts of flooding and on extreme hot and cold weather alerts in England)

Relevant works have been cited throughout this document and may be sourced directly for further details of methods used.

This document also incorporates previous national weather plan iterations and evaluations of the Cold Weather and Heatwave Plans for England, as well as updates to associated national policy and guidance documents, cold and heat-associated mortality data and methodologies, and details of recent adverse weather events experienced in England.

This is a living document and as such, its content, methodologies, and format will continue to be improved and updated in consultation with key stakeholders through an iterative process, as illustrated in Figure 1. This will ensure that the plan and guidance are supported by the latest evidence and meet the needs of end users.

Figure 1. Lifecycle of the Adverse Weather and Health Plan (AWHP): supporting evidence



Text equivalent version of Figure 1.

Figure 1 shows the lifecycle of the Adverse Weather and Health Plan (AWHP): supporting evidence. The processes involved in developing the document are described in 2 cycles that interconnect through ongoing processes of stakeholder engagement and identification of evidence gaps and needs prioritisation.

Cycle 1 – review of existing research, includes: literature review, data extraction and synthesis, addition of new information, publication of the AWHP: supporting evidence document.

Cycle 2 – develop new research, includes: add to research strategy, research design, conduct research, publication, share and publish research results.

End of text equivalent

2. Health effects of adverse weather

This chapter provides an overview of the indirect and direct impacts of adverse weather on the health and wellbeing of exposed populations. As outlined in Chapter 1, climate change is increasing the frequency and severity of adverse weather events and the health effects are well-documented. Adverse and extreme weather events place greater pressures on health and social care sector services, including morbidity and mortality and worsening inequalities. These services should prepare and ensure they can provide adequate and appropriate services for those at most risk during adverse weather events. There is strong evidence that many harms to health associated with adverse weather can be effectively reduced or prevented through targeted actions.

Adverse weather events already cause significant numbers of deaths each year and these are expected to increase in future years, for both heat and cold, as the climate changes. Extreme heat episodes in England have resulted in significant heat-associated mortality in recent years, and evidence suggests that the risk of mortality increases at high temperatures in all populations (12). As the HECC report 2023 highlights, based on plausible worst-case scenarios, without adaptation, annual heat-associated deaths are projected to increase to approximately over 21,000 in the 2070s. For context, as detailed in the Heat mortality monitoring report: 2022 (13), an estimated 2,985 heat-associated deaths were observed in summer 2022.

Threats to health from cold weather are still high in the UK despite rises in average ambient temperature under climate change. The output of the FluMoMo model adapted by UKHSA, estimated that 5,533 deaths in winter 2022 to 2023 could be attributed to periods of extreme cold (14) (see Section 2.1.4 Winter Mortality for further details). Cold weather can compound the effects of other hazards such as respiratory viruses and increase pressures on health and social care services. Cold-associated deaths due to extreme cold weather are predicted to peak around 2030, with deaths from moderate cold peaking in the 2050s. Therefore, cold weather will continue to present a burden of mortality for England in the coming years (15).

These projections underscore the need for the AWHP. The plan has been developed to help health and social care agencies, other key national and local stakeholders, and the general public to prepare, build and respond to future adverse weather events to protect lives and promote health and wellbeing.

It is important to differentiate between the specific meanings of the terms ‘adverse weather’, ‘severe weather’ and ‘extreme weather’ as they are used throughout this document.

Box 1. Defining 'adverse weather', 'severe weather' and 'extreme weather'

'Adverse weather' describes weather events such as episodes of hot or cold weather or flooding from heavy rainfall, that have an impact on public health and wellbeing. The level at which risks to health start to increase are not necessarily severe or extreme.

'Severe weather' refers in general to any destructive weather conditions that increase the risk of harm to public health and wellbeing, with impacts being felt across sectors.

'Extreme weather' relates to exceptionally adverse, severe, unusual or unexpected weather conditions for the season and location.

2.1 Cold weather

Mortality is significantly higher during the winter months (December to March in the UK) compared to other seasons, although the number of additional deaths vary annually. This period also sees a substantial increase in respiratory illnesses and other illnesses which are exacerbated by exposure to cold. The reasons for increased winter mortality are often complex and interlinked, and include:

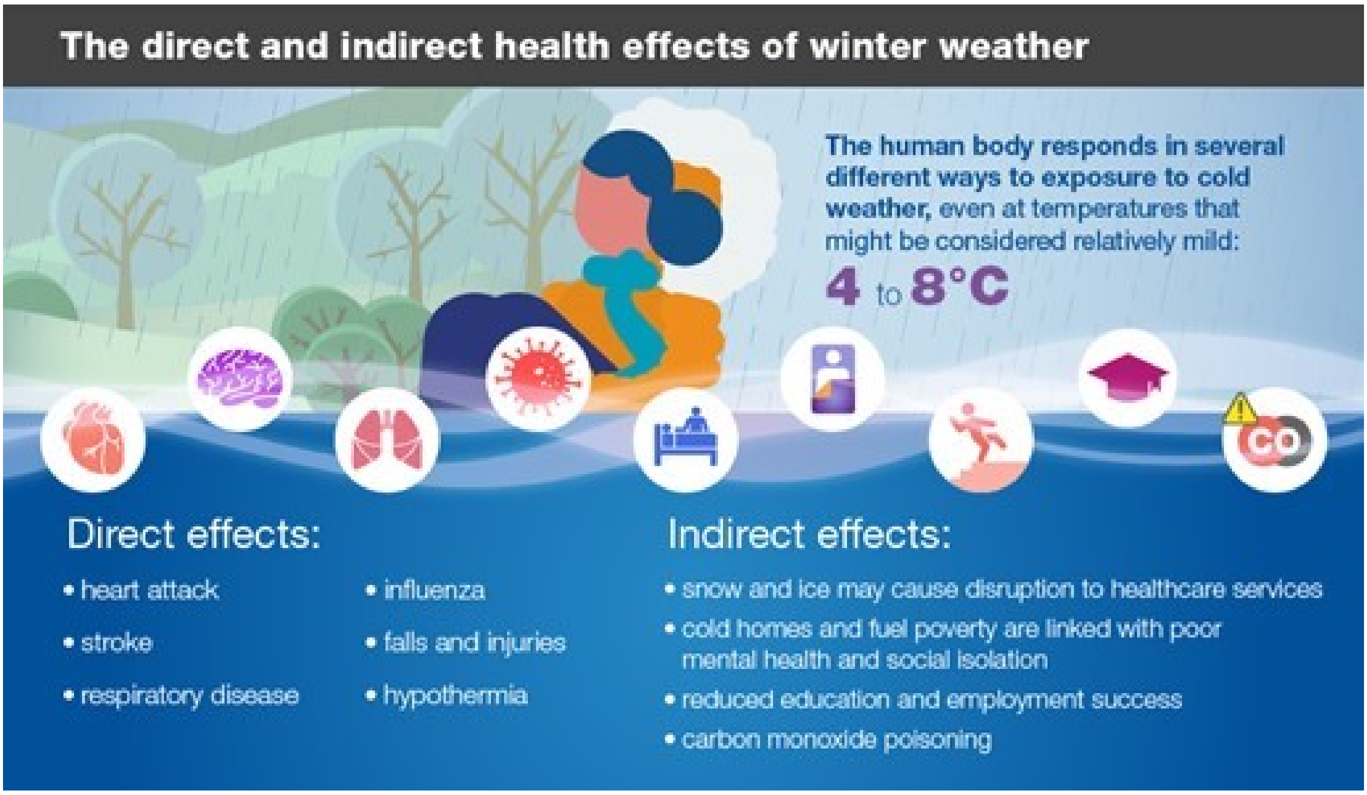
- individual vulnerability, for example age and pre-existing medical conditions
- circulating infectious diseases, particularly flu and norovirus
- attitudes to cold and associated behaviours, for example ability to look after oneself in cold weather
- seasonal factors, for example snow and ice
- housing and economic factors – poor quality housing, particularly cold homes

Climate change has differential impacts on different groups of people. People who are experiencing these complex set of conditions may also be experiencing health inequalities which are considered to avoidable, unfair and systematic differences in health outcomes experienced by different groups of people (16).

2.1.1 Health effects from cold weather

There is an established evidence base on the risks to health from cold weather. The effects of cold weather on health are predictable and generally preventable. Cold temperatures and winter weather have direct and indirect effects on health (see Figures 2 and 3).

Figure 2. The direct and indirect health effects of winter weather (17)



Accessible text equivalent of Figure 2. The direct and indirect health effects of winter weather (17)

The human body responds to cold exposure in different ways (see Figure 4). Importantly, effects are seen even at temperatures that might be considered relatively mild (4°C to 8°C). We can distinguish between direct and indirect effects of cold weather on health. Direct effects occur when cold exposure leads directly to a health impact. Indirect effects on health from cold usually only occur when other factors are also present that influence a health impact.

Direct effects include:

- heart attack
- stroke
- respiratory disease
- influenza
- falls and injuries
- hypothermia

Indirect effects include:

- snow and ice causing disruption to healthcare services which in turn affects whether people can access care

- cold homes and fuel poverty which are linked with poor mental health and social isolation
- reduced education and employment success, both of which are linked to poorer health outcomes over the long-term
- carbon-monoxide poisoning

End of text equivalent

Indirect effects include mental health effects from depression, reduced educational and employment attainment. There is also a risk of carbon monoxide poisoning from poorly maintained or poorly ventilated boilers, cooking and heating appliances with combustion sources.

Although exposure to extreme cold can kill directly through hypothermia, respiratory and circulatory conditions, dementia and Alzheimer’s can also result in cold-related illness and death. People with dementia and Alzheimer’s do not readily recognise that they are feeling cold.

An increase in cold weather-related deaths is observed shortly after the onset of cold weather. These mortality rates can remain raised for up to 4 weeks after the initial cold snap. Deaths caused by cardiovascular conditions are observed first, followed by deaths from stroke and then respiratory conditions. It is important to note that negative health effects start at relatively moderate outdoor mean temperatures of 4°C to 8°C. Generally, the risk of death increases as temperatures fall, however, health impacts also increase with the number of days at moderately cold temperatures. Therefore, although action to protect health on the coldest days remains important, shifting the emphasis to all year-round planning is essential to protect population groups most at-risk from the impacts of cold weather and to address winter pressures in the NHS and social care. These align closely with the National Institute of Health and Care Excellence (NICE) guidance on ‘Excess winter deaths and morbidity and the health risks associated with cold homes’ (18).

The following sections examine the different health effects of cold weather in more detail.

2.1.1.1 Cardiovascular disease

Exposure to cold temperatures increases blood pressure and risk of blood clotting in healthy people who are sedentary and/or wearing minimal clothing. There is consistent evidence that temperatures of below 18°C (+/- 0.5°C) are associated with negative effects on health, and that this is the threshold temperature at which these effects start to occur (18). The effects include: an increase in erythrocyte count and fibrinogen, both of which are needed for thrombus (blood clot) formation and increase in blood pressure (19). If clots occur in the heart and brain vessels, they can lead to a heart attack and stroke respectively. High blood pressure can increase the risk of heart attack, heart failure, kidney disease, stroke, or dementia.

2.1.1.2 Respiratory illnesses

When the weather is cold, people tend to spend more time indoors where they are more likely to be near one another. If ventilation is not sufficient, this can aid the spread of communicable diseases including respiratory ill-health (18). Exposure to low indoor or outdoor temperatures suppresses the immune system, diminishes the lungs' capacity to fight off infections and increases constriction of the airways which stimulates mucus production. These factors are associated with an increased risk of bronchitis and pneumonia. It is estimated that GP visits for respiratory illness increase by up to 19% for every 1°C that drops below 5°C of the mean temperature (19).

When a house is damp as well as cold, mould is likely to occur. This increases the risk of respiratory illness, particularly asthma. Home energy efficiency measures have been shown to significantly reduce absence from school in children due to asthma, and recurrent respiratory infections (20). For further details, see Section 2.1.2.2.2 Damp and mould.

Evidence suggests that older people who were living in fuel-poor households, or who did not own their home, had significantly worse respiratory health (measured by peak expiratory flow rates) (21).

2.1.1.3 Influenza ('flu')

In the UK, influenza seasons vary from year to year and can start from October and last until February each year. For most healthy people, seasonal flu is an unpleasant but self-limiting disease that they recover from within a week. There are particular risks of severe illness from flu in older people, the very young, pregnant women or those with certain long-term health conditions such as chronic respiratory, cardiac disease or those who are immunosuppressed.

2.1.1.4 Other infectious diseases

As well as influenza, cold weather is associated with an increase in the incidence of several other respiratory infections. These include:

- COVID-19
- respiratory syncytial virus (RSV)
- adenovirus
- human metapneumovirus (hMPV)
- parainfluenza
- rhinovirus (20)

For further information, please visit the influenza, COVID-19 and other respiratory viruses: sources of surveillance data page (24).

Bacterial infections such as Group A Streptococcus, and viral gastroenteritis (winter vomiting disease) such as norovirus and rotavirus, also have a seasonal pattern and may increase in winter.

2.1.1.5 Hypothermia

Deaths directly caused by hypothermia represent only a small proportion of the total amount of deaths that occur during periods of cold weather. Hypothermia is a potentially fatal lowering of core body temperature caused by exposure to cold. One study looked at patients over 65 years attending emergency departments found peaks in incidence of hypothermia coinciding with periods of cold weather. More than one third of patients with core body temperature below 35ºC died. The majority of patients lived in relatively deprived postcodes (25).

2.1.1.6 Falls and injuries

Winter weather and cold homes affect mobility and increase the likelihood of falls and injuries – especially in frail and older adults due to:

- symptoms of arthritis worsen in cold and damp houses
- strength and dexterity decrease as temperatures drop, increasing the risk of non-intentional injuries
- snow and icy conditions increase the risk of trips and falls outdoors (26)

In England, the number of emergency hospital admissions due to falls on snow and ice varies considerably from one winter to winter. One study showed that the weekly rate of emergency hospital admissions for falls on snow and ice is inversely related to the mean weekly temperature. In other words, as the temperature falls, there is an observed increase in those admitted for falls (27). Not only is this often a life changing event for an older adult, but the number of people suffering such injuries can lead to additional winter pressures on the health and social care services.

2.1.1.7 Mental and social health and wellbeing

Damp, cold housing is associated with an increase in mental health conditions, such as depression and anxiety (28). Living in these homes can affect people’s ability to go about their daily lives. Some people become socially isolated as they are reluctant to invite friends or family to a cold house, while others seek refuge outside the home (28).

Cold housing can also negatively affect children’s emotional wellbeing and resilience. It can be difficult for children to study or do homework in a cold house; this can affect educational and long-term health and work opportunities. Studies have suggested that more than 1 in 4 adolescents living in cold housing are at risk of developing mental health conditions, compared with 1 in 20 adolescents who have always lived in warm housing (29).

It is difficult to measure a direct increase in demand on mental health services due to cold weather. However, there is an established association between common mental disorders (CMD) including depression and anxiety and cold, damp homes (30). A questionnaire which linked proxy measures for fuel poverty (As defined by the Marmot Review Team: "Fuel poverty occurs when a household cannot afford to adequately heat their home or meet basic energy requirements" (31)) to CMD showed that 10% of those with CMD reported not being able to keep their home warm enough in winter compared with just 3% without CMD. Of those with CMD, 15% said they had mould in their homes compared to 8% with no CMD (31). For more information, see Section 4.3.1. Cold homes and fuel poverty.

2.1.2 Indoor environmental impacts

2.1.2.1 Indoor temperatures, cold weather and warm spaces

Maintaining suitable temperatures indoors is important for health and wellbeing. A systematic literature review found that indoor temperature <18°C was associated with adverse health effects including cardiovascular (blood pressure) and respiratory (COPD symptoms, respiratory viral infection) diseases impacting older people and people with chronic health problems (32).

During 2022 and in response to the cost-of-living crisis, there were serious concerns across England about people being able to heat their homes in the winter. This prompted many local areas to set up a programme of warm spaces. Warm spaces are community buildings where people can gather for free to keep warm. Based on a systematic literature review, a small survey of local authorities across England and guidance from an expert network of providers of such spaces, UKHSA developed guidance and a Warm spaces toolkit for local organisations. This provides a framework for organisations seeking to develop or evaluate a warm space for their local population during the winter. The toolkit includes case studies sharing examples of best and promising practice as well as signposting to resources to support organisations in developing their warm space offer (33).

2.1.2.2 Indoor air quality and cold weather

Exposure to indoor air pollutants can be associated with significant adverse health effects. People are exposed to air-borne emissions from various sources, including building materials, through to emissions from activities such as cooking, consumer products used for cleaning, the use of heating systems, fires and solid fuel stoves (34, 35). The sources of indoor pollution may pose threats to health if ventilation is inadequate, not working properly or windows are kept shut in order to reduce heat loss and to save on energy bills; behaviours which would be taken during periods of cold weather (36).

Household cleaning and consumer products contribute to total volatile organic compound (TVOC) concentrations that are up to 50 higher indoors than outdoors, especially during winter when ventilation is reduced (34, 35). Solid fuel burning, including coal and wood, is increasing in popularity in UK households despite evidence that they can increase average particulate matter concentrations (PM2.5 and smaller) to nearly 3 times the level of homes without wood burning stoves (36, 37, 38). Therefore, the weather can play a role in the composition of indoor air quality.

Modelling work indicates that a large majority of houses in England do not allow sufficient ventilation to keep indoor air pollutant levels within WHO recommendations (39).

2.1.2.2.1 Carbon monoxide:

Heating and cooking appliances (such as those using oil, gas, coal or wood), especially gas boilers, that are incorrectly installed, poorly maintained, malfunctioning, poorly ventilated, un-flued or with blocked flues are the major sources of carbon monoxide (CO) exposure and poisoning in the home (40, 41). CO poisoning increases in winter months (40, 42), as people may also use malfunctioning or inappropriate appliances to heat their homes or may also try to reduce ventilation.

Exposure to CO may be acute or chronic (43). It can have effects on the cardiovascular and neurological systems and may lead to death (44). It can also cause harm to an unborn child.

Symptoms of CO poisoning can include:

- headache
- dizziness
- confusion
- disorientation
- memory loss
- fainting
- coma
- death

While the number of hospitalisations and deaths from unintentional non-fire related CO poisoning have declined over time, between 2017 to 2021 there were still around 20 deaths a year in England and Wales (45).

2.1.2.2.2 Damp and mould:

Biological contaminants in the home include many varieties of fungi (mould), bacteria and pollutants such as dust mites. It is estimated that damp and mould affect between 4% to 27% of UK homes (46, 47) and some of the main causes include inadequate ventilation, leaks, structural issues, and condensation (48). Not heating a home adequately warm leads to moist air condensing onto cold surfaces, such as walls and windows. This, in combination with the desire to minimise energy bills keeping the windows shut to trap heat indoors, creates an environment in which mould can thrive. Using a combination of mechanical ventilation with heat recovery (MVHR), extractor fans in bathrooms and kitchens, and opening trickle vents can help keep relative humidity low and minimise the risk of condensation, even during the cold season (49, 50).

Damp and mould have been associated with respiratory health outcomes, such as exacerbation of asthma, respiratory infections and allergic airway diseases such as rhinitis, and general symptoms of cough and shortness of breath, as reported in several studies (51) (found that exposure to damp and/or mould was associated with approximately 5,000 new cases of asthma and approximately 8,500 lower respiratory infections among children and adults in the UK. Other reported health effects include eczema, eye irritation, fungal infections and worsened mental health, due to living in unpleasant conditions, damaged property, landlord-related frustrations or fear of eviction. Recently published guidance on damp and mould for social and private sector landlords provides an overview of the main causes of its occurrence (52).

2.1.3 Effects on health and social care services

Deaths and illnesses during the winter months are significantly higher than at other times of the year and there is a rise in the demand for health services, across the health and social care services from primary and community care to NHS emergency services, commonly called ‘winter pressures’. This may be further exacerbated by staff shortages due to illness.

Evidence shows that there is an increase in hospital admissions from cold-related illnesses as temperatures fall. Analysis of colder winters in Suffolk County found that all rate ratios for hospital admission in colder winters compared to warmer winters were significantly raised with effects of 2 to 5% (53). Further, a study on the impact of extreme temperatures on emergency hospital admissions in England found “the largest effect on admissions from a day of extreme cold was observed for injuries with an increase of approximately 20.9% per hospital on the day of the event, relative to a 10 to 15°C day”, with stronger and larger effects observed for the elderly and more deprived populations (54). Admissions for chronic obstructive pulmonary disease increase as temperatures fall, particularly in socio-economically deprived areas (54, 55). Admissions for chronic obstructive pulmonary disease increase as temperatures fall, particularly in socio-economically deprived areas (54, 55). Admissions for chronic obstructive pulmonary disease increase as temperatures fall, particularly in socio-economically deprived areas (55).

Cardiovascular, respiratory, and infectious diseases with a seasonal increase, as well as weather-related accidents, contribute to raising the number of admissions. Prolonged in-patient episodes can occur, either due to medical complications or a delay in discharging patients because of lack of suitable accommodation.

Extreme weather can also have an impact on the number of ambulance call outs and response times. For every 1°C reduction in air temperature there is an estimated reduction of 1.3% in service performance (measured by response rate and response times). This may be related to the increase in volume of emergency calls and potentially adverse road weather conditions (56).

2.1.4 Winter mortality

There is strong evidence that many winter deaths are related to cold temperatures, living in cold homes and infectious diseases such as influenza (20). The rate of winter deaths observed in England are twice the rates observed in some northern European countries, such as Finland (22, 57). Even with climate change, cold-related deaths will continue to represent the biggest weather-related cause of mortality (23). As mentioned previously, the HECC report 2023 estimates that cold-related deaths will continue to increase before they start to decline by the 2070s, but the total burden from moderate cold will still exceed that from heat well into the 2070s (15).

2.1.4.1 Measuring winter mortality

Until 2023, The Office for National Statistics (ONS) produced an annual winter mortality report for England and Wales. This report estimated the additional number of deaths that occur in the winter months (December to March) compared to the average number of deaths which occur in the non-winter months. This was calculated as winter deaths (deaths occurring in December to March) minus the average of non-winter deaths (deaths occurring in the preceding August to November plus deaths occurring in the following April to July divided by 2).

An extension of this calculation was the winter mortality index. This took the number of winter deaths calculated by ONS and divides it by the average of non-winter deaths on a 5-year rolling basis. This showed the percentage of additional deaths that occurred in the winter and was calculated so that comparisons can be made between cause of death, sexes, age groups and geographical areas.

Between 2021 and 2022, ONS estimated 13,400 more deaths occurred in the winter periods (December 2021 to March 2022) compared to the average in non-winter periods (58). During this same period, the winter mortality index was highest for those aged 90 years and older, for COVID-19 and in London.

Both ONS methods used all-cause mortality to estimate the impact of winter on seasonal mortality. With these methods it is not possible to determine the relative impacts of underlying causes such as influenza or extremes of temperature.

At time of writing, these methodologies are under review and publication of the annual winter mortality report for England and Wales by ONS has been paused (59) (REF).

Another method for assessing winter mortality trends in use across Europe is the European Mortality Monitoring (EuroMoMo) programme. EuroMoMo's aim is to detect and measure excess deaths related to seasonal influenza, pandemics, and other public health threats. An experimental extension to the EuroMoMo method that is more focussed on estimating the contribution of specific causes to spikes in winter mortality is FluMoMo (60). The FluMoMo model aims primarily to estimate the number of deaths related to flu.

UKHSA adapted the model for winter 2022 to 2023 to allow estimates for deaths associated with periods of extreme cold and COVID-19 [12].

The output of the adapted model estimated that 5,533 deaths in winter 2022 to 2023 could be attributed to periods of extreme cold. Estimates of deaths due to cold from the model between 2012 to 2022 fluctuated over time but deaths peaked at >5000 in 2012 to 2013 and 2022 to 2023.Estimates of extreme cold-associated deaths from the adapted FluMoMo model for winter 2023 to 2024 will be published in spring 2024.

Determination of the number of deaths attributed to cold weather is complex. As described, there are several models available to aid decision making. Currently, none of the models are perfect and decision-making is likely to be dependent on triangulating all available data.

2.1.4.2 NICE guidelines on winter mortality

NICE guideline (NG6) (18) makes recommendations on how to reduce the risk of death and ill health associated with living in a cold home. The aim is to help meet a range of public health and other goals which include:

- reducing preventable winter death rates
- improving health and wellbeing among vulnerable people
- reducing pressure on health and social care services
- reducing ‘fuel poverty’ and the risk of fuel debt or being disconnected from gas and electricity supplies (including self-disconnection)
- improving the energy efficiency of homes

Improvements to make homes warmer may also help reduce unnecessary fuel consumption (although where people are living in cold homes because of fuel poverty their fuel use may increase). In addition, such improvements may reduce absences from work and school that result from illnesses caused by living in a cold home.

The health problems associated with cold homes are experienced during ‘normal’ winter temperatures, not just during extremely cold weather. Year-round planning and action by many sectors is needed to combat these problems. The guideline outlines a role for health and other practitioners in:

- prioritising which homes are tackled first
- shaping and influencing decisions about how homes are improved
- highlighting the importance of research, implementation, and evaluation

NICE has also published a quality standard that covers reducing the health risks (including preventable deaths) associated with cold homes (18). It includes identifying people at risk who are particularly vulnerable to the cold, such as young children, older people and people with cardiovascular disease or mental health conditions. It describes high-quality care in priority areas for improvement. It also describes high-quality care in priority areas for improvement helping to prevent winter deaths and illness associated with cold weather.

2.2 Hot weather

Extreme heat is increasing worldwide at an unprecedented rate (61). There has been a 6-fold increase of concurrent heatwaves since the 1980s which are compounding the impacts of other natural hazards, such as drought, wildfires and flash flooding (62).

The Intergovernmental Panel on Climate Change (IPCC) assessed with very high confidence that “globally, population exposure to heatwaves will continue to increase with additional warming, with strong geographical differences in heat-related mortality” unless further action is taken (63). Increasing temperature extremes are a growing health risk due to rapid urbanisation and demographic changes in countries with ageing populations. Actions are required to adapt urban infrastructure (particularly housing) to ensure that planning for such events takes account of people who are vulnerable to the health impacts of hot weather.

Climate change is already causing warmer temperatures in the UK. All the warmest years on record in the UK have occurred since 2002. The summer of 2022 saw the highest recorded temperature in England at 40.3°C in July, which prompted the first ever Level 4 Heat-Health Alert (HHA) and Red National Severe Weather Warning Service (NSWWS) Extreme Heat warnings to be issued. As previously stated in the introduction to this chapter, during summer 2022, there were an estimated 2,985 heat-associated deaths across 5 heat episodes, the highest number in any given year. For further information, see the Heat mortality monitoring report: 2022.

This section presents strong evidence on the risks to health from hot weather. Evidence from the UK CCRA3 suggests that heatwaves remain an under-managed risk and will impact population health and health system delivery. Thus, heat is a priority risk for urgent action for England (6).

As they are used throughout this document, it is important to clarify what is meant by the terms: ‘National Severe Weather Warning Service (NSWWS) Extreme Heat Warning’, ‘UKHSA Heat-Health Alert’, and a ‘heatwave’ (see Box 2).

Box 2. What is the difference between the National Severe Weather Warning Service (NSWWS) Extreme Heat Warning, UKHSA Heat-Health Alert (HHA) and a heatwave?(64)

NSWWS Extreme Heat Warning: an impact-based warning issued by the Met Office designed to highlight the potential impacts of extreme heat to protect lives and property, helping people make better decisions to stay safe and thrive.

UKHSA Heat-Health Alert (HHA): an England-only service provided by UKHSA that considers the impact of adverse heat on public health, especially those with long-term health conditions.

Met Office 'heatwave' definition: a threshold-based meteorological definition designed to provide the media and public with consistent and reliable messaging.

2.2.1 Health effects of hot weather

Hot weather can be associated with an increased risk to health. Hot weather increases the risk of heart attacks, strokes, lung illnesses and other diseases. There are some groups, such as older people, young children and people with some long-term medical conditions who can be particularly vulnerable to the effects of hot weather. Many of the harms linked to heat exposure are preventable if a few simple actions are taken.

The body normally cools itself using 4 different physiological mechanisms:

- radiation in the form of infrared rays
- convection via water or air crossing the skin
- conduction by a cooler object being in contact with the skin
- evaporation of sweat

Increasing temperatures above 25ºC are associated with increased risk of heat-related deaths, with higher temperatures associated with even greater risk of death. At 27ºC or over, those with impaired sweating mechanisms may find it especially difficult to keep their bodies cool.

When the ambient temperature is higher than skin temperature, the only effective heat-loss mechanism is sweating. Thus, any factor that reduces sweating such as dehydration, lack of breeze, tight-fitting clothes or certain medications can cause the body to overheat.

Thermoregulation is controlled by the hypothalamus and can be impaired in the older adults, those with certain long-term health conditions and potentially in those taking certain medications making them more vulnerable to overheating. Young children produce more metabolic heat, have a decreased ability to sweat and have core temperatures that rise faster during dehydration.

Babies and children sweat less than adults, and this reduces their ability to cool down during hot weather, particularly if they are exercising or being active. This puts babies and children at a higher risk of overheating and developing a heat-related illness as well as making any existing illnesses worse. Babies and children need to be carefully watched during hot weather for signs of heat stress (65).

The main causes of illness and death during a heat episode are respiratory and cardiovascular diseases. Additionally, there are specific heat-related illnesses that can affect the general population. These include:

- heat cramps – caused by dehydration and loss of electrolytes, often following exercise
- heat rash – small, raised spots, an itchy feeling and mild swelling
- heat oedema – mainly in the ankles, due to vasodilation and retention of fluid
- heat syncope – dizziness and fainting, due to dehydration, vasodilation, cardiovascular disease and certain medications
- heat exhaustion (more common) – occurs as a result of water or sodium depletion, with non-specific features of malaise, vomiting and circulatory collapse and is present when the core temperature is between 37ºC and 40ºC (left untreated, heat exhaustion may evolve into heatstroke)
- heat stroke – a condition whereby the body's thermoregulation fails. It is a medical emergency characterised by symptoms of confusion, disorientation, convulsions, unconsciousness, hot dry skin and core body temperature exceeding 40ºC for between 45 minutes and 8 hours. It can result in cell death, organ failure, brain damage or death. Heatstroke can be brought on by excessive exposure to extreme heat (classical) or exertional (for example in athletes) (66)

Heat can exacerbate chronic conditions such as cardiovascular and respiratory systems but can equally increase the chances of other serious health issues such as:

- heart attacks
- strokes
- respiratory problems
- kidney diseases
- electrolyte disorders
- skin cancer

Extreme heat can also exacerbate a range of other health risks from increased transmission of food, vector and waterborne diseases, mental health manifestations, and drive increasing health inequities. Extreme temperatures stress health-system provision of emergency and ambulatory services and complicate responses to other health emergencies, such as the coronavirus (COVID-19) pandemic.

The following sections examine the different health effects of hot weather in more detail.

2.2.1.1 Cardiovascular

For the body to keep cool, large quantities of extra blood are circulated to the skin; this causes a strain on the heart. In the older adults and those with chronic health problems this can be enough to precipitate a cardiac event, such as heart failure.

Sweating and dehydration affect electrolyte balance. For people on medications that control electrolyte balance or cardiac function, this can also be a risk. Medicines that affect thermoregulation, the ability to sweat, or electrolyte imbalance can make a person more vulnerable to the effects of heat. Such medicines include anticholinergics, vasoconstrictors, antihistamines, drugs that reduce renal function, diuretics, psychoactive drugs and antihypertensives.

Air pollution such as ozone and particulate matter (PM10, PM2.5) also increases the level of cardiovascular-related deaths, as fine particles have been shown to enter the blood stream via the lungs and affect the heart. A recent scoping review indicated that there were quantifiable compound effects of temperature and air pollution on cardiovascular issues (67).

2.2.1.2 Respiratory

High temperatures are also linked to poor air quality with high levels of ozone which are formed more rapidly in strong sunlight; particulate matter also increase in concentration during hot, still air conditions (28). Both are associated with respiratory and cardiovascular mortality.

Hot weather can cause respiratory issues to flare up, particularly if the person becomes dehydrated. Hot weather can cause ozone levels and other air pollutants to rise in the air these can cause and trigger breathing problems. Humidity during hot weather can also make breathing problems worse.

During the spring and summer months grasses and weeds lead to increased pollen levels so hay fever and long-term lung conditions, such as chronic obstructive pulmonary disorder (COPD), can also be exacerbated.

2.2.1.3 Skin and eye health

Ultraviolet (UV) radiation may cause harm during heat episodes but also at other times when people expose themselves to the sun. A small amount of UV radiation is essential in the production of vitamin D, however too much exposure to the sun can have serious effects on your skin and eyes. Excessive exposure may have consequences ranging from premature skin ageing to skin cancer. The World Health Organization (WHO) states that the number of cases of malignant melanoma has doubled every 7 to 8 years over the last 40 years, mostly due to a marked increase in the incidence of skin cancers in fair-skinned populations that have been reported since the early 1970s (68).

Children are most at risk, as exposure to the sun during childhood appears to set the stage for the development of skin cancer later in life. UV radiation can also severely damage the cornea and lens of the human eye, a long period of exposure may result in photo keratitis and a lifetime of cumulative exposure contributes to the risk of cataracts and other forms of ocular damage.

2.2.1.4 Renal health and electrolyte disorders

Hot weather can lead to dehydration and this in turn can lead to low blood pressure which can cause a decrease in kidney function (28). Many metabolic systems start to shut down in response to heat illness and a decline in kidney function is part of that abnormality in metabolic systems. There is breakdown of muscle tissue that results in kidney failure.

2.2.1.5 Mental health and wellbeing

Mental health disorders contribute significantly to the global health burden of disease (69). Findings from a recent systematic literature review that was conducted to investigate the association between high temperatures and mental health outcomes showed that higher temperatures increased the risk of adverse mental health outcomes. This review also found significant gaps in our understanding of the impacts of heat on mental health outcomes, the strongest evidence exists for an increased risk of suicide in high temperatures. There was also evidence that risk of hospital admission for mental illnesses increased in high temperatures. Further evidence is highlighted in Table 2, which summarises the results of the systematic review, which mainly comprised international studies (70).

Table 1. Number of studies and headline findings of review by outcome group (70)

Outcome group	Number of studies	Main findings
Suicide	17	• 49% of all included studies examined the association between suicide and temperature • 15 out of 17 studies found a positive and significant association between increasing temperatures and suicide frequency • 4 studies found a positive and significant association between violent suicides and increasing temperature
Bipolar disorder, mania and depression	5	• a positive and significant association between admissions due to bipolar disorder and increasing temperature • no significant association was found between mania or depression and increasing temperature
Schizophrenia	5	• a positive and significant correlation between temperature and exacerbation of schizophrenic symptoms • risk of mortality more than double during episodes of heat wave
Organic, dementia, Alzheimer's disease and senility	5	• risk of admission for organic mental disorders increased significantly during periods of heat wave • agitation with disruptiveness of nursing home residents with known dementia increased significantly with temperature
Alcohol and substance misuse	2	• risk of mortality due to alcohol and substance misuse increased significantly during episodes of heat wave
Other mental health outcomes and service use	7	• a number of outcomes were covered by only one study with mixed findings • risk of admissions to psychiatric hospitals increased significantly during episodes of heat wave • mortality of those diagnosed with mental health illness increased significantly during periods of heatwave

2.2.1.6 Infectious diseases

Evidence exists that links increased ambient temperatures and associated dehydration with an increased risk from bloodstream infections caused by bacteria such as Escherichia coli (71). The risk is greatest in individuals aged 65 years and over and so it is important to ensure adequate fluid intake in older people during periods of raised temperatures. Further evidence is presented in Chapter 7 of the HECC report 2023, findings from a scoping literature review on the evidence of the impacts of weather and climate on foodborne, waterborne and respiratory infectious pathogens of public health importance have been discussed (72).

2.2.2 Effects on health and social care services

As previously outlined in this chapter, hot weather already presents a significant risk to public health, and the increasing frequency and severity of hot weather events can burden health and social care services, with associated impacts on staff, patient safety, and service delivery.

Healthcare infrastructure in England is generally not designed to cope with extreme heat and air conditioning is not routinely installed (73). An estimated 90% of hospital buildings are vulnerable to overheating (74) and National Health Service (NHS) estates are at risk of high indoor temperatures even during moderately warm summers (75); temperatures in some wards can exceed 30ºC even when external temperatures are 22ºC (76). Existing standards for healthcare premises recommend temperatures from 18ºC to 28ºC in general wards and 18ºC to 25ºC for more sensitive areas, such as birthing and recovery rooms (76). In 2019 to 2020, there were 3600 instances of overheating above 26ºC reported in NHS Trust buildings in England (77). Evidence suggests that new hospitals are currently more at risk of overheating during hot weather compared with older, more traditionally built hospitals, although maladaptation of older buildings can lead to a loss of this adaptive capacity (5).

A UKHSA (78) study critically assessed the impacts of very hot weather during summer 2019 on frontline staff in hospitals in England and on healthcare delivery and patient safety. The study found that hot weather in 2019 caused significant disruption to health services, facilities and equipment, and caused staff and patient discomfort and an acute increase in hospital admissions. Levels of awareness varied between clinical and non-clinical staff of the Heatwave Plan for England, Heat-Health Alerts, and associated guidance. Staff response to heat episodes was affected by competing priorities and tensions including infection control, electric fan use and patient safety. This study intentionally aimed to provide more evidence on the healthcare workforce dealing with overheating in healthcare estates as a routine summer issue, rather than its response to more unusual extreme heat conditions.

In light of this, since 2017, the NHS has required trusts and commissioners to submit data on the percentage of clinical areas covered by thermal monitoring, and the number of overheating events in clinical areas. This has been supplemented by statutory net zero guidance under the Health and Social Care Act 2022, which includes mandatory adaptation planning. Data (including on overheating) is now gathered quarterly in the Greener NHS dashboard (79).

2.2.2.2 Impact on social care

A 2016 study (80) provides qualitative evidence about potential causes of indoor overheating in care homes and indicates that they may be overheating even in relatively cool summers. Building design and management issues, including insufficient knowledge of heating system controls were found to be important contributing factors.

Heat mortality monitoring reports from UKHSA have repeatedly shown older people aged 65 years and over are at risk of adverse effects of heat and more so for older people in care homes (81). People aged 65 years and over spend more than 80% of their time in residential environments or care settings and for people aged 85 years and over it is more than 90% (82). Therefore, the indoor environment is a significant moderator of heat exposure in older populations: poor building design and the lack of effective heat management in care settings may contribute to increased indoor heat exposure with detrimental health impacts falling on the most vulnerable residents.

Care facilities function as both a home for residents and a workplace for staff, meaning that the people sharing those spaces can have diverging needs and preferences making overheating prevention measures difficult to enforce. The Climacare: Climate Resilience of Care Settings project was launched in 2019 to develop methods that will support a system of care provision in the UK that is adequately prepared for rising heat stress under climate change (83). The project aimed to undertake pilot work in 5 care settings in the UK to monitor the thermal environment and conduct surveys with residents, frontline care staff and care home managers. Within these buildings, it will test novel approaches for understanding the comfort levels of the residents and relating this to the thermal environment. It will also test novel measurement techniques for assessing impact of heat on the health of the residents (83).

2.2.2.3 Risk of power outages

Power outage related health impacts were reported in literature with very few making an association to mortality, of which majority were found in grey literature. Associated impacts from power outages affect technology-assisted patients disproportionately, with insufficient alternative measures during an outage.

As increased individual risks to health are thought to be mediated by exposure to high temperatures indoors (84) and even during a relatively cool summer, 1 in 5 homes in the UK are likely to overheat (85), evidence highlights the need to develop cooling solutions in buildings (86).

Certain features of a building’s design can make it more prone to overheating such as bad design, poor management or inadequate services. The Chartered Institute of Building Services Engineers (CIBSE) suggests that overheating as indoor temperatures that are above 28°C for a long period of time can make the occupants uncomfortable, increase dissatisfaction and reduce productivity (87). The Energy Follow Up Survey (EFUS) provides evidence from 750 homes in the UK between 2017 and 2019. Table 3 shows the key factors highlighted by EFUS that affect overheating (46).

Table 2. Energy Follow Up Survey (EFUS): key factors affecting overheating (46)

Instructure problem	Evidence
Dwelling type	In flats, 30% of the living rooms were overheated compared with 12% in houses. The prevalence of overheating in the bedrooms of flats (17%) was not significantly different from that in houses (19%).
Floor area	In dwellings with a floor area <50m2, 35% of living rooms were overheated compared with 7% to 16% in larger dwellings. There were no significant differences seen for main bedrooms
Region	The prevalence of overheating in living rooms and bedrooms was significantly higher in the London region compared with all other regions.
Energy efficiency	There was some evidence to suggest that the prevalence of overheating in living rooms was greater in dwellings with an Energy Performance Certificate (EPC) rating of A to C (15%) compared with dwellings with EPC D or below (10%).
Occupancy	Overheating in living rooms was more common in households with a pensioner present (24%) than in those without (11%). Households in the lowest 2 income quintiles had a higher prevalence of overheating in the living room (24% and 21%) compared with those in the highest income quintile (5%). Households with none in employment had a higher prevalence of overheating in the living room (24%) compared to those without (11%).
Tenure	Households in the social sector had a higher prevalence of overheating, both in the living room and in the main bedroom (26% and 29% respectively) compared with households in the private sector (13% and 17%).
Type of window	Those with large plate glass windows or converted flats from office blocks with large windows – can result in very high internal temperatures due to solar gains in summer.

Instructure problem	Evidence
	A study in 2018 found maximum internal temperatures of almost 50°C in a London office building converted to apartments, when they had no shading.

2.2.3.4 Outdoor air quality and heat

Heat is associated with increased concentrations of ozone (O_3), nitrogen dioxides (NO_x) and particulate matter ($PM_{2.5}$ and PM_{10}), particularly during periods of extreme heat (88). Due to climate change, more frequent and intense episodes of extreme heat are likely, which will affect ambient air quality and increase related health risks (88).

There is some evidence to suggest that extreme heat has a modifying effect on the short-term health effects associated with ambient air pollution. Some studies have indicated that all-cause mortality associated with ozone is related to higher temperatures (89 to 91). Current evidence suggests that there is a seasonal effect: short-term exposure to ozone was significantly associated with an increased risk of total morbidity and, specifically, of stroke, asthma, and pneumonia during the warm season (92). However, the effect size is difficult to determine due to heterogeneity within the literature and other factors that affect health, such as the quality of health care available, human behaviour, and other environmental factors such as weather. There is also evidence to suggest that the health impacts associated with PM_{10} and $PM_{2.5}$ increase with temperature, including cardiovascular disease and respiratory disease mortality (93). There is inconclusive evidence to suggest that the health effects associated with NO_x are modified by temperature, and more research is required in this area (89 to 91).

Some reviews have examined the interactive effect of air pollution and temperature upon different health outcomes (74), the evidence is not clear and further work is needed. UKHSA is currently undertaking a systematic review on the evidence for the health effects due to exposure to short-term ozone modified by increases in temperature. Understanding the links between the effect of ozone and temperature on health is important given increasing frequency, intensity and duration of extreme heat, and the potential for ozone episodes to coincide with such events in future.

2.2.3.4.1 Wildfires

High temperatures are also related to an increased rate of wildfires (95). Smoke from large-scale wildfires can contain a mixture of gases and fine particles, decreasing the local air quality and leading to short-term health impacts, including irritation of the eyes, nose, throat, and lungs, and may cause coughing, wheezing, breathlessness and chest pain, as well as exacerbation of pre-existing conditions such as asthma and chronic obstructive pulmonary disease (COPD) (96). A recent study showed that intense bushfire smoke exposure resulted in both acute and persistent symptoms among people who had severe asthma (96).

2.2.3.5 Indoor air quality and heat

Adverse hot weather conditions such as wildfires, extreme heat and rainfall also affect the indoor environment, including indoor temperature, air quality and noise, which can have an impact on occupants' health and wellbeing (94 to 99). Due to climate change, dwellings in the United Kingdom will be at increased risk related to heat exposure, flooding, as well as chemical and biological contamination indoors (99).

Outdoor weather conditions such as temperature, wind speed and direction are relevant to indoor environments, as they can promote or hinder the ingress of outdoor air pollution indoors, but also dictate the extent of window-opening by occupants, especially during periods of extreme heat. During these periods, building overheating is particularly sensitive both to the structure and characteristics (such as orientation) of a dwelling and to occupants' response to the elevated temperature.

Ventilation of buildings has a vital role to play: to dilute air pollutants generated from indoor sources, and to help reduce indoor temperatures to minimise the risk of overheating. Opening windows in the summer reduces CO2 levels generated from occupant exhalation and VOC concentrations generated from indoor sources (103). However, the indoor concentrations of air pollutants generated from outdoor sources for example, nearby traffic and industry such as particles, NO2 and ozone, can increase if windows are opened. In the UK, most dwellings rely on natural ventilation to improve indoor air quality. However, some occupants are not able to open windows overnight due to security or noise concerns, or due to structural reasons, which further increases their risk of overheating and associated negative health effects (104). Trickle vents can be used to increase the air exchange rate without opening a window (105) but cannot be solely relied upon for providing adequate ingress of fresh air (106).

2.2.3.5 Humidity

Humidity is an important factor in terms of thermal comfort, however its importance from an epidemiological perspective in relation to heat-associated mortality remains unclear. Studies that we are aware of, suggest that adding humidity into epidemiological models do not improve the predictive ability of those models in England. Therefore, currently we do not explicitly consider humidity in setting our decision-making and Heat-Health Alert threshold temperatures. However, humidity is considered as one of the wider factors within the decision-making process of the joint dynamic risk assessment when deciding whether to issue a Heat-Health Alert (107).

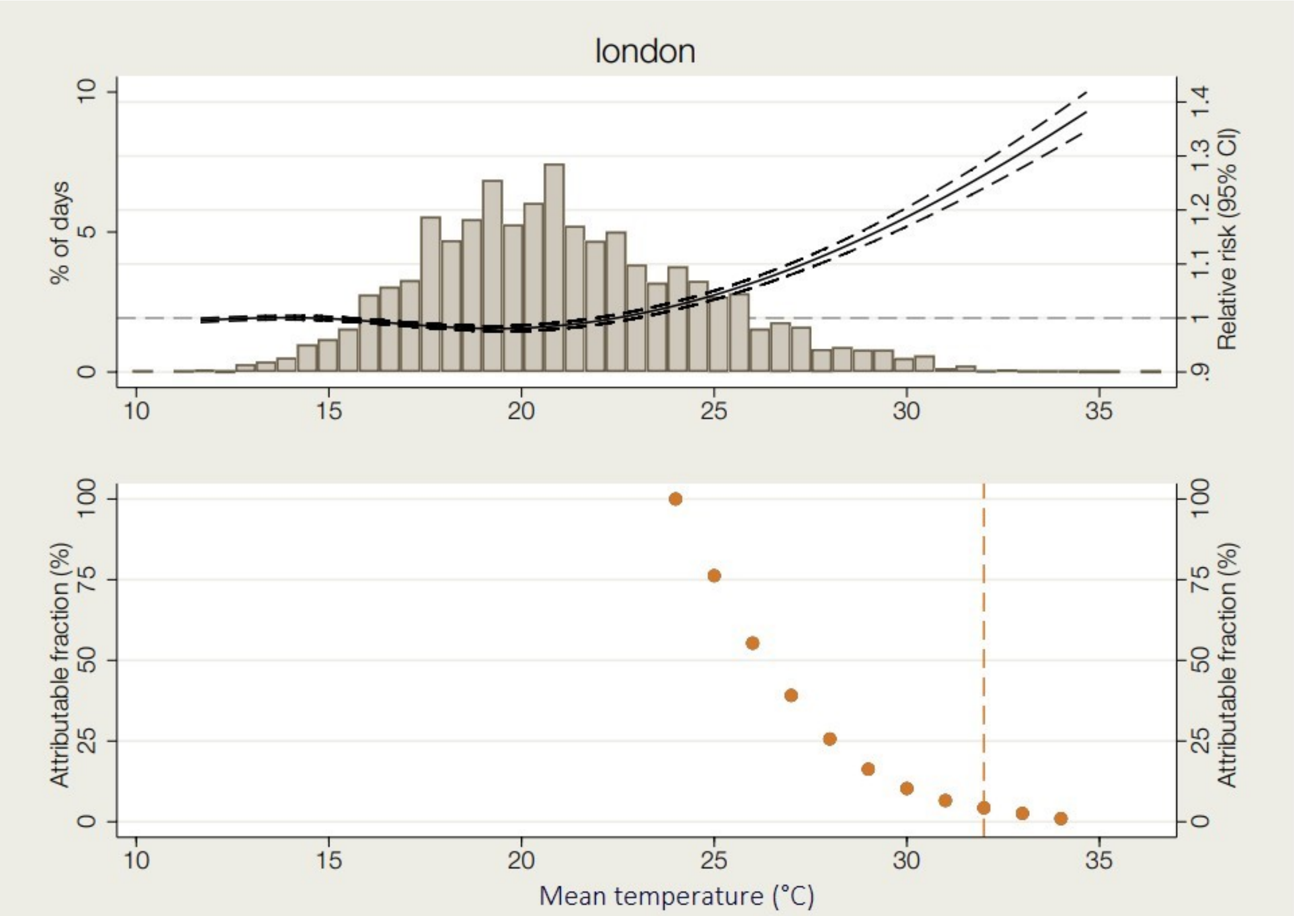
2.2.3 Heat-associated mortality

There is strong evidence that as temperatures increase above an optimum temperature, the risk of mortality also increases (12, 21, 66, 77, 81, 108 to 117). The temperatures at which these increases start to occur is also dependent on the geographical location (118). The impacts on mortality during periods of hot weather are generally observed within 24 hours of the onset of those high temperatures, and this can be seen in daily mortality time series. When temperatures increase daily mortality figures also increase, and then fall back towards expected daily values as the temperatures fall back to average levels.

During hot weather, the majority of heat-associated mortality is observed in older adults (63, 108 to 111). Evidence from the UK in 2020 showed significant heat-associated mortality in people aged 65 year and over in care homes and at home across all 3 extreme heat events recorded that summer. In hospital heat-associated mortality for this age group was only significant for the first and last periods of extreme heat of the season, which differed to 2016 and 2018, when heat-associated mortality in hospital was only significant during the first heat episode of the season (111). Evidence from Italy also suggests the risk of mortality during hot weather is raised for those already in hospital at the time of the heat as opposed to those entering the hospital on the hot days, with the risk the highest for those in the general medicine wards (77, 114).

Nationally, we have observed a clear link between increased daily mortality and when UKHSA has issued a Heat-Health Alert. However, impacts also occur at more moderate temperatures on non-alert days (118). The evaluation of the Heatwave Plan for England calculated the attributable burden on mortality across the observed temperature range and concluded that once alerting temperatures were reached the attributable fraction of avoidable mortality was very low (118). In other words, assuming that actions initiated once an alert is issued were 100% effective, only a very small proportion of the overall mortality would be avoided (118). This suggests that longer term strategic actions to address heat risk are as vital as emergency responses when heat episodes occur.

Figure 4. Adjusted temperature-mortality relationship in London and heat-attributable fractions (118)



Accessible text equivalent of Figure 4. Adjusted temperature-mortality relationship in London and heat-attributable fractions (118)

The figure shows 2 panels. First, the temperature mortality relationship for London in summer, with the relative risk of mortality for each temperature degree. Underneath this plot is a histogram of the proportion of days at each temperature. Here it can be clearly demonstrated that risk of mortality increases as temperature increases, with risk beginning to increase around 24C in London. When the proportion of days are also plotted, it can be seen that the majority of days over a summer period typically hover around 20C.

The bottom panel of figure 5 shows the attributable fraction of heat-associated mortality at each temperature above 24C, where the risk of death begins to increase, as seen in the top panel. Assuming that all deaths that occur at temperatures above 24C are due to heat, the attributable fraction of heat-associated deaths can be calculated for each temperature. By the time an AMBER Heat-Health Alert may be issued for London, around 32C and indicated by the dashed line on the figure), most of the heat-associated deaths would have already occurred, meaning that even if the actions triggered by the HHA were 100% effective, only a very small proportion of the heat-associated deaths would have been avoidable.

End of text equivalent

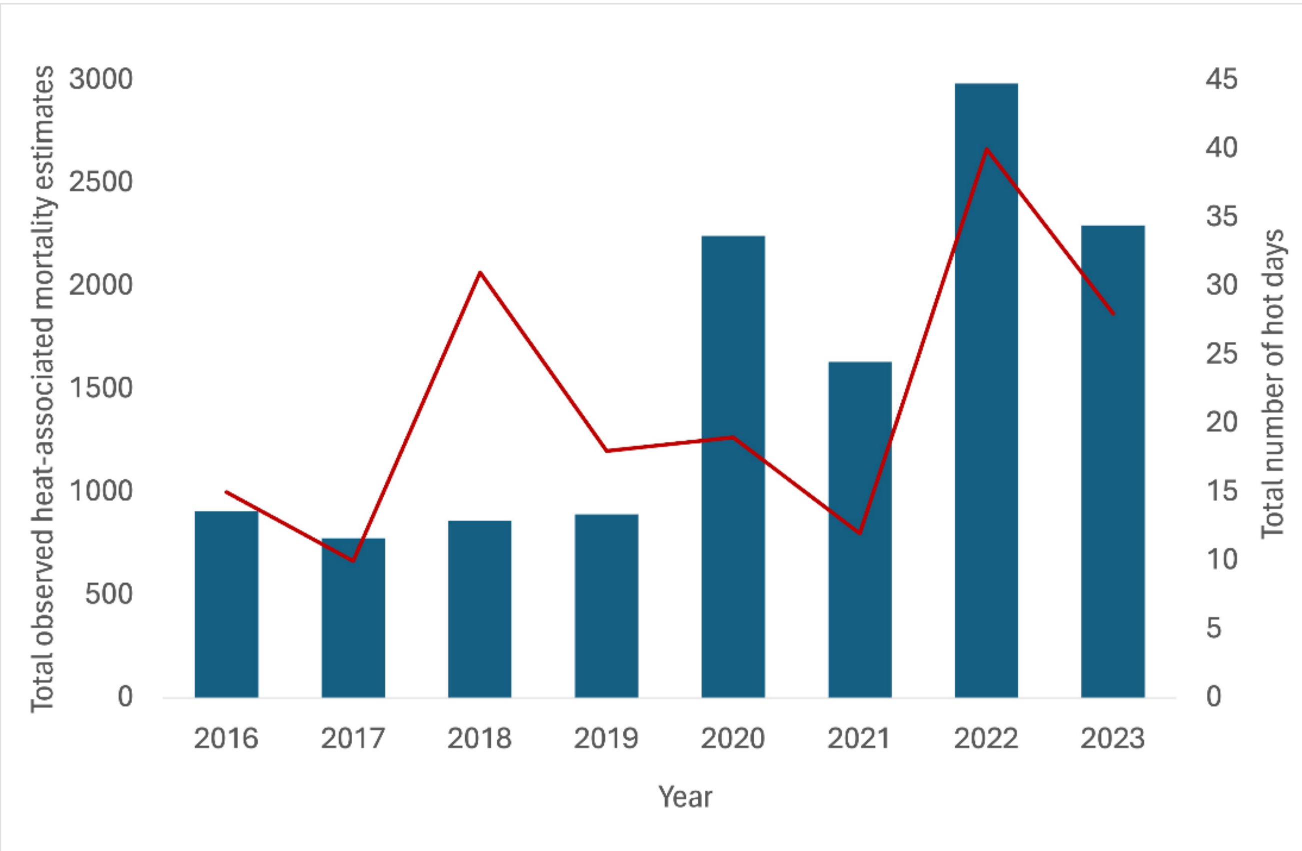
2.2.4.1 Summary of heat mortality monitoring reports

Heat mortality monitoring reports have been published annually by UKHSA and formerly Public Health England (PHE) and have been since 2016. These reports aim to summarise the estimated heat-associated mortality observed during the core Heat-Health alerting periods (1 May to 30 September). Heat mortality monitoring helps to inform public health actions during periods of extreme heat. The reports have previously been used to inform sections of the Heatwave Plan for England and will also now feed into the AWHP and the new impact-based Weather-Health Alerting System.

The methodology used to calculate estimated heat-associated mortality was previously based on work by Green and others (112). However, following the COVID-19 pandemic, the methodology was updated to account for the impact of COVID-19 on mortality to allow the impact of heat to be isolated.

In England, there appears to be an increasing trend in terms of extreme heat days and heat-associated deaths as can be seen in Figure 5, which shows the estimated total deaths from 2016 to 2023 in England. This aligns with the wider evidence-base that periods of extreme heat will occur more often, be more intense and last longer, leading to increased impacts (63).

Figure 5. The estimated total heat-associated deaths (blue bars) and the number of days which met the UKHSA definition of heat episode used to estimate the observed heat-associated mortality each year (red line) from 2016 to 2023 in England



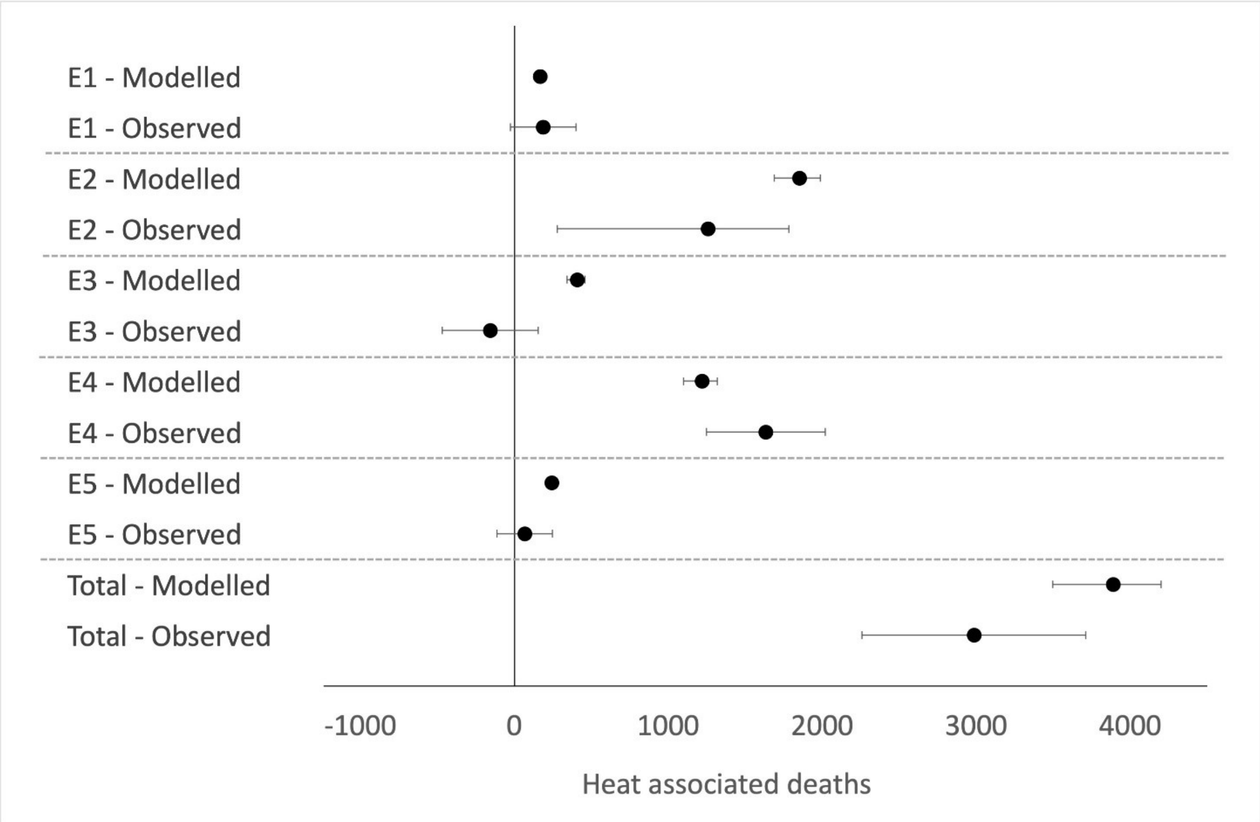
Note: Full details of the definition used is available in the annual UKHSA Heat Mortality Reports.

In Figure 5 an overall increasing trend can be seen in the total annual heat-associated death estimates (blue bars) and the number of days on which a Heat-Health Alert was issued (red line) in England, since 2016.

Recent years have led to the challenge of estimating mortality during heat episodes with respect to the concurrent risk of COVID-19. Observed mortality reported in 2020 was higher than would have been expected based on the temperature mortality relationship alone (81). This suggests that there may have been other factors other than temperature alone which may have increased heat risk. In addition, there is some evidence to suggest that following the pandemic risk of cardiovascular disease outcomes has also increased which is one of the main causes of death during a heat episodes. More work is needed to fully understand this and other shifting patterns in mortality since the pandemic (111).

For the first time, in 2022 UKHSA employed 2 methodologies to assess heat-associated mortality. In addition to the use of observed estimates described above, regional temperature-mortality associations were established using daily all-cause deaths (excluding COVID-19 deaths) which occurred in late spring and summer (May to September) between 2018 and 2022 and regional daily average temperatures. These associations were then applied to the observed temperatures during the specific heat episodes to model the number of heat-associated deaths, which are presented in Figure 6.

Figure 6. Comparison of total all-cause excess mortality estimates using observed deaths and modelled excess all-cause mortality by heat episode and total estimate across all episodes in England summer 2022



Note: Black dots indicate estimate values, and lines indicate the 95% confidence intervals.

Figure 6 outlines differences between the observed number of heat-associated deaths that occurred during each heat episode in summer 2022 and the modelled estimated based in the historical relationship between temperature and mortality, and the observed temperatures over summer 2022 and their 95% confidence intervals. While the 95%CI overlap suggesting there was no significant difference between the observed and modelled estimates, the general trend was for the modelled estimated to be larger than the observed estimates.

When these modelled estimates were compared to the estimates using observed mortality, no statistically significant difference was observed overall between the estimates produced by the 2 methods. However, the point estimates for 3 out of the 5 heat episodes in 2022 and the totals were misaligned, with the observed estimate lower than modelled during the period in which the Level 4 HHA occurred, but higher during a late season period of heat. There are several potential reasons for the differences in the modelled and observed estimates. These include methodological differences in the 2 approaches, but it is also plausible that the enhanced response, including issuing of a Level 4/Red NSWWS warning in summer 2022 and increased communications during prolonged hot conditions may have also contributed. More work is required to assess the effectiveness of the HHA system and associated activities in reducing the number of heat-associated deaths, as this was not explored within this analysis.

2.3 Flooding

The third UK Climate Change Risk Assessment (CCRA3) (6, 119) published in 2022, identified flooding as one of the most important climate change adaptation challenges facing the UK. In all future climate change scenarios, direct and indirect flood risks are projected to rise over the 21st Century (119). The health impacts of flooding are well known and understood. These include, physical health effects including injury and exposure to potentially harmful environmental contaminants, a wide range of impacts on mental health such as stress or anxiety, to more severe mental health impacts which may require specialist health interventions.

Over the 21st century, increasingly higher average rainfall and changing rainfall patterns alongside rising sea levels will contribute to a predicted rise in the frequency and severity of flood events. Flood risk is predicted to increase in the future across all major flood risk categories: fluvial (river), groundwater, surface water and coastal flooding. While the greatest damages are likely to remain to be caused by river flooding, the greatest increase in relative risk is projected to be coastal related, which is expected to be more than 2 times compared to current levels (119). This is important given that coastal flooding is associated with greater risk to life and livelihoods.

The HECC in the UK report 2023 details the current and future modelled impacts of flood events on the UK's population. The report also includes information on research gaps and priorities, interventions to improve public and infrastructural resilience from flooding such as protection measures and spatial planning (120).

2.3.1 Health effects of flooding

Flooding has extensive and significant impacts on health that is frequently associated with both acute and long-term effects on health and wellbeing.

Direct health effects associated with flood water and its debris include:

- drowning
- physical trauma (for example concealed or displaced objects, electrocution, fire)
- skin and gut infections from exposure to contaminated flood water

Longer-term health effects that may occur as a consequence of flooding:

- mental health impacts
- carbon monoxide poisoning due to inappropriate use of generators
- respiratory disease from mould and damp
- rodent-borne disease

Flood events can significantly impact all aspects of a community due to deaths, harm to health, damage to homes, businesses and personal belongings, loss, or power of water supplies to homes, and reduced access to essential public services. Floodwaters can contain contaminants that cause infections or irritation, that may remain, even after the water has receded. These can build up in the surrounding environment such as in soil and waterways and be harmful to humans, pets, and livestock.

Moreover, floods can damage the sewage system when groundwater, rivers, and coastal waterbodies overflow, resulting in sewage, and human and animal waste entering flood waters. If exposed, this can be a health risk to affected populations and requires a specific clean-up process.

Often only the immediate traumatic deaths from flooding are recorded. It is not always easy to identify the longer-term health effects associated with flooding, such as effects caused by displacement, destruction of homes, delayed recovery, power outages, water shortages and disruption of access to health services (121). That said, it is reported that in England, most of thehealth burden associated with flooding is due to the impacts of flooding on mental health and wellbeing.

Some groups are at greater risk of health effects due to flooding than others. This may be due to specific vulnerabilities, for example age, but multiple risk factors may also coincide; for example, a household with children living in rented accommodation may be especially vulnerable to flood-related distress and other mental health impacts. It should also not be assumed that having a risk factor(s) automatically implies vulnerability – a person with a risk factor may also have resilience if they are prepared and have the appropriate support. In comparison, people who are either less prepared or have less access to support can experience adverse health impacts.

2.3.1.1. Mental health impacts

Flood events can cause significant disruption to day-to-day activities. As a consequence of flooding, this can have mental health impacts even in the absence of being flooded. Loss of gas, water and electricity services, loss of access to health and social care services and health concerns are significant stressors associated with flood-related mental health burden.

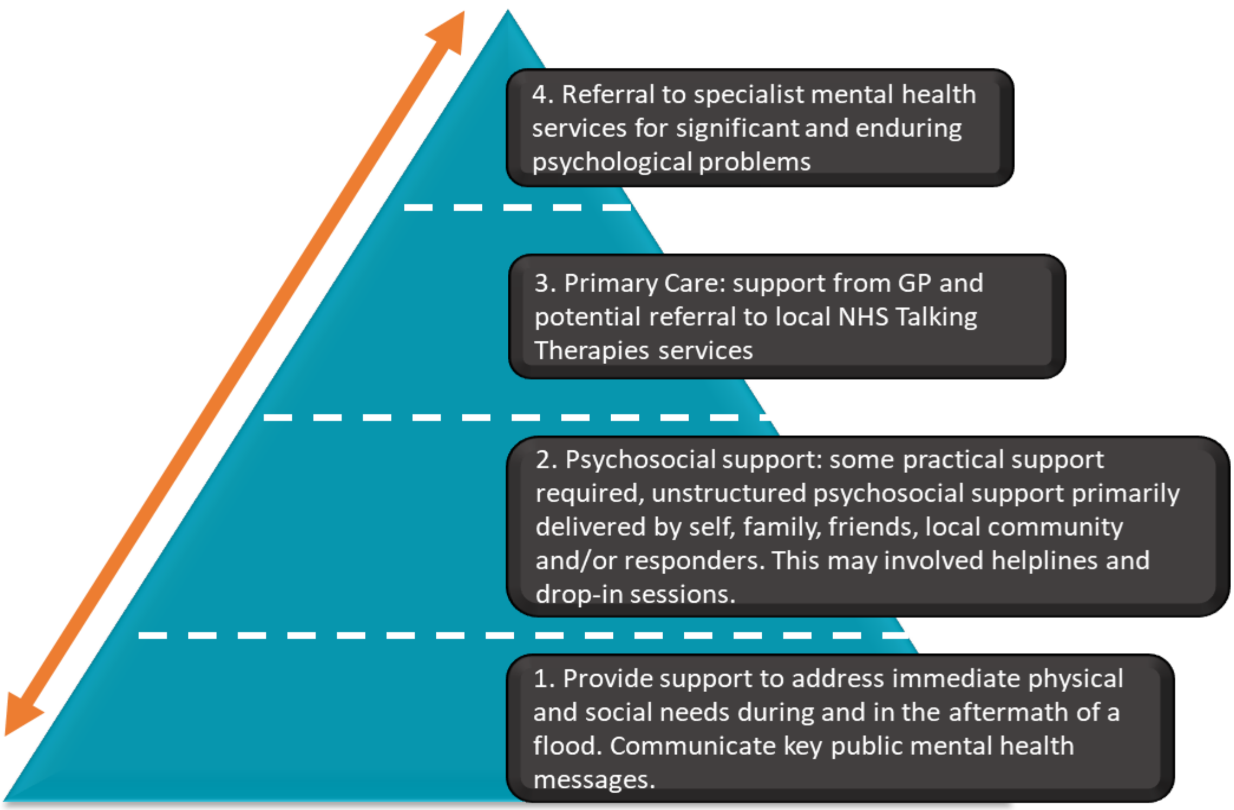
Primary and secondary stressors are factors that are either directly or indirectly associated with flooding which may be amenable to action to reduce their public health impact. See here for more information on primary and secondary mental health stressors associated with flooding.

For the majority of people affected, the psychosocial impacts of flooding will be temporary and can cope with adequate social, practical, and emotional support. A smaller group of people will experience more severe impacts such as depression, post-traumatic stress disorder (PTSD) in the short to long term. While others can experience an exacerbation of pre-existing mental health conditions.

Often people with symptoms of mental ill health do not seek help from formal sources. It is likely there is a significant unrecognised burden of mental ill health after flooding within communities. With improved identification, individuals who would benefit from access to specialist psychological healthcare can be supported to access the right support to meet their personal needs and circumstances.

A phased approach to care is based on the principle that support may be required over an extended period and the level of support required may change during that period, as illustrated in Figure 7. Figure 7 illustrates the 4 tiers of care; the first 2 represent the response activities that encompass the actions needed for the majority of the population, followed by more focused and targeted care for those at higher risk. For more information on the phased approach to mental health care following a flood, please see here: Recovering from a flood: assessment and management of mental health.

Figure 7. Phased approach to mental health support for people affected by flooding



Accessible text equivalent of Figure 7. Phased approach to mental health support for people affected by flooding

A pyramid with 4 sections or tiers. Each represents a stage of the phased care approach for people affected by flooding.

The base of the pyramid is the support needed by the majority of people affected. This is to provide support to address immediate physical and social needs during and in the aftermath of a flood. Communicate key public mental health messages.

The next tier is to provide psychosocial support, such as practical support required. Provision of unstructured psychosocial support primarily delivered by self, family, friends, local community and/or responders. This can involve helplines and drop-in sessions.

The third tier is provision of primary care, with support from GP and potential referral to local NHS Talking Therapies services.

The fourth and final tier, which it the tip of the pyramid requires referral to specialist mental health services for significant and enduring psychological problems.

End of text equivalent

2.3.2 Flooding case study

Box 3. Case study: the Somerset Levels Emotional Wellbeing Recovery Programme

In March 2014, 3 part-time Emotional Flood Support Workers were contracted by the Somerset Village and Community Agents to support the emotional health needs of people affected by floods. Together with the Agents, they integrated into communities affected by flooding in the Somerset levels and attended or participated in 83 events. The majority of events were coffee mornings held at village halls, bowling clubs and visitor centres among others, with an average attendance of 15 people, with over 1,000 people attending in total.

Care and attention were given to people attending these sessions involving gentle informal conversations.

Following their contact, each individual was asked how they were managing. At the start of the meetings 80% of attendees reported feeling a lack of control and 75% reported feeling anxious. At the end of the meetings, 75% reported that they were at least coping, but 25% still reported feeling either distress or despair. Over 30 individuals received extended contact with flood support workers, either face to face or by telephone, with an average of over 10 contacts per recipient of support.

Working with other agencies was key to offering appropriate support at the right level to suit the needs of the individuals. Somerset Counselling offered free counselling sessions to people affected by the floods. Several individuals followed this through with 10 sessions each. Other referrals were made to village agents, GPs and to the Samaritans listening service, set up to support victims of flooding. In addition, there was also signposting to adult social care, coffee mornings, the Environment Agency, a Men’s Shed, rotary advocates, Somerset Volunteers, talking therapies and the Warrior Programme (a charity supporting ex-service personnel in Somerset). A short film about the project is available on YouTube (121).

2.3.3 Effects on health and social care services

More severe weather, both flooding and extreme temperatures, pose risks to the delivery of health and social care. Flood risks to NHS and social care assets are likely to increase with climate change. Future projections indicate an increase in the number of GP surgeries, care homes, emergency service stations and hospitals in the flood risk zone, with the largest change in risk generally shown for care homes.

Future iterations of the AWHP's supporting evidence document will include more information on the impacts flood events have on health and social care estates and delivery of service.

3. Health effects of emerging hazards

There are several emerging hazards that have jumped up the public health agenda in the UK in recent years, including thunderstorm asthma, drought, and storms.

3.1 Storms

Storms are termed an emerging hazard due to the growing body of evidence on how storms impact human health. These impacts can be categorised as direct and indirect impacts on health and wellbeing. The direct impacts from storms are physical injury and trauma, in severe cases, even fatal.

Climate change has already altered the risk of certain types of extreme weather in the UK, with evidence suggesting that the frequency and intensity of storms are likely to increase in the future. The UK has experienced several severe storms over the last few years, including Storm Eunice in 2022, which brought gusts higher than 100mph. Impacts of the storm across the UK included 3 fatalities, school closures, power cuts and nationwide cancellations of transport services.

Examples of successive storms include Storm Ciara and Dennis in 2020. Where the second storm hinders recovery from the first, it can lead to an even greater impact on human health, as well as environmental and economic impacts than individual events. Consecutive storms could damage infrastructure, including power supply, communications, transport networks, homes, and businesses, lasting 1 to 4 days and extending to more than 5 days in remote rural locations.

Concurrent risks such as flooding and windspeed can worsen the impact of a storm, aggravating the impact on public health from the combined effects of these weather hazards.

3.2 Drought

The global frequency of concurrent heat episodes and droughts has increased since the 1950s with strong scientific evidence for this having been driven by human influence (122). Between 1970 and 2019, more deaths were attributed to drought globally (650,000) than any other water-related hazard (123). As a consequence of the increase in global temperature, the frequency of droughts will increase, causing significant impact on human health and livelihood (122).

Unlike other adverse weather events such as heat episodes and flooding, droughts have a slow onset. The health effects of droughts are difficult to identify and are also not well understood. Droughts have a direct impact on health as they can affect water quality and quantity, and harm crop yields, impacting access to food supply and nutrition. Droughts also have indirect effects such as impact on vector-borne diseases as they can influence vector habitat, as well as environmental factors by way of biodiversity loss (124).

UKHSA recently published the Health Effects of Climate Change in the UK report, which details the current and future trends in drought for the UK. The report states that the UK is vulnerable to multi-season, longer duration hydrological droughts (124, 125). However, different areas of the UK are vulnerable to different types of droughts: the north-west is vulnerable to shorter, heatwave-driven droughts, whilst the south-east is more vulnerable to multi-year groundwater droughts (124, 126).

The report also highlighted the summer of 2022 as a recent and significant period of drought, when temperatures in England reached 40 degrees Celsius in mid-August. This period also had low levels of rainfall, resulting in it being the fifth driest summer for England and Wales since 1836 (124, 127).

3.1.1 Health effects of droughts

The health effects of drought in many countries are relatively understudied compared to other adverse weather events, such as hot weather and flooding, as droughts generally do not tend to have immediate visible impacts. Health effects are harder to identify due to their slow onset and can be compounded due to concurrent weather events such as heat episodes and wildfires (124). Multiple factors such as drought severity, underlying population vulnerabilities and existing health and sanitation infrastructure can all influence the extent and impact of drought on public health (128).

Droughts can also affect people's mental health due to disruption in day-to-day activities, water shortages, damage to property and impact to livelihoods such as farming and agricultural communities by way of loss of crops and livestock. More research is needed to better understand the widescale impacts on health from droughts including mental health effects, to inform interventions that support affected communities.

Impacts arising following droughts can be categorised as both direct and indirect (Figure 8).

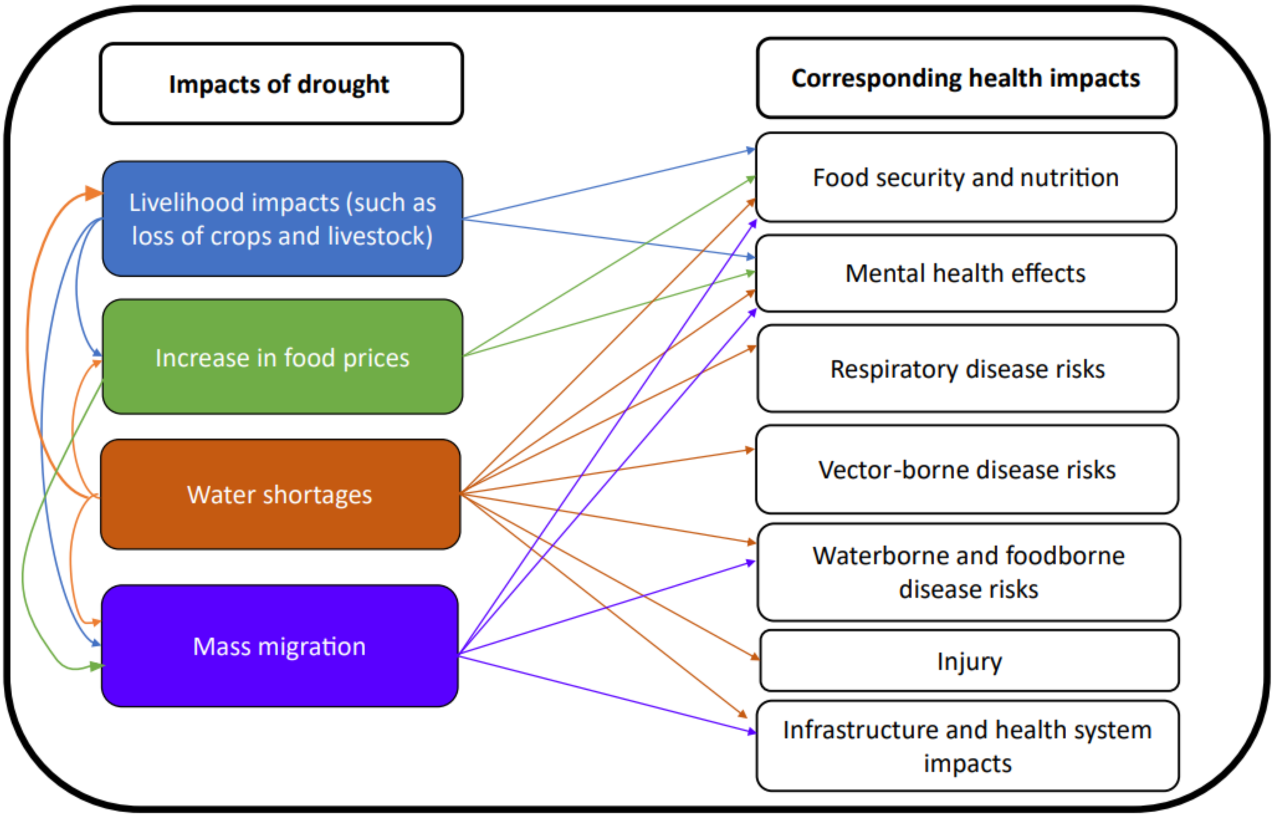
Direct impacts include:

- limited water supply
- loss of crops
- damage to infrastructure
- physical injury

Indirect impacts include:

- ecosystem changes (changes in breeding conditions for vectors, biodiversity loss)
- supply chain disruption – potential food insecurity and malnutrition (129)

Figure 8. Impacts of drought and corresponding health impacts, adapted from (110)



Text version of Figure 8. Impacts of drought and corresponding health impacts, adapted from (110)

Figure 8 shows the direct impacts of drought on society on the left-hand side and the right-hand side shows the potential corresponding health impacts as a result of these on the right-hand side.

Potential negative health impacts from livelihood loss include food shortages, consequential impacts on nutrition and impacts on mental health. Increases in food prices may affect food security, nutrition, and mental health. Water shortages may impact food security, nutrition, mental health, vector-borne disease risk, respiratory disease risks, waterborne and foodborne disease risks, injury and infrastructure and health system impacts. Mass migration may adversely affect food security and nutrition, mental health, waterborne and foodborne disease and infrastructure and health system impacts.

End of text equivalent

For more information on public health messages, please see UKHSA's Public health impact of drought: advice for the public.

3.2 Thunderstorm asthma

Since the 1980's, there have been instances where thunderstorm activity has been linked to increases in people reporting symptoms of asthma and seeking medical attention for issues with their breathing. These episodes have been termed 'thunderstorm asthma'.

The largest thunderstorm asthma event recorded globally occurred in Melbourne, Australia on Monday 21 November 2016. This was the first hot day of the year with temperatures in the high- to mid-30°C's following a wet and warm spring. A severe thunderstorm warning was issued mid-afternoon. The storm moved from the west of the state of Victoria, with the storm front moving across the region of Melbourne from about 17:00hrs. From about 18:00hrs the health care sector saw a surge in patients complaining of shortness of breath, with respiratory or asthma-related symptoms. The ambulance service, hospitals and emergency departments, general health care providers all felt the strain of increase service use, which continued into the following morning. Following a coroner's inquest, 10 deaths were associated with the event (130).

Evidence suggests that those most at risk during these events are younger in age, those with asthma (both diagnosed and undiagnosed) and allergic rhinitis. The underlying mechanisms that trigger these events are not fully understood. However, air flow within a thunderstorm system, humidity and windspeed in the presence of high pollen and fungal spore counts are important factors. It is thought that when the pollan or fungal spore are within the thunderstorm system they rupture to produce inhalable micro partials which then fall back towards the population where they can cause exasperate respiratory issues for vulnerable individuals.

In England, the first recorded episode of thunderstorm asthma occurred in Birmingham in July 1983. Since then there have been a number of recorded events across the country (131). Since 2019, a significant spike in individuals presenting with asthma related symptoms has been observed across UKHSA syndromic surveillance systems associated with thunderstorm activity (132). However, for one episode observed in June 2021, the thunderstorm activity did not occur within the vicinity of where the impacts were observed, however there was a record of a strong wind gust in the area rather than thunderstorm activity (133).

So far, predicting these events has proven difficult as not all thunderstorms result in spikes in asthma like symptoms, and similarly not all spikes in asthma indicators are associated with thunderstorms. As the climate changes, there is evidence that pollen concentrations in the air are increasing with longer growing seasons (134), higher temperatures and more CO2 leading to increased growth. Asthma prevalence and the number of people with severe allergies are also growing (135, 136) with longer growing seasons (134), higher temperatures and more CO2 leading to increased growth.

UKHSA is currently working with colleagues across government and with academic partners to further understanding of thunderstorm asthma events, who is at risk and what actions can be taken to prevent these episodes. As the evidence emerges, UKHSA and its partners will work to developing advice and guidance for the health and social care sector and for the public.

4. Populations most at risk from adverse weather

The impacts of adverse weather events can affect everyone and can put a strain on many aspects of our lives, including our health. However, the extent to which individuals, societies, and nations experience the negative health impacts of adverse weather events will vary based on their ability to adapt to the stressors imposed by such events. Certain populations face a disproportionate burden of the adverse health outcomes as a result. Therefore, understanding the concerns of such populations as well as factors that underpin their vulnerability help to inform the appropriate societal and national responses needed to reduce their adverse health outcomes.

For further information, see guidance produced by the Office for Health Improvement and Disparities (OHID), published in 2022, Vulnerabilities: applying All Our Health (137). The AWHP Equity Review and Impact Assessment, published alongside this document, outlines in detail evidence on adverse weather risks for different populations including those with protected characteristics.

4.1 Key populations most at risk from cold weather

Cold-related ill-health is a complex issue involving many factors. However, there are a variety of health risks that can be brought on or exacerbated by cold weather. Populations that are particularly at risk from the effects of cold weather include:

- older people (aged 65 years and over – at the population level, this age band at which epidemiological studies suggest the risk starts to increase)
- babies and young children (particularly those aged 5 years and under – studies suggest a relationship between living in cold homes and poor infant weight gain, attributed to the fact that children living in colder homes need greater calorific intake to fulfil growth potential
- people with long-term health conditions such as cardiovascular or respiratory disease, or a mental health condition
- pregnant women (evidence suggests an association with low temperatures in late pregnancy, pre-eclampsia and risk of preterm birth
- people with learning disabilities
- people at risk of falls
- people who live alone and may be unable to care for themselves
- people who are housebound or have low mobility
- people living in deprived circumstances
- people experiencing homelessness or people sleeping rough

4.2 Key population groups most at risk from hot weather

Everyone is at risk from the health consequences of hot weather, but there are certain factors that increase an individual's risk. Populations that are particularly at risk from the effects of hot weather include:

- older people (aged 65 years and over – at the population level, this age band at which epidemiological studies suggest the risk starts to increase)
- babies and young children (particularly those aged 5 years and under – evidence suggests that children cannot control their body temperature as efficiently as adults during hot weather)
- people with health conditions, including: heart problems, breathing problems, dementia, diabetes, kidney disease, Parkinson's disease, mobility problems or a mental health condition
- pregnant women (evidence suggests potential risk of preterm birth)
- people on certain medications that potentially affect heart or kidney function, cognition, or ability to sweat
- people who are already ill and dehydrated (for example, from diarrhoea and vomiting)
- people who experience alcohol or drug dependence
- people who live alone and may be unable to care for themselves
- people who are physically active and spend a lot of time outside
- people who work in jobs that require manual labour or extensive time outside
- people experiencing homelessness, including rough sleepers and those who are unable to make adaptations to their living accommodation such as sofa surfers or those living in hostels

4.3 Socioeconomic factors and the built environment

Under the umbrella of wider determinants of health, social determinants are the non-medical factors that influence health outcomes. They are conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems that shape the conditions of daily life. These forces and systems include economic policies and systems, development agendas, social norms, social policies, and political systems.

The social determinants have an important influence on health inequalities; the unfair and avoidable differences in health status seen within neighbourhoods, cities and regions of a given country. No matter the level of development or income of a country, health and illness follow a social gradient where the lower the socioeconomic position, generally the worse the health. Examples of social determinants that can influence health equality are income and social protection, education, employment, housing and the surrounding environment and access to health and welfare services. Studies show that socioeconomic status plays a bigger role in how it influences people's health outcomes than previously understood (138).

The built environment influences human choices, which in turn affect health and the global climate. Distinct from the natural environment, the built environment is comprised of manmade components of people's surroundings, from small-scale settings (for example offices, houses, hospitals, shopping centres and schools) to large-scale settings (for example neighbourhoods, communities and cities), as well as roads, sidewalks, green spaces, and connecting transport systems (139). Neighbourhood design not only influences health by affecting physical activity, respiratory and cardiac health, injury risk, chronic disease risk, social connectedness, and mental health (140), but many current community design practices also adversely contribute to global climate change.

For more information on the health effects of cold and hot weather and indoor environments please see Section 2.1.2 (cold weather) and Section 2.2.5 (hot weather).

4.3.1 Cold homes and fuel poverty

As previously outlined in this document, there is strong evidence that low indoor temperatures can have a serious impact on health, especially if individuals have existing medical conditions or are older.

Evidence suggests that fuel poverty is one of the major causes of cold homes and is determined by the interaction of 3 key drivers:

- energy efficiency of the home
- household income
- energy costs

In 2018, the English Housing Survey found that 2.6 million (11%) homes in England have at least one Category 1 hazard for excess cold (the most serious harm outcome as defined by the Housing, Health and Safety Rating System (HHSRS) for England and Wales) (141). The total repair cost to bring all these dwellings to an acceptable level is estimated to be around £9.8bn (141).

In 2022, a report on fuel poverty, cold homes and health inequalities in the UK (30) found that health inequalities are exacerbated by cold homes as a result of fuel poverty. The report (30) found that some populations are more likely to experience the health impacts of fuel poverty than others, including: older adults, children, and households that are home to people living with chronic illness and disability.

A range of health impacts from living in cold homes were identified by the report, including: cold homes can cause and worsen respiratory conditions (for example, children living in cold homes are more than twice as likely to suffer from a variety of respiratory problems than children living in warm homes), cardiovascular diseases, poor mental health, dementia, hypothermia and problems with child development. In some circumstances, health conditions may be exacerbated to such an extent that they result in death. Reported estimates suggest that some 10% of excess winter deaths are directly attributable to fuel poverty and 21.5% are attributable to cold homes (30).

Although average temperatures are expected to increase over the next 100 years, cold is likely to remain a significant public health problem. Hard-to-heat homes are a major determinant of the burden of cold-related mortality and morbidity. There are limited opportunities in reducing cold-related deaths from a warming climate. This is because pre-existing issues such as poor housing, fuel poverty and an ageing population will continue to generate a significant vulnerable population to cold-weather harms in the future (142).

Treating adverse health effects directly linked to cold, damp homes place an additional burden on the NHS. In 2019 it was estimated the NHS spends at least £2.5 billion per year (30); whilst research from 2023 estimated that the hazard of cold homes in London alone costs the NHS more than £40 million per year (143).

For further information, see Section 2.1.2.2.2 Damp and mould.

4.3.2 Housing and air quality

Housing tenure is linked to socioeconomic position, meaning that poorer households are more likely to experience lack of control over quality of housing and of ability and resources to undertake necessary improvements. There are also inequalities with access to good indoor air quality.People living and working in the most deprived areas were found to have poor indoor environments. These homes are more likely to be overcrowded, with shared spaces, poor ventilation and thermal performance, and limited amenities. These factors can lead to poor indoor air quality, cold, damp and mould, and higher fuel use (144). In 2023, information and guidance on understanding and addressing the health risks of damp and mould in the home was published in 2023 (52).

4.3.3 Healthcare facilities and risks of overheating

Hospital design and construction influence thermal comfort and ventilation during heat episodes (77, 145, 146). Hospitals in urban settings may also be affected by urban heat islands and the presence ofgreen space or blue space nearby. In-depth studies of building and ward types have shown thatsome building characteristics increase the risk of overheating. For example, few hospital wards in northern Europe are air-conditioned; instead, the internal temperature is maintained by natural or mechanical ventilation.

An estimated 90% of hospital buildings are vulnerable to overheating (78) and NHS estates are at risk of high indoor temperatures (overheating) even during moderately warm summers (74).

Temperatures in some wards can exceed 30˚C even when external temperatures are 22˚C (75). Existing standards for healthcare premises recommend temperatures from 18˚C to 28˚C in general wards and 18˚C to 25˚C for more sensitive areas, such as birthing and recovery rooms (76). In 2022 to 2023, there were 6822 instances of overheating above 26°C reported in NHS-trust buildings in England which is an increase of 23% from the previous year (146).

4.3.4 High temperatures and benefits of green spaces

Green infrastructure (GI) plays an important connectivity role across cities, towns, coastal and rural areas, forming an integral component of ecological networks and building more resilient landscapes. Multi-functional GI innovations offer a way to combat resilience challenges and address stresses of urban living to improve health and wellbeing (26). Examples include:

- living in closer proximity to green spaces which is associated with improved wellbeing, reduced mental ill-health and reduced health inequalities – children with attention deficit hyperactivity disorder (ADHD) in contact with naturalenvironments and green spaces have reported significant improvements in symptoms when in
- green spaces
- exposure to natural environments or scenes of nature have shown changes in physiological stress indicators such as blood pressure, muscle tension and EEG alpha-wave activity
- access to green spaces and natural environments can increase the likelihoodof physical activity and active travel in adults and children

Urban green space is a component of green infrastructure. It is an important part of public open spaces and common services provided by a city and can serve as a health-promoting setting for all members of the urban community. It is therefore necessary to ensure that public green spaces are easily accessible for all population groups and distributed equitably within the city.

4.3.5 Flooding and built environment

The local geography, including the location of and proximity to watercourses, waterbodies and the sea, and the physical arrangement of homes, other buildings, streets, parks, and agricultural land, can be factors contributing to peoples' risk of experiencing flooding. For example, homes built on flood plains are at greater risk, and basement flats may be more at risk than other flats within the same building.

Actions to reduce the risk of flooding, and its consequential effects on mental health, include building new developments in areas at lower risk of flooding. For reducing the risks to existing households in areas of flood risk, sustainable drainage systems (SuDS) should be considered. Examples of SuDS include increasing green spaces, removing paving for natural drainage, or introducing small-scale SuDS interventions such as green roofs or rain gardens can assist. However, effective spatial planning is one of, if not the main method that can prevent flood exposure for the built environment (119, 120). However, effective spatial planning is one of, if not the main method that can prevent flood exposure to build environment (119, 120).

These actions can contribute to co-benefits of improved mental wellbeing associated with green space, air and water quality, and increased biodiversity, as well as drainage (147).

4.4 Behavioural factors: studies of older adults' health risk perception during hot and cold weather

Risk perception refers to an individual's judgement or assessment of the immediate or long-term threats to their health and wellbeing. An individual's perception of risk will influence the behaviours which may have a direct impact on their health and wellbeing. For example, if a person perceives themself to be at risk from exposure to long periods of extreme heat, if they are able, they may then take actions to reduce that risk. However, evidence and understanding of the predictors associated with heat and cold risk perception in older adults in England has been limited. UKHSA has commissioned academic and market researchers to explore public perceptions, awareness, and experience of the risks of both hot and cold weather. Findings from the studies have been used to inform public messaging and guidance materials.

Please note, the use of the term 'older adults' refers to people aged 65 years and over.

4.4.1. Overview of factors influencing risk perception

In 2021 to 2022, UKHSA conducted a scoping literature review to understand factors influencing perception of personal health risks in vulnerable groups as a result of exposure to hot and cold weather events (148).

The review identified 8 factors from the literature that were associated with older adults' personal health risk perception of hot and cold weather events:

- knowledge of the relationship between hot or cold weather and health risks
- presence of comorbidities
- age and self-identity
- perceived weather severity
- beliefs associated with regional climate
- past experience with weather
- misconceptions regarding the effectiveness of protective behaviours
- feeling that risks of extreme weather were outside of their control

4.4.2. Risk perception of cold weather

In 2019, UKHSA commissioned a representative survey of people aged 65 years and over in England on risk perception of the health effects of cold weather. Quotas were set for age by gender, region, working status and tenure. A binomial logistic regression model was again used to assess associations between participants' risk perception and demographic characteristics (Model 1) and whether they reported taking action (Model 2) (149).

Older adults' risk perception of their own health and their perception of other vulnerable groups' health risk during cold weather are illustrated in Figure 7. Similarly, to the responses by older adults in the hot weather survey, a higher percentage of older adults who perceive their own health to be at risk during cold weather also reported people of the same age and older adults to have an increased risk. A slight increase in the percentage of older adults who reported not perceiving their own health to be at risk but identify those with long-standing physical health conditions and people living on a low income as having a risk to their health during cold weather

Participants were asked what their reasoning was for taking certain actions to reduce potential harm to their health compared to more or all suggested actions during cold weather. The most reported were:

- "I didn't think there was a need"
- "It didn't occur to me"
- "My health was not at risk"

Annual income, education and tenancy were the demographic predictors for older adults' health risk perception in cold weather. Those who earned over £25,000 were 26% less likely to perceive their health as at risk. Additionally, older adults who had a degree or higher or owned their own home were 32% and 35% less likely to perceive their health as at risk in cold weather. In both the hot and cold weather surveys, perceiving people of the same age or people living alone as at risk increased the likelihood of an older adult perceiving their own health to be at risk during recent hot weather or cold spells.

4.4.2.1. Cold weather-related symptoms

Older adults reported experiencing fewer symptoms during recent cold weather. Approximately 60% reported having no health issues. However, approximately 10% of participants reported experiencing one of:

- difficulty keeping warm
- flu or flu-like symptoms
- difficulty staying active
- feelings of depression

Older adult respondents who stocked up on food and medicine or wrapped a scarf around their mouth to protect their lungs were more likely to perceive their health to be at risk, although the latter association was relatively weak. Finally, older adults who checked the forecast and planned ahead were 27% less likely to agree that their health is at risk during cold weather.

4.4.2.2. Cold weather-related behaviours

The proportion of adults reporting at least one action to reduce the impact of cold was high (89%). The most frequently reported behaviours adopted (more than half of respondents) were:

- layering clothing (80%)
- heating home to at least 18˚C (77%)
- having boiler checked by an engineer (61%)
- heating rooms most occupied (59%)
- keeping bedroom window closed at night (59%)
- checking the forecast and planning ahead (53%)
- drinking warm drinks (58%)

Perceiving people of the same age or people living alone or other older adults' health as at risk increased the likelihood of an older adult perceiving their own health to be at risk during hot weather or cold spells.

4.4.3. Risk perception of hot weather

In 2022, UKHSA commissioned a qualitative study with older adults to gain insights on their experiences of the record-breaking high temperatures of that summer. This comprised of focus groups with 14 older adults aged 65 years and over, to understand both their perceptions of the summer 2022 heatwave and its impact on their physical and mental wellbeing.

In 2019, UKHSA commissioned a survey focused on health risk perception of hot weather following a period of very hot weather in the UK and Europe. A representative sample of the English population aged 65 years of age and over was used for this survey. Quotas were set for age by gender, region, working status and tenure. A binomial logistic regression model was used to assess associations between participants' risk perception and demographic characteristics (Model 1) and whether they reported having taken action (Model 2).

In the 2022 study, most focus group participants perceived themselves to be moderately at risk or not at risk at all due to the heat; including those individuals with objectively higher risk due to health comorbidities linked to a higher heat strain. This level of risk perception was rationalised by participants by comparing themselves to other vulnerable groups who participants perceived to be at a higher than themselves (for example babies, individuals aged 85 years and over), and believing that risks were mitigated by performing well-established and effective coping strategies.

Some participants who were more vulnerable (that is individuals with single or multiple comorbidities) perceived themselves to be at risk; however, they primarily acknowledged the potential for acute illness and did not recognise the potential of increased mortality risk. Other factors associated with risk perception identified by participants included:

- location (that is, urban areas and the south of England were thought to be more exposed to heat)
- people living alone were thought to be more vulnerable due to lack of access to support from other household members
- participants who felt worried about the increasing trend of heatwaves in the future perceived a higher sense of risk

In the 2019 survey, a higher percentage of older adults who perceived their own health as at risk also perceived other vulnerable groups to be at risk. Interestingly, over a quarter of older adults who did not perceive their own health as at risk reported perceiving other older adults' health as being at risk during hot weather. However, when older adults were asked about the risk to health of people of the same age as themselves, the perception of risk decreased considerably, suggesting a lower risk perception for themselves and their current age group.

The findings from this analysis showed there was no clear demographic determinant (such as age or income) that predicted older adults perceiving themselves to be at risk in hot weather. Additionally, perceiving other older people aged 65 years and over was associated with an increased likelihood of older adults' personal risk perception.

4.4.3.1. Hot weather-related symptoms

In the 2022 focus groups, some participants indicated that they relished the hot weather in summer 2022; others did not enjoy the extreme heat episodes but did not find the weather physically uncomfortable and felt they could manage it easily.

According to the experiences and impact described by older adults included in the study, those living with respiratory conditions, heart conditions, diabetes, and those on certain types of medication, tended to suffer the most, as well as those with mobility issues and those who felt isolated.

Nearly everyone described some impact of the hot weather on their mental health at some stage during the heat episodes that summer. This ranged from simply being over tired and anxious because of lack of sleep due to the heat, to more extreme sensations of feeling trapped and isolated due to not being able to go outside.

In the 2019 survey, approximately 20% of older adults included in the hot weather survey reported having no associated symptoms. The most reported heat-related symptoms were:

- difficulty keeping cool and feeling too hot (40%)
- difficulty sleeping (52%)
- physical symptoms such as a headache, dehydration, or sunburn (11%)

4.4.3.2. Hot weather-related behaviours

Common behaviours reportedly adopted to cope in the heat by participants in the 2022 focus groups included:

- using fans or water sprays and eating ice lollies to stay cool
- ensuring sufficient water intake
- eating lighter and smaller meals more often
- ensuring protection from the sun by applying extra sun cream and wearing hats or caps and light clothing
- avoiding going out in hottest parts of the day
- changing daytime routines by leaving the house only early or late in the day

Individuals perceived closing curtains and windows as critical behaviours to protect themselves against heat. However, participants reported that this behaviour needed more explaining as it was not clear for everyone as to the circumstances under which this behaviour should be undertaken (for example, depending on the orientation of the window and the outdoor temperature in comparison to indoors).

In terms of preparedness, while some participants with pre-existing health co-morbidities prepared a few days to a week in advance, most participants carried out little to no planning in anticipation of the heat episode.

In the 2019 survey, the proportion of adults reporting at least one action to reduce the impact of heat was high (90%). Commonly reported heat related behaviours were:

- drinking more fluids (84%)
- opening windows at night or during cooler parts of the day (61%)
- wearing loose clothing and/or a hat (59%)
- finding somewhere that felt cool (53%)
- keeping curtains closed on windows exposed to direct sunlight (50%)

Older adults who reported using or buying a fan during hot weather were 45% more likely to perceive their health to be at risk in hot weather. Older adults who reported staying indoors or limiting strenuous activity to cooler parts of the day were significantly more likely to perceive their health as at risk in hot weather. Keeping the windows or curtains exposed to direct sunlight closed increased the likelihood of older adults perceiving their health to be at risk in hot weather by 32%.

Furthermore, participants were asked what their reasoning was for taking certain actions to reduce potential harm to their health compared to more or all suggested actions during hot weather. The most reported were:

- “I didn’t think there was a need to act”

- “My health was not at risk”
- “I didn’t think this would be relevant to me”
- “I didn’t think it would make a difference”
- “It didn’t occur to me”

Insights from this research have been used to update associated UKHSA guidance on supporting vulnerable people before and during hot weather for social care managers, staff, and carers. A specific example is the development of hot weather and health action cards for providers and commissioners of social care to accompany heat-health alerts.

5. Recommendations mapping

The table in Appendix 1 presents a comprehensive list of 77 recommendations to inform action on adverse weather risks to health that were identified through a review of a series of national policy plans from a wide range of sources, including national government and executive agencies as well as independent, academic and other research bodies. In addition, it has been informed by primary and secondary evidence (including evaluation and guidance documents). The recommendations are organised by code recommendation, its source and the recommendation itself.

This long list of recommendations has informed the development of a series of high-level recommendations for best practice to improve health and wellbeing with respect to adverse weather events and climate change, including, but not limited to:

For all sectors

To increase awareness of the health impacts of adverse weather and climate change at all levels in local areas – this includes public engagement that is:

- developed using an evidence-based approach to behaviour change
- focused on more effective messaging regarding adverse weather and health risks, especially for those populations most at risk, on preparedness and taking protective actions, such as seeking financial advice, health treatment or advice, checking the weather forecast

For commissioners

Ensure a long-term strategic approach by commissioners, directors of public health, Health and Wellbeing Boards (HWBs), local Integrated Care Boards (ICBs), Local Resilience Fora (LRFs), and other local bodies, to assess needs and then commission, plan, implement, monitor, and evaluate interventions to reduce harm to the public or population from adverse weather – this includes:

- emphasis on year-round planning with a multi-agency approach to tackle wider determinants, such as economic, social, and housing issues
- regular reviews throughout the year of plans and strategies to ensure they meet local needs and draw on the capacities, assets and organisations that exist in a specific place
- move from emergency response to adaptation with a focus on preparation, transformation and building community resilience to adverse weather and climate change

- define and identify populations most at risk from adverse weather events, effective actions, culturally appropriate communications, and effective system-wide approaches that build trust and meet needs

For health and social care providers

Recommendations:

- priority for capacity development to improve health system resilience to current and future adverse weather and health risks by improved strategic, long-term planning and investment as required
- development of the health and social care workforce to gain a better understanding of the risks to health posed by adverse weather and climate change and the benefits to be achieved by taking preventive action both on a long-term basis and in readiness for specific adverse weather events

The recommendations from these reports are directed to a wide range of organisations. It is for them to consider these recommendations, and how they might guide long-term strategic planning. The listed recommendations do not necessarily represent acceptance by the organisations concerned, nor do they necessarily represent agreed government policy. However, UKHSA has considered the various recommendations and taken these into account, where appropriate, in its development of the AWHP and associated guidance materials that have been published to date.

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Appendix 1: Results summary – review of published recommendations

This table presents a list of recommendations to inform action on adverse weather risks to health that have been identified from a review of publications including: previous national weather and health plans, associated primary and secondary evidence (such as, evaluation and guidance documents).

Code	Source	Published recommendation
SED24R01	DEFRA. 'The National Adaptation Programme and the Third Strategy for Climate Adaptation Reporting – Making the country resilient to a changing climate' 2018	Ensure all clinical areas in NHS trusts have appropriate thermal monitoring inplace, with number of overheating events.
SED24R02	DEFRA. 'The National Adaptation Programme and the Third Strategy for Climate Adaptation Reporting – Making the country resilient to a changing climate' 2018	Local plans should have regard to the cumulative impacts of flood risk, rather than from individual development sites. Clarify policy on the exception test that may need to be applied when considering development in locations at risk of flooding.
SED24R03	DEFRA. 'The National Adaptation Programme and the Third Strategy for Climate Adaptation Reporting – Making the country resilient to a changing climate' 2018	Actions to improve the resilience to new hospitals buildings and care homes to overheating within an organisational adaptation plan and an expectation of coverage of adaptation in mandatory Sustainable Development Management Plans (SDMP), and an expectation of coverage of adaptation in trusts' annual reports.
SED24R04	DEFRA. 'The National Adaptation Programme and the Third Strategy for Climate Adaptation Reporting	Encourage all NHS providers to use the Sustainable Development Assessment Tool to self-assess progress on adaptation.

Code	Source	Published recommendation
	– Making the country resilient to a changing climate' 2018	
SED24R05	DEFRA. 'The National Adaptation Programme and the Third Strategy for Climate Adaptation Reporting – Making the country resilient to a changing climate' 2018	Encourage NHS trusts to report consistently on risk assessment for overheating events. The thermal monitoring and numbers of overheating events should be incorporated into the Model Hospital to allow benchmarking of performance.
SED24R06	DEFRA. 'The National Adaptation Programme and the Third Strategy for Climate Adaptation Reporting – Making the country resilient to a changing climate' 2018	Annual review of the coverage of adaptation by NHS SDU in mandatory provider trust and commissioners' sustainability reports. Include sustainabledevelopment metrics in the annual Health check report.
SED24R07	DEFRA. 'The National Adaptation Programme and the Third Strategy for Climate Adaptation Reporting – Making the country resilient to a changing climate' 2018	Best practice in adaptation to be recognised annually thought the SustainableHealth and Care awards.
SED24R08	Zaid Chalabi, Bob Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015 Lorraine Williams, Bob Erens, Stefanie Ettelt, Shakoor Hajat, Tommaso Manacorda, Nicholas Mays. 'Evaluation of the Heatwave Plan for England' Policy Innovation Research Unit 2019	Improve communication about the importance of general preparedness represented by level 0 and 1. Emphasis to year-round planning with multi-agency approach to tackle wider determinants, such as economic, social and housing issues.

Code	Source	Published recommendation
SED24R09	Zaid Chalabi, Bob Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015 Lorraine Williams, Bob Erens, Stefanie Ettelt, Shakoor Hajat, Tommaso Manacorda, Nicholas Mays. 'Evaluation of the Heatwave Plan for England' Policy Innovation Research Unit 2019	Identify and provide preventive services to vulnerable people who are not routinely in contact with health or social care providers: guidance and strategy.
SED24R10	Public Health England (PHE). 'Heatwave Plan for England – Making the case: the impact of heat on health – now and in the future' 2015 PHE. The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection, Public Health England. 2014	Joint strategic needs assessments to identify challenges and joint health and wellbeing strategies to agree actions in operational plans, reflecting elements of the Cold Weather Plan for England (CWP) and Heatwave Plan for England (HWP).
SED24R11	Lorraine Williams, Bob Erens, Stefanie Ettelt, Shakoor Hajat, Tommaso Manacorda, Nicholas Mays. 'Evaluation of the Heatwave Plan for England' Policy Innovation Research Unit 2019	Improve the communication and the preparedness to the risk of adverse health effects during temperatures below the current heat-health alert thresholds.
SED24R12	Lorraine Williams, Bob Erens, Stefanie Ettelt, Shakoor Hajat, Tommaso Manacorda, Nicholas Mays. 'Evaluation of the Heatwave Plan for England' Policy Innovation Research Unit 2019	Improve the mechanisms to monitor activities during and following a heatwave alert.

Code	Source	Published recommendation
SED24R13	Lorraine Williams, Bob Erens, Stefanie Ettelt, Shakoor Hajat, Tommaso Manacorda, Nicholas Mays. 'Evaluation of the Heatwave Plan for England' Policy Innovation Research Unit 2019	Make the managers and frontline staff to improve their awareness of the HWP. To recognise the role of NHS providers, CCGs and local authorities in the HWP.
SED24R14	Lorraine Williams, Bob Erens, Stefanie Ettelt, Shakoor Hajat, Tommaso Manacorda, Nicholas Mays. 'Evaluation of the Heatwave Plan for England' Policy Innovation Research Unit 2019	UKHSA and the Local Government Association to review the capacity and capability of local authorities and other health and social care partner organisations to implement actions from the HWP, including the partnershipbetween primary and community care organisations.
SED24R15	Lorraine Williams, Bob Erens, Stefanie Ettelt, Shakoor Hajat, Tommaso Manacorda, Nicholas Mays. 'Evaluation of the Heatwave Plan for England' Policy Innovation Research Unit 2019	Review the advice provided to local authorities and health and social care providers.
SED24R16	Lorraine Williams, Bob Erens, Stefanie Ettelt, Shakoor Hajat, Tommaso Manacorda, Nicholas Mays. 'Evaluation of the Heatwave Plan for England' Policy Innovation Research Unit 2019	Revise public health advice to improve public awareness of the risks of hot weather to health: realistic self-assessment of risk among population groups, focus on the risk of under-estimation of the risks, tailor messages and media usage of different population groups, increase knowledge of the effectiveness of the protective behaviours.
SED24R17	Lorraine Williams, Bob Erens, Stefanie Ettelt, Shakoor Hajat, Tommaso Manacorda, Nicholas Mays. 'Evaluation of the Heatwave Plan for England' Policy Innovation Research Unit 2019	Provide evidence-based recommendation on air conditioning in hospitals, care home and other facilities.
SED24R18	Lorraine Williams, Bob Erens, Stefanie Ettelt, Shakoor Hajat, Tommaso Manacorda, Nicholas Mays. 'Evaluation of the Heatwave Plan for England' Policy Innovation Research Unit 2019	Mandatory training about the HWP awareness and the health risks of coldweather and actions for all healthcare staff.

Code	Source	Published recommendation
SED24R19	Lorraine Williams, Bob Erens, Stefanie Ettelt, Shakoor Hajat, Tommaso Manacorda, Nicholas Mays. 'Evaluation of the Heatwave Plan for England' Policy Innovation Research Unit 2019	Improve healthcare and social staff welfare during severe events.
SED24R20	PHE. 'Heatwave Plan for England – Making the case: the impact of heat on health – now and in the future' 2015	Work heatwave and cold weather planning into the new health and social care structures, including LRFs and Health and Wellbeing Boards in preparation and response and longer-term actions.
SED24R21	PHE. 'Heatwave Plan for England – Making the case: the impact of heat on health – now and in the future' 2015	Work in partnership with local authorities and social care services to identify vulnerable populations and geographical areas to target planning.
SED24R22	PHE. 'Heatwave Plan for England – Making the case: the impact of heat on health – now and in the future' 2015	Preparation of the directors of public health to take an active role in setting alocal agenda.
SED24R23	PHE. 'Heatwave Plan for England – Making the case: the impact of heat on health – now and in the future' 2015	Use the Green Infrastructure Partnership (DEFRA, DHSC, DLUHC) to inform the local practitioners on the benefits of green infrastructure including opportunities (parks, trees, ponds or lakes, cool pavements, cool or green roofs).
SED24R24	PHE. 'Heatwave Plan for England – Making the case: the impact of heat on health – now and in the future' 2015	Promote homes insolation and ventilation by targeted communication with vulnerable occupants at local level: external wall insulation can be better thaninternal wall insulation in preventing overheating. Open windows when the air outside is cooler at night time or in the early morning.

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SED24R25	PHE. 'Heatwave Plan for England – Making the case: the impact of heat on health – now and in the future' 2015	Medium term (10 to 30 years): Target vulnerable areas to renew the buildingdesign of hospitals and other healthcare facilities to aid passive cooling. Consider build underground car parks, not extend car parks, insulation of buildings, reflective paint, increase opportunities for night-time ventilation, and maximise green space.
SED24R26	PHE. 'Heatwave Plan for England – Making the case: the impact of heat on health – now and in the future' 2015	Medium term (10 to 30 years): Encourage active transport and public transport. Use of low emission vehicles for NHS business.
SED24R27	PHE. 'Heatwave Plan for England – Making the case: the impact of heat on health – now and in the future' 2015	Long term (30+ years) planning to build zero-carbon and energy-minimised hospitals and healthcare facilities and with green space and water surrounding to aid passive cooling. Development of temperature-resistant drugs and laboratory materials.
SED24R28	Zaid Chalabi, Bob Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015 PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	Development of information governance and data-sharing guidance between partners to enable impact on the community.
SED24R29	Zaid Chalabi, Bob Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin	Development of existing information sharing platforms to local areas (examples of best practice and practical case studies).

Code	Source	Published recommendation
	Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015 PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	
SED24R30	Zaid Chalabi, Bob Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015	Improve the model of cost effectiveness of the plan.
SED24R31	Zaid Chalabi, Bob Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015	Integration of actions into local strategies and plans by local emergency planner. Development of local arrangements to ensure that cold weather planning as an integral element of wider winter resilience planning locally with roles and responsibilities clearly laid out and review of the actions.
SED24R32	Zaid Chalabi, Bob Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015	Provide further guidance to raise the profile of the plan and prevention of Excess Winter Deaths, on the agenda of Health and Wellbeing Boards and the Local Health Resilience Partnerships.

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SED24R33	Zaid Chalabi, Bob Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015	Include the plan into the local Joint Strategic Needs Assessments with GPs and CCGs.
SED24R34	Zaid Chalabi, Bob Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015	Link the CWP with local Community Risk Register Assessments to allow a flexibility in the local response (level of graduation and 'scalability' in the actions within an alert level more proportionate).
SED24R35	Zaid Chalabi, Bo Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015	Sustainable, rapid, and easy to conduct annual evaluations and reviews of the plan. Factors: direct and indirect costs of implementation, evaluation of variables relating to mental health, long-term cost benefit analysis, mortality mapping for rural-urban differences.
SED24R36	Zaid Chalabi, Bob Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015	Cold weather alerts: geographically specific, reduced frequency (that is alerting at start and end of winter period, only when there is a change in alert level, alerting to renew or extend expiring alert, focussing on periods when threshold levels are reached), adding specific recommendations, colour-coded (like flooding alerts), including link to Met Office weather alert and weather pattern maps.
SED24R37	Zaid Chalabi, Bob Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin	Targeted resources at those who live in cold homes who are socially isolated.

Code	Source	Published recommendation
	Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015	
SED24R38	Zaid Chalabi, Bob Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015	CWP should encourage better joint working across agencies and proactive response. Implementation of the plan should be led by public health manager.
SED24R39	Zaid Chalabi, Bob Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015	Focus on the level of care provided by health services over a longer period after a cold spell to track the delayed effects of cold alert.
SED24R40	Zaid Chalabi, Bob Erens, Shakoor Hajat, Catherine Heffernan, Lorelei Jones, Nicholas Mays, Benjamin Ritchie, Paul Wilkinson. 'Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012' Policy Innovation Research Unit 2015	Scoping study to explore the current work in the economics of improving andadapting the housing stock, research, and policy issues and possible methodologies.
SED24R41	PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	Identify and target actions to the housings with children in poverty and knownto have asthma and recurrent infections, adults with chronic conditions who work and live in low temperatures, to increase energy efficiency through installing

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		insulation and efficient heating systems, maximisation measures (that is, benefit checks).
SED24R42	PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	Provide interventions to tackle each of these fuel poverty factors, such as insulation, efficient central heating systems, and income maximisation measures increase the likelihood that the home can be kept warm affordably.
SED24R43	PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	Communication to encourage the communities and individuals to look after themselves and others, focused on those engaging with social care and those who care for them, and the socially isolated people.
SED24R44	PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	Communication and education about the indirect impacts of fuel poverty and low indoors temperatures: lower dietary opportunities, impacts of wellbeing, falls and injuries over 65s, flu vaccination coverage, cardiovascular and respiratory diseases under 75.
SED24R45	PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	Adaptation and mitigation strategies should also be incorporated into sustainability plans. The key influence for this indicator is the Climate Change Act 2008 which sets out targets for the reduction of carbon emissions by 2050.
SED24R46	PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	Insist on the level 0 and 1 actions in the interventions to prevent cold-related illness and death. Communicate about the negative health effects of cold temperatures start at

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		relatively moderate outdoor temperatures of around 4°C to 8°C (depending on region).
SED24R47	PHE. ‘Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing’ 2017	Continue to the cost-benefit of energy efficiency against fuel poverty measures for health, using both quality adjusted life years (QALY) and impacts of estimated net present value (NPV) by DECC.
SED24R48	PHE. ‘Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing’ 2017	Improve the methodology to capture the wider benefits of measures to address fuel poverty, such as the full impacts on mental health and wellbeing, lifestyle and social justice in both the short and long term.
SED24R49	PHE. ‘Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing’ 2017	Encourage to include the Warm Homes Healthy people programmes in theintegrated care board (ICB) and local authority commissions.
SED24R50	PHE. ‘Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing’ 2017	Include fuel poverty and excess winter mortality and morbidity into core business of JNSAs and joint health and wellbeing strategies (HWSs), to inform year-round commissioning.
SED24R51	PHE. ‘Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing’ 2017	Central and sustainable fundings to allow local authority to take a year-round,long-term approach in the development of the programmes planning recommended by ‘level 0’ in the plan, for example simple measures to tackle fuel poverty.
SED24R52	PHE. ‘Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing’ 2017	Messages should be simplified for maximal inclusivity and relevance.

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SED24R53	PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	Identify hospitalised people who are living in low temperatures or with fuel poverty and follow them after they are discharged home to avoid readmissions.
SED24R54	PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	Identify those people who have Category 1 fall hazards in their home and take remedial action will reduce the risk of fall.
SED24R55	PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	Improve the communication about the beneficials helps to the targeted public living in cold houses.
SED24R56	PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	Helpline for housing and fuel poverty queries, and single point contact of referral to help, accessible and easy to find. Single point contact could be housing association or community centre for sharing of information.
SED24R57	PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	Help the health professionals in signposting and referring individuals to these sources of winter warmth or financial support.
SED24R58	NICE. 'Excess winter deaths and illness and the health risks associated with cold homes' 2015	Ensure there is a 'single point of contact' health and housing referral service for people living in cold homes, who could provide tailored solutions. Inspections to buildings to ensure they meet ventilation and other trading standards.
SED24R59	NICE. 'Excess winter deaths and illness and the health risks associated with cold homes' 2015	Develop presential or virtual trainings, that is: • train health and social care practitioners, housing professional, faith, and voluntary sector to help people living in cold houses • train heating engineers, meter installers and those providing building insulation to help vulnerable people at

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		home • raise awareness among practitioners and the public about how to keep warm a house
SED24R60	NICE. 'Excess winter deaths and illness and the health risks associated with cold homes' 2015	Ensure that health (primary and secondary) and social care, voluntary sector, housing services, installation and maintenance contractors, trading standards officer and environmental health offices could: • identify people at risk • make every contact count with an assessment of the heating needs of people • discharge vulnerable people from health and social care to a warm home
SED24R61	PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	Make the level 1 focused around shorter term initiatives such as seasonal flu immunisation, rapid winter warmth initiatives (implemented through WHHP), awareness campaigns for health and social care provider staff (incorporate action into routine care of vulnerable individuals as signposting or referral), checking emergency and business continuity plans.
SED24R62	PHE. 'Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing' 2017	Establish more research about the potential benefits of preventive healthmeasures targeted at vulnerable groups at the right time for example by sending text alerts direct to patients or making automated calls direct to patients. The evidence remains inconclusive.

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SED24R63	PHE. ‘Cold Weather Plan for England – Making the Case: Why long-term strategic planning for cold weather is essential to health and wellbeing’ 2017	Consider the geographical variabilities and the adaptation to climate change in the calculation of the excess winter mortality.
SED24R64	PHE. The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection	Increase the monitoring and evaluation of projects (increase resources locally and create a national evaluation framework, funding bodies should require to report back on the projects).
SED24R65	PHE. The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection	Improve the data-sharing and personal data protection: creation data governance protocols, consent forms or referral schemes.
SED24R66	PHE. The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection	Local equity audit to ensure programmes do not exclude those most at need. It would help to ensure that interventions are focused on addressing inequalitylocally and are proportionate to the level of need.
SED24R67	PHE. The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection	Better understanding on the local pathways in the local strategic plans.
SED24R68	PHE. The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection	Protect and nurture partnerships to continue to explore a pragmatic and collaborative approaches at strategic and organisation level. Fundings needs to be ensure for collaborative projects. Involvement of the voluntary and private sector (energy companies), and the health sector (including engaging and training professionals).
SED24R69	PHE. The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection	Implement a system wide approach of interventions.

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SED24R70	PHE. The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection	Establish more research about the links between prolonged exposed to cold and damp conditions at home and poor health outcomes.
SED24R71	PHE. The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection	Focus on awareness raising in the communication strategies, with the provision of advice and education, linked with other campaigns as community energy efficiency events, benefits checks and debt advice, flu jab programme, hygiene advice older people's festival.
SED24R72	PHE. The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection	Services provided through affordable warmth and other similar programmesneed to describe the distribution of urban or rural populations and the distribution of interventions across the locality. To be implement with further research and investigation.
SED24R73	PHE. The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection	Ensure that contacts were not missing or out of date before the cold weather alert levels 2 and 3 to have an efficient information cascade system.
SED24R74	PHE. The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection	Short term interventions for emergency assistance: delivery of warm packs, supply of emergency heating, provision of warm meals, snow wardens providing a snow clearance service, emergency shopping and ensuring access to medical services, hardship grants and other short term emergency payments, provision of blankets and warm clothing, handyman emergency repair service, targeted support for people experiencing homelessness and people sleeping rough.

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SED24R75	PHE. The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection	Longer term interventions for sustainable home: energy efficiency grant schemes operated through or funded by energy supplier, installing home safety measures, boiler servicing, repairs, replacement, installing major energy saving measures (for example loft or wall insultation), installing minor energy saving measures (for example draught proofing).
SED24R76	PHE The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection	Target actions on social isolation and fuel poverty, for example: raising eventsfor community healthcare staff, referential patients with respiratory and heart failure to financial inclusion checks, presentation by environmental health andhousing officers to local healthcare workers, for example identify and refer vulnerable people virtually with the Healthy Housing Hub.
SED24R77	PHE The Cold Weather Plan Seminar 2014: Convened by Extreme Events and Health Protection	Creation of steering groups as ‘Be prepared for winter SG’ including representatives from public health, local authority risk and resilience, neighbourhood services, NHS providers, social care, housing, care and repairservices, voluntary organisations, CCG, environmental health, energy efficiency officers and financial inclusion.

About the UK Health Security Agency

UKHSA is responsible for protecting every member of every community from the impact of infectious diseases, chemical, biological, radiological and nuclear incidents and other health threats. We provide intellectual, scientific and operational leadership at national and local level, as well as on the global stage, to make the nation health secure.

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