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POSTnote 723

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Public health impacts of heat

Overview

- The frequency, duration and intensity of extreme heat and heatwaves in the UK has been increasing. Five periods of extreme heat were recorded in England in 2022. Temperatures exceeded 40°C for the first time.
- Heat impacts the body and can lead to illness and death. The summer 2022 heat periods were associated with 2,985 deaths in England.
- The number of heat-related deaths is projected to increase with climate change, and as the population grows and ages.
- The impact of heat on health varies across the population. Vulnerability factors include: advanced age; physical and mental health conditions; pregnancy; environmental factors such as living in urban areas; housing conditions; occupational setting; homelessness; poverty; low educational attainment and being an immigrant.
- The Adverse Weather and Health Plan, published by the UK Health Security Agency, constitutes the overarching policy framework responding to heat-health risks. The plan includes an impact-focused heat-health alert system.
- Stakeholders from the academic, healthcare and charity sectors stress the importance of a joint policy response, including building regulations, urban planning, healthcare, public communication and research.

Background

Climate change is increasing the frequency, duration and magnitude of extreme heat events, including heatwaves (Table 1). This is a threat to public health.[1–3]

Table 1 Main definitions of heat events	
Heatwaves	Heatwaves are defined by the Met Office as periods of at least three consecutive days in which a temperature threshold is met or exceeded. Thresholds differ between counties, reflecting regional differences in climate.[4] There is no universal definition of a heatwave.
Heat periods	Heat periods are defined by the UK Health Security Agency (UKHSA) as at least one day with an amber Heat-Health alert[a] in at least one region and/or the mean Central England Temperature being at least 20°C. The Office for National Statistics (ONS) and UKHSA use heat periods to report heat mortality statistics on excess heat-deaths.[5]

This POSTnote outlines the effects of heat on health and actions that can be taken to prevent them. Policies and measures to address heat risks are part of climate change adaptation. There is wide consensus that adaptive measures to respond to climate change are not alternatives to mitigations,[6] discussed in other POSTnotes.[7–10]

Climate change adaptation and public health policy are devolved. Unless otherwise specified, policies and guidelines mentioned here refer to England.

Hot weather in a changing climate

UK climate observations record rises in mean and peak annual temperatures.[11] The 10 hottest years since 1884 have all occurred since 2003.[12] Annual maximum temperatures are rising at a faster pace than mean temperatures.[11 b]

Human-induced climate change makes heatwaves more likely and more extreme.[1,2] For example, in 2022, the Met Office declared three heatwaves in the UK, and temperatures exceeded 40°C for the first time.[11,13] While the chance of UK temperatures currently exceeding 40°C is low, climate predictions indicate such heat extremes would occur every 15 years by 2100 under the current greenhouse gas emissions trajectory.[14] Hot days are predicted to become more frequent in England. Projections indicate an increase of 37 to 55 days per year reaching 25°C if global

[a] Heat-Health Alerts are issued by the UK Health Security Agency and the Met Office. An amber alert indicates heat impact on the whole health service and potential risk for the whole population (Box 2).

[b] A comparison between the years 2013 – 2022 and 1961 – 1990 showed mean temperatures increased by 1.1 °C, the warmest 3 – 4 days of the year (99th percentile) by 1.9°C, and the hottest day by 2.8°C.

warming reaches 4°C.[15] [a] The Intergovernmental Panel on Climate Change[b] projections indicate that heat extremes are *very likely*[c] to increase in frequency and intensity.[17]

Heat effects on the body and health

Heat exposure triggers the body to try to maintain a stable core temperature. This is called thermoregulation.[18] It involves two main mechanisms:

- blood flow is redistributed to the skin (vasodilation), transferring heat from warmer deep body tissues to a cooler environment
- sweating removes heat through evaporation.

The effect of heat and the body's ability to respond are also affected by humidity[d,e], air movement and sun exposure (radiant heat).[20]

Extreme heat, particularly when coupled with high humidity, can exceed the body's ability to thermoregulate.

Physiological mechanisms of thermoregulation have impacts on the body.[20,21] Blood redistribution due to vasodilation can cause cardiovascular strain, which can lead to adverse cardiovascular outcomes such as heart attacks[f]. Elevated body temperature (39-40°C) combined with the physiological stress of vasodilation can damage multiple organs.[21] Sweating can cause dehydration, which decreases blood volume and can cause cardiovascular strain and, in prolonged exposures, kidney injury and failure.[22]

These responses can lead to heat illness, including heat cramps (muscle cramps and spasms) and heat exhaustion (fatigue, dizziness and nausea).[18] Heatstroke is the most severe form of heat illness.

[a] Global warming reaching 4 °C means the hypothetical scenario of the average global temperature increasing by 4 °C above pre-industrial levels.

[b] The Intergovernmental Panel on Climate Change is the United Nations body for assessing the science related to climate change.[16]

[c] The term *very likely* here indicated an estimated likelihood of 90-100%.

[d] Humidity is a measure indicating how much water vapour the air contains. High humidity can impair the body's ability to sweat.

[e] While humidity has been suggested to play an important role to the bodily response to heat from a physiological perspective, epidemiological studies show no impact of humidity on heat-related mortality.[19]

[f] Adverse cardiovascular outcomes may include heart attacks, heart failure and heart arrhythmias (irregularity in the heartbeat).

Impact of recent heat events on population health

Heat-related mortality

There is robust evidence that heat is associated with increased death rates. Across the UK, heat-mortality in people aged 65 years and over increased by 57% when comparing 2018-2022 to 2000-2004.[23]

Heat-related mortality is predicted to increase.[24–27] The magnitude depends on the climate change scenario, degree of adaptation and changes in population demographics.[28] A study projected that by 2050, assuming no further climate adaptation and an ageing population, UK heat-mortality could increase from 2.52 to 7.80 deaths per 100,000 in the least severe climate scenario, and to 24.11 in the most severe.[29a]

Heat can impact health and cause excess mortality for those most vulnerable outside heat periods. In London, excess mortality is observed from a maximum temperature around 24°C.[30] The threshold used to trigger public health alerts is 28°C.[31b]

Deaths during the 2022 heat periods

Different methods were used by Government bodies to estimate heat-related mortality in 2022. A UKHSA analysis reported an estimated 2,985 excess deaths associated with the five heat periods in England (Figure 1).[32]

Using a slightly different baseline, an Office for National Statistics (ONS) analysis reported 3,271 excess deaths associated with the five heat periods in England and Wales.[33] The ONS also estimated there were 3,363 – 5,587 heat-related deaths in England in all of 2022.[34c]

Peaks in excess deaths during heat periods may be followed by a drop in deaths below the average within subsequent days. This could indicate that some heat-related deaths occur in very frail individuals whose deaths are brought forward by a few days, into the heat period.

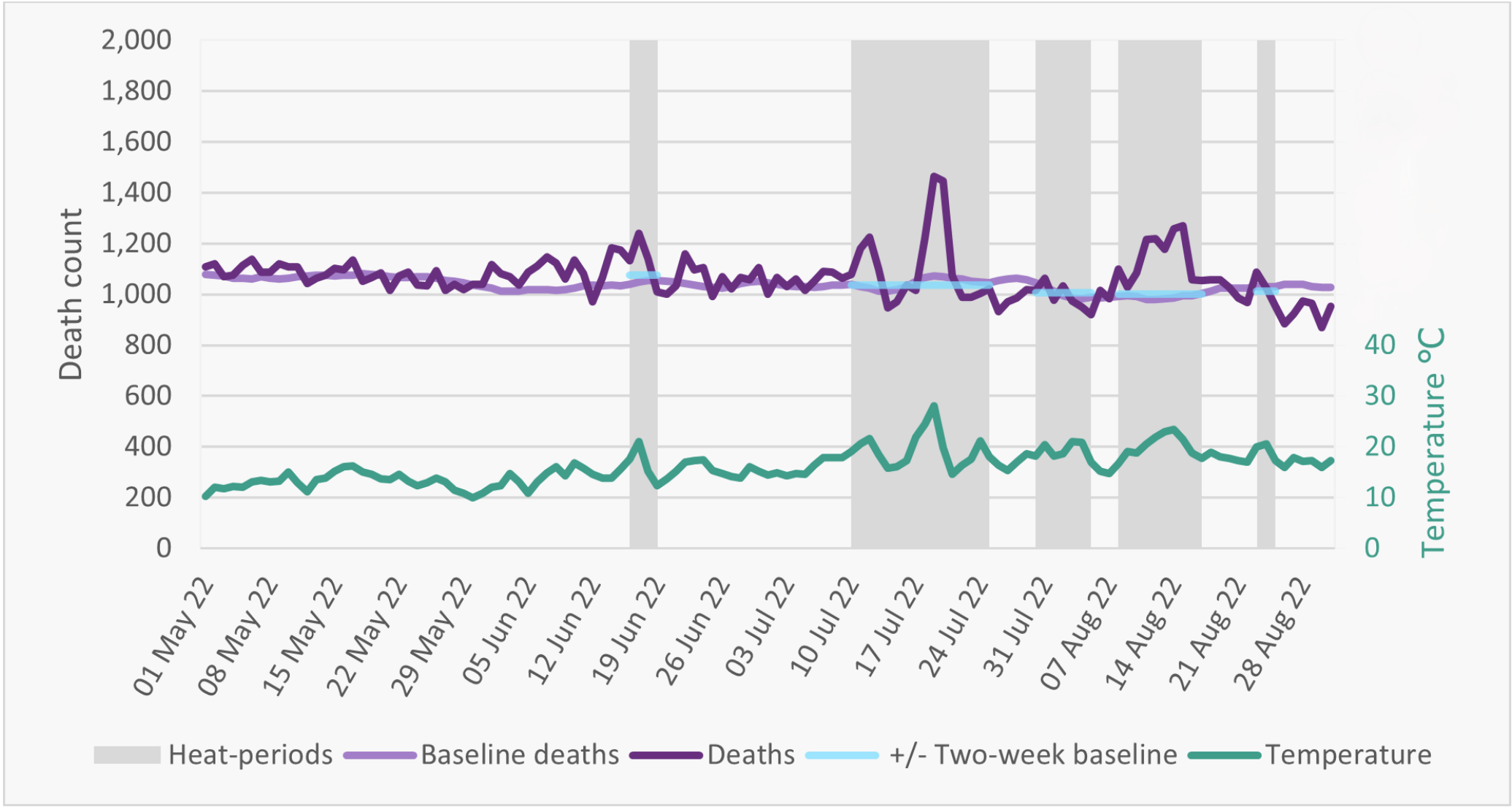
[a] Here, climate projections are based on 12 climate scenarios from the UK Climate Projections 18. The least severe scenario means lower levels of greenhouse gas emissions, leading to slower climate change and less extreme weather events. The most severe means higher greenhouse gas emissions, leading to faster progressing climate change and more extreme weather events, like heatwaves.

[b] As Heat-Health alerts are issued based on an impact assessment, temperature thresholds merely serve as decision-making aids.

[c] The ONS notes these results are based on experimental statistics which are under development, meaning estimates may be subject to change. Hence, results should be interpreted with caution.

Figure 1 Daily mortality in people aged 65 and older during summer 2022.

Note: The death count is adjusted for registration delays and excludes deaths from COVID-19. Observed deaths are compared to a 5-year baseline and a +/- two-weeks baseline. The 5-year baseline death rate is defined as the average daily deaths across the same day and the two weeks before and after, from 2015 to 2019. The +/- two-week baseline is defined as the average daily deaths, excluding COVID-19, in a period of up to 14 non-heat-period days before and after each heat-period.



Source: ONS: Estimated excess mortality (excluding COVID-19) during heat-periods, England

Other heat-related health impacts

High temperatures exacerbate symptoms of chronic disease. An average of 1,780 yearly hospital admissions were associated with warm days in England between 2010 and 2018.[35a] Injuries, cardiovascular-related diagnoses, mental health problems and dehydration were the main contributors.

Health-related surveillance data during a 2013 heatwave in England showed increased demand on GPs and emergency departments for heat-illness.[36] Increased GP demand was highest for children aged 4-14 and people aged 75 and over. Data from 18 to 24 July 2022 indicate large increases in reported symptoms of heat stroke and heat exhaustion.[37]

Other, more indirect health impacts of heat are listed in Table 2.

Heat impacts on health services

Extreme heat impacts healthcare, due to increased admissions, impact on facilities and equipment, and thermal discomfort of patients and staff.[38–40]

- In Birmingham between 2007 and 2011, ambulance call-out response times were negatively impacted by hot weather.[41]
- In a survey of UK doctors during the 2022 heatwaves, one in five reported cancellations of surgeries due to extreme heat.[42] Cancellations primarily resulted from staff and bed shortages, and overheating in surgical theatres.
- Extreme heat in 2022 resulted in the failure of IT systems of London's largest NHS hospital trust[43] with impacts on healthcare in three hospitals.

[a] This analysis considered the four warmest months of the year and considered "warm days" as those with a daily mean temperature above 15.4°C.

Table 2 Other public health impacts	
Wellbeing	Extreme heat and heatwaves can negatively impact psychological wellbeing and functioning, even in the absence of a mental health condition.[44] High temperature can impair the way we perceive and process information and affect productivity.[45] Heat can disrupt sleep patterns, with subsequent negative effects on wellbeing.[46]
Violence and crime	An analysis of London Metropolitan Police data from years 2010-2018 found an average 14% increase in violent crime when temperatures were above 18°C compared to below 10°C.[47,48] These observations align with international studies.[49–56] However, overall evidence in the UK is limited. Reasons may include temperature effects on aggressive, impulsive and general behaviour (for example, spending more time outdoors; consuming more alcohol).[57] Elevated rates of crime-related injury may increase emergency and hospital service demand.[51]
Accidents	A systematic review in high-income countries reported that hot weather can increase the risk of accidents and unintentional injuries.[58] In England, each 5°C increase in maximum daily temperature was linked to a 1.8% increase in trauma admissions.[59] This effect was most pronounced in children, where a 10% increase in admissions was observed for each 5°C increase in maximum temperature. A study of unintentional drownings between 2012 and 2019 showed an increase in drowning risk for males by over 7% per 1°C temperature increase.[60] The Royal Lifesaving Society reported 105 accidental drownings in the UK in summer 2022, 83% of which were males.[61]

Heat-health vulnerability factors

The impact of heat on health varies across the population. Many factors render individuals more sensitive to negative impacts, increase their heat exposure, or impair their ability to adapt. Some factors overlap, with some groups having multiple contributory risks arising from their physiology, and several social and environmental determinants.

Age

Older individuals

The body's ability to thermoregulate declines with age.[62,63] Older people[a] are less likely to behaviourally adapt to heat (such as seeking shade, removing clothing), due to a reduced sense of temperature increases.[65] Reduced thirst perception also puts older individuals at risk of dehydration.[66]

Older age is associated with other vulnerabilities described below, including chronic illness, medication intake, physical immobility, social isolation and living in care.

The greatest proportion of heat-related mortality in the UK is in older people.[33]

Babies and children

Children aged under four years are less able to thermoregulate, leading to elevated temperature during heat.[67] Older children (6-12 years) show differences in thermoregulation, but successfully regulate their temperature.[68–70] Children have a higher ratio between body surface and body mass, elevating the risk for overheating.[71]

During heat periods, children younger than 4 years are at an increased risk for death, particularly those under 12 months.[72–75] For older children, evidence is inconclusive but suggests no increased risk of death compared to adults.[73]

Health status – physical and mental health

Chronic physical health conditions and medication

Chronic conditions (Table 3) and medications (Box 1) increase individuals' risks of heat-illness and mortality through several pathways. This includes impaired thermoregulation, predisposition to heat-illness and interactions between heat and symptom severity.[76]

Cardiovascular and respiratory disease are the main causes of mortality during heat-waves, both in England[35] and globally.[77]

[a] Most studies define older people as those aged 65 and older.[64]

Table 3 Health conditions increasing heat vulnerability	
Cardiovascular disease	Redistributing blood to the skin to regulate body temperature (vasodilation) puts a strain on the heart. For those with cardiovascular disease, this can lead to outcomes such as heart failure.[21] Dehydration can aggravate this strain.[42]
Respiratory disease	Heat exposure can exacerbate respiratory disease symptoms, particularly when people are dehydrated.[21] This is likely related to air quality, that tends to be poorer during heat periods, and the physiological stress of thermoregulation.[21]
Kidney disease	Dehydration due to sweating can lead to acute kidney injury and failure.[79] Chronic kidney disease can strain the heart, increasing the risk of cardiovascular events during heat.[80]
Diabetes	People with type 1 or 2 diabetes are less able to thermoregulate due to an impaired ability to sweat and redistribute blood to the skin.[81,82] People with diabetes are also at a higher risk of cardiovascular events.[80] Heat exposure increases the risk of acute and possibly fatal complications of diabetes,[83] as heat exposure and dehydration affect blood sugar regulation.[84]
Epilepsy	During hot weather, 62% of people with epilepsy reported an increase in seizures.[85a] The mechanisms are not fully understood but there is evidence that genetic variants associated with epilepsy alter the ability to regulate body temperature.[86,87] Further, disrupted sleep during heat periods can trigger seizures.[88,89]
Multiple Sclerosis	Many people with multiple sclerosis experience a worsening of symptoms when exposed to heat. This can include fatigue, pain, blurred vision, problems with concentration, a loss of balance and difficulty walking.[90–93]
Dementia & Alzheimer's Disease	There is evidence heat exposure and heat stroke can affect disease mechanisms involved in dementia and Alzheimer's disease.[94] People living with dementia are also likely less able to behaviourally adapt to heat.[95]
Parkinson's Disease	Thermoregulation may be impaired in Parkinson's disease.[96] Sweating abnormalities (reduced and excess sweating) are common in Parkinson's disease. People also report worsening of symptoms during heat.[97]

[a] Results are from a non-academic survey by the Epilepsy Society UK, including reports of over 1000 people with uncontrolled epileptic seizures.

Box 1: Medications increasing vulnerability to heat risks

Several widely used drug groups can make individuals more vulnerable to heat risks, including:[98–102]

- anticholinergics[a]
- antidepressants (such as selective serotonin reuptake inhibitors and tricyclic antidepressants)
- antiepileptics
- antihistamines
- antipsychotics (typical and atypical)
- blood-pressure medication (including beta-blockers and diuretics)

Mechanisms of risks include impaired sweating, reduced thirst, dehydration, reduced ability for blood redistribution (vasodilation) and cognitive impairments affecting behavioural adaptation.[102] This list is not exhaustive, as most medications have not been studied for temperature interactions.[20]

Mental health

People with mental health conditions may be at higher risk for negative heat-health effects due to an increased vulnerability to heat-related illness and worsening of symptoms during heat.

Increased risk for heat-related illness and death

Individuals with mental health conditions have an increased risk for poor health and heat-related illness after heat exposure.[103–108] There are reports of an increased risk of death in those with mental health conditions,[103,109–114] particularly schizophrenia[115] and substance misuse.[116] However, other studies do not report this effect.[103,117]

Several mechanisms are involved.[103] People with mental health conditions may be less likely to be aware of heat-related health risks and less able to adapt behaviourally.[118,119] Co-occurring health conditions (Table 1) and using medications (Box 2) also contribute. Further, poor mental health is associated with factors such as poor quality housing, increasing heat exposure and vulnerability.[120]

Worsening of mental health symptoms

The most widely studied mental health outcome in relation to heat is suicide, with consistent reports of increased risk.[44,121–126] A meta-analysis of global literature

[a] Anticholinergic medications are used to treat conditions related to the bladder (such as incontinence), the digestive system (such as irritable bowel syndrome), the brain (such as Parkinson's disease) and the lungs (such as chronic obstructive pulmonary disease).

reported a 1.5% increase in deaths by suicide per 1°C increase in monthly temperature and a 1.7% increase per 1°C increase in daily temperature.[44]

Higher temperatures increase mental health service use.[44,127,128] In England and Wales, mental health admissions increased during warm days.[35] A global meta-analysis reported a 9.7% rise in admissions during heatwaves.[44] Increased admissions are reported for bipolar disorder.[129–131] Evidence for schizophrenia[132,133] and depression[130,132,134] is mixed.

How heat impacts mental health symptoms is not fully understood but may include effects on physiology, cognition, sleep, medication use (Box 1) and daily activities.[119,122,135]

Maternal health and pregnancy

Heat is associated with increased risk of pre-term birth[a] and still-birth[b].[137–143] Heat illness (when core body temperature is raised during pregnancy) increases risk of congenital birth defects.[138–141,143] Maternal health can be affected, as an increased likelihood for high blood pressure in pregnancy during heat has been reported.[144]

Pregnancy likely does not impair thermoregulation although there is a lack of evidence regarding heat stress in late pregnancy.[145] The mechanisms for high temperatures causing pre-term birth are not fully understood.[146] Physiological heat responses may trigger early delivery due to inflammation or reduced placental blood flow.[146]

Behaviour

Physical activity

Physical activity releases heat in the body, increasing temperature. This can overwhelm the body's ability to thermoregulate, particularly in combination with heat and humidity[147] and result in "exertional heatstroke".[148]

In the UK, exertional heatstroke has been reported in long-distance runners, outdoor workers and army personnel.[149,150]

Alcohol consumption and illegal drug use

Alcohol does not impair physiological heat responses[151,152], but can cause dehydration.[153] Drugs including cocaine, methamphetamine and MDMA impair thermoregulation by reducing sweating and blood redistribution to the skin. They can reduce the behavioural response to heat by weakening heat sensation and increasing body heat through increased activity (agitation).[153–155]

[a] Pre-term birth is defined as a baby born alive before 37 weeks of pregnancy.[136]

[b] A stillbirth is the death of a baby after 24 weeks of pregnancy, before or during birth.

The built environment

Urban areas

83% of the population in England live in urban areas,[156a] projected to rise by 2050.[157] Urban areas are on average warmer than rural areas, a phenomenon called the Urban Heat Island (UHI) effect[158] resulting from:

- materials absorbing heat (concrete)
- fewer green and water spaces
- tall buildings trapping heat
- human activity producing heat[159]

The UHI effect is pronounced at night, when absorbed heat is released.[160] In English cities, UHIs can be up to 10°C hotter than surrounding rural areas.[161]

UHIs have detrimental health effects.[162,163] During the 2003 heatwave in the West Midlands, the UHI effect was estimated to account for 50% of heat-related deaths.[164] Health impacts are not distributed equally across urban areas, but impacted by population density, built environment and socioeconomic profile, thereby exacerbating inequalities.[165]

Housing conditions

A large proportion of UK homes experience overheating.[166,167b] Table 4 outlines characteristics that increase risk:

Workplace setting

Those working in physically demanding jobs, outside or in hot areas (such as using hot machinery) and those required to wear protective clothing that can prevent heat dissipation are at increased risk of heat-related health impacts. Impacts in occupational settings often occur at lower temperatures than those in the general population.[22,168]

[a] Statistics reported based on 2020 mid-year population estimates.

[b] An estimated 4.6 million English homes experience bedroom overheating during summer[167] and over half of UK homes are at risk of overheating.[166] This is projected to increase to 90% of homes under a 2°C global warming scenario.

Table 4 Building characteristics increasing the risk for indoor overheating[166,169–173]	
Dwelling type	Flats have a higher risk compared to detached houses.
Dwelling size	Dwellings with a smaller floor area are at high risk.
Floor level	Top floor apartments are at higher risk, particularly those with inadequate roof insulation.
Windows	Single-aspect flats[a] are at risk due to limited ventilation. Dwellings with large windows are at higher risk due to heat gain from the sun.
Shading	Buildings with limited shading are at higher risk due to heat gain from the sun.
Insulation	The role of insulation in overheating risk is complex. UK dwellings with high levels of insulation overheat more frequently, possibly due to decreased airflow.[174] However, adequately installed insulation can effectively prevent overheating, particularly combined with ventilation.[175]
Occupant behaviour	Occupants can reduce overheating by adjusting ventilation and cooling systems. However, access to such measures can vary and is often linked to socioeconomic status. Many cannot afford cooling systems (see below), and opening windows for ventilation is not always desirable or possible due to concerns for safety, noise and air quality.[176]

Care homes

Overheating in care homes is a risk and widely studied.[177,178] This risk falls on a highly vulnerable resident population due to increased age and illness. Reports show mortality increases of care home residents during heatwaves in 2003 and 2020.[179,180]

Overheated care homes result from a lack of awareness of heat risks, building features[b], ineffective heat management[c] and miscommunication on heat management[d].[177]

[a] Single aspect flats are flats with three closed sides.

[b] For instance, restrictions on window opening, which are installed for safety reasons.

[c] For instance, year-round use of central heating.

[d] For instance, a lack of clarity on who is responsible to manage indoor heating and temperature.

Schools and educational settings

In school, children have limited possibilities to thermoregulate behaviourally, relying on teachers for guidance.[169,181] Heat may also disrupt learning, potentially widening educational inequalities.[165,182]

There is a lack of evidence on the prevalence of overheating in schools across the country.[169]

Prisons

Prisons are at risk for overheating due to building design and regulations.[169] Prisoners have limited behavioural possibilities to adapt to heat. Between 2016 and 2017, the Ministry of Justice received almost 500 overheating-related reports and complaints.[183]

Social isolation

Social isolation increases vulnerability to heat-health impacts and death during heatwaves.[114,184,185] People living in isolation are less likely to receive community support and help during heat events. In older people, social isolation impacts health[186], possibly increasing physiological vulnerability. Reducing social isolation of older people decreases heat mortality.[187]

Sociodemographic factors

Assessing the effect of sociodemographic factors on heat vulnerability is complex, as they overlap and interact. Some people are impacted by multiple factors, some of which may counteract each other.[188a]

Health inequalities are more likely to be experienced by people from ethnic minority backgrounds.[189] However, data exploring the link between heat vulnerability and ethnicity in the UK are limited.

Socioeconomic status

People with lower socioeconomic status are more likely to have poor health, live in poorer quality housing and deprived neighbourhoods (including less access to green and blue spaces[b] and poor air quality[190]), and have physically demanding and/or outdoor jobs.[191,192] Examining the link between socioeconomic status and heat vulnerability is challenging; research in the UK reports mixed findings:

- England: Increases in emergency hospital admissions during extreme heat were most pronounced in socioeconomically deprived areas.[193]

[a] For instance, higher levels of education decrease heat-vulnerability through association with better health. Simultaneously, higher levels of education are related to higher life expectancy and older age, which negatively impacts heat vulnerability.[188]

[b] Blue spaces refer to any type of natural or artificially made bodies of water.

- London: Higher temperatures were found in areas with higher levels of income deprivation and social-rented housing. However, no significant association was found between socioeconomic variables and heat-related mortality.[194]
- Scotland: People living in socioeconomically deprived areas had a higher risk for heat-related mortality.[195]
- England and Wales: No association was found between heat mortality and socioeconomic deprivation.[196]

Educational attainment

Global and European studies indicate that high educational attainment is associated with lower heat-related mortality.[188,197] Low educational level may influence people's response to extreme heat, for instance due to less knowledge and awareness about protective measures.[20]

Homelessness

People experiencing homelessness or living in insecure housing are more exposed to heat and related health impacts, due to limited access to shade, cool spaces and drinking water. Correlations between homelessness and other vulnerability factors, including health conditions, urban environment and social isolation, amplifies this risk.[198]

In London between 2011 and 2019, homelessness was associated with a higher risk of hospitalisation during heat.[199]

Migrants and refugees

There is limited data available but migrants and refugees in the UK are vulnerable to heat impacts, due to limited access to and understanding of public heat advice and differences in conditions to their place of origin.[200a]

Responding to heat and heat-related health impacts

Policy framework

Heat and health are affected by policy and collaborative work across sectors and government departments. Strategies can be grouped into emergency responses to heat, and longer-term planning on adaption and heat resilience.

[a] For instance, people may be used to other means of adapting their housing to heat, such as using outside shutters, which are not available in England.

The Adverse Weather and Health Plan (AWHP), published by the UKHSA in 2023, constitutes the overarching policy framework for weather and health, including responding to heat-health risks.[201]

The AWHP was a commitment under the Third National Adaptation Programme (NAP3, published by the Department for Environment, Food and Rural Affairs [DEFRA] in 2023).[202] This outlines actions to adapt to climate change. The NAP is informed by the Government's Climate Change Risk Assessment.[203]

In the Health Effects of Climate Change in the UK (HECC) report (2023), the UKHSA provides evidence, analyses and recommendations based on UK climate change projections.[204] It is designed to influence heat-related policies across sectors.[165]

Emergency response to extreme heat and heatwaves

Early warning systems and emergency response

Early warning alerts are among the most cost-effective interventions to protect public health (Box 2, Picture 1).[205] The AWHP is underpinned by an impact-focused heat-health alert system.[1]

Locally, responding to heat alerts is the responsibility of local authorities. Local resilience forums (LRFs) coordinate emergency response arrangements (such as local government and the NHS) and voluntary organisations.[201] Local health resilience partnerships support the health sector in LRFs.

A lack of integration between national and local policy has been criticised in an independent academic policy publication.[165]

Box 2: Public messages about heat events

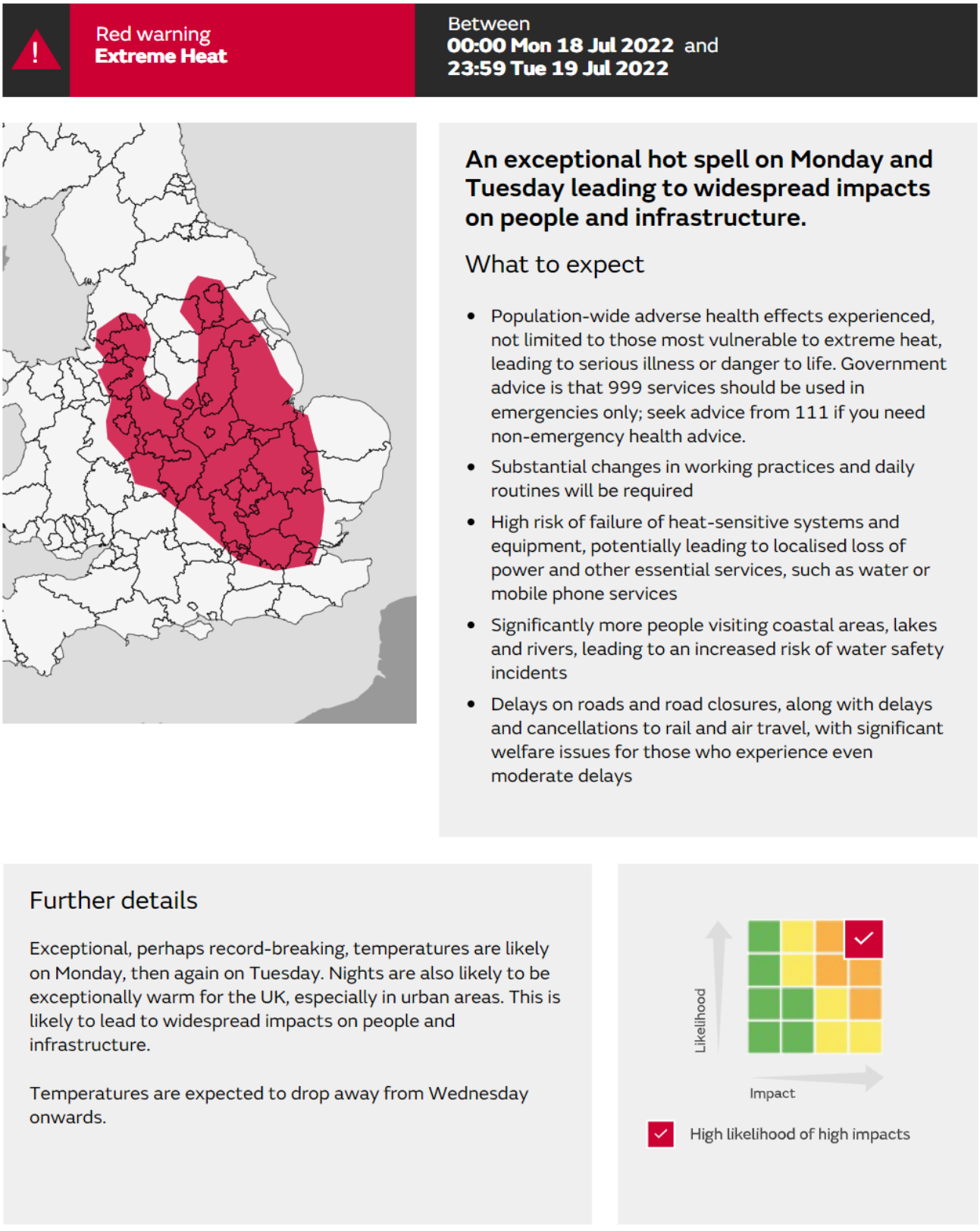
- **Extreme heat warnings** are issued by the Met Office National Severe Weather Warning Service to highlight the potential impact of extreme heat. Warnings are UK-wide and issued at three impact levels (yellow, amber and red), indicating the impact and likelihood of negative events (Picture 1).[206]
- **Heat-Health Alerts** are issued by the UKHSA in partnership with the Met Office from June to September and aimed at health and social care professionals. Alerts cover England only. Coloured alerts (yellow, amber and red) indicate the impact and likelihood of adverse health impacts:[207]
  - Green (summer preparedness): No alerts; preparation should take place.
  - Yellow (response): Impact unlikely to affect most people but could affect the most vulnerable; *or* low confidence in a weather-forecast, but possibly significant impacts.
  - Amber (enhanced response): Impacts the whole health service; potential risk for the whole population.
  - Red (emergency response): Significant risk to life for the whole population; Red alerts are issued in conjunction with a red extreme heat warning and declare a national emergency.

The UKHSA and Met Office collaborate to align extreme heat warnings and Heat-Health Alerts. Alerts are cascaded to the public, government departments and agencies, the NHS and local authorities.

It has been suggested that Heat-Health Alerts can be enhanced by incorporating likely indoor temperature before and after heatwave events.[208]

Picture 1 Example of a Met Office Red Warning for Extreme Heat.

Warnings include a specification of the affected area, and an assessment of the likelihood and impact of the event as well as advice and guidance to protect public health from heat impacts at the respective warning level.



Source: Met Office

Public communication of heat-health alerts

Public heat-health alerts are communicated by the UKHSA through print, broadcast and social media. Guidance material is available in 13 languages.[209] Communication toolkits are provided to organisations such as local authorities.

Stakeholders from the academic and charity sectors stress the importance of effective public communication and engagement in the emergency response. This requires tailored and targeted communication including TV, social media, print newspaper and radio, and community engagement.[210] Further, advice on how to protect oneself should be specific where possible[a] and vulnerability factors made explicit[b].

In the UK, 40% of adults report to have never seen information on protecting themselves during heatwaves. Among some vulnerable populations, this proportion is higher.[c211]

Independent policy reviews suggest naming heatwaves to improve risk communication.[212,213] The House of Commons Environmental Audit Committee (EAC) suggested a trial period of naming heatwaves in 2024.[175] The Government does not plan to introduce this, sharing the World Meteorological Organisation's position.[175,214]

Adapting to increasing heat

Protecting the vulnerable

Academics stress the importance of prioritising vulnerable populations. Mapping tools can be used to identify communities and neighbourhoods, to target interventions.[d] There are mixed views about the validity and effectiveness of this approach.

Improving the heat resilience of buildings

Indoor overheating is a key concern as the building stock in England is unprepared for extreme heat,[216] and noted in:

- The Heat and Buildings Strategy, published in 2021 by the Department for Business, Energy and Industrial Strategy[e], acknowledges the importance of considering the risk of overheating when future-proofing buildings.[217]

[a] For instance, telling people how much to drink rather than merely to drink more.

[b] For instance, providing age ranges rather than referring to "older people".

[c] This includes outdoor workers (62%), people with a heart condition (57%) and those who are expecting a child or have a child under three years old (53%).

[d] An example for this is the "Keep Bristol Cool mapping tool", which can be used by policy makers and practitioners to explore vulnerabilities across neighbourhoods.[215]

[e] The Department for Business, Energy and Industrial Strategy is now the Department for Energy Security and Net Zero.

- The National Building Regulations introduced a new standard addressing overheating mitigation in new residential buildings ('Part O'), effective from June 2022.[218]

In an independent assessment, the Climate Change Committee (CCC) criticised the lack of policy commitments on overheating in existing buildings, which account for most future dwellings.[219,220]

Other academic experts highlight the importance of considering overheating risks when retrofitting and accounting for regional weather and climate differences and projected future changes. Further, the EAC notes the importance of evaluating impacts of regulation, which is disregarded in current policy.[175]

The EAC further pointed out the opportunity of combining retrofitting for energy efficiency with efforts to prevent overheating.[175] They set out recommendations for a national retrofitting programme, encouraging local delivery, long-term funding, prioritising vulnerable populations, and consideration of a "cooling hierarchy" (see below).

A Government consultation on the Future Homes and Building Standards includes specific questions on the expansion of Part O to conversions[a] but not refurbishments.[221] It also seeks out views on mandatory post-occupancy performance testing.

Keeping buildings cool – sustainable cooling

Academic stakeholders note that more sustainable, passive cooling solutions[b] should be prioritised over those that contribute to emissions (for example air conditioning). The EAC recommends a cooling hierarchy, as set out in the Mayor of London's Energy Assessment Guidance.[222] Accordingly, cooling measures should be implemented in priority order:

- Minimising heat entering buildings (through shading, shutters, insulation, cool and green roofs[c])
- Energy efficient design to reduce internal heat generation
- Heat management through high ceilings and materials that absorb heat
- Passive ventilation (such as suitable window design, dual aspect units)
- Mechanical ventilation (such as fans)
- Active cooling (air conditioning) only if passive measures provide insufficient cooling.

[a] Conversions from non-residential to residential buildings, also referred to as "material change of use".

[b] Passive cooling solutions are those that do not rely on energy.

[c] Cool roofs are made from or painted in light-coloured material, reflecting energy from the sun and thereby reducing heat gained from sun exposure. Green roofs are completely or partially covered in soil and growing plants.

The Cooling in the UK study, commissioned by the Department for Business, Energy and Industrial Strategy, stated energy consumption and capital cost associated with cooling can be reduced by policy interventions prioritising passive cooling.[223]

Sustainable cooling is discussed in POSTnote 642.[224]

Urban areas and city planning

Several measures and designs can reduce outdoor temperatures. Stakeholders note the effectiveness of nature-based solutions[225,226], such as incorporating green and blue spaces into urban areas to reduce outdoor temperature locally or for specific buildings.[227]

A 2023 progress report stated that policies addressing the UHI effect are limited.[228] Recent commitments and guidelines take account of this (for instance, the Environmental Improvement Plan[229], the Urban Tree Challenge Fund[230], the Tree Action Plan[231]), but are not backed by clear legal requirements. Natural England's Green Infrastructure Framework provides evidence-based guidance to reduce heat risks.[232] However, this is criticised by the CCC for only applying to new developments.[228]

A lack of mandatory reporting of green infrastructure limits the understanding of progress towards adapting urban areas to heat. Data indicates a decreasing trend in the proportion of urban green and blue spaces.[228]

The CCC and the Environment, Food and Rural Affairs (EFRA)[a] Committee point out the potential for local authorities, businesses and individuals to implement green infrastructure.[228,233] However, a consistent funding programme to support initiatives is lacking. The CCC notes such funding should cover public and private investments and consider longer-term costs (rather than provision by one-off grants).[228]

Local cooling centres

Academic and third sector stakeholders are discussing the utility of cooling centres, providing shelter, drinking water and medical care.[175] The Greater London Authority has a website mapping cool spaces[b], resembling cooling centres.[234] However, these are not targeted at vulnerable populations and do not provide medical support.

Governmental stakeholders stress the importance of evaluating such interventions.

Heat resilience of the health and social care sector

The NHS core standards for Emergency Preparedness, Resilience and Response (EPRR) requires organisations to have effective arrangements for adverse weather, including heat and heatwaves.[235] The AWHP provides guidance on how health and social care sectors can prepare and respond.[236]

Health providers must have a Green Plan to reduce their environmental impact. Current guidance provides limited information on heat adaptation but this is

[a] The EFRA Committee is conducting an inquiry on benefits of urban green spaces.

[b] Mapped cool spaces include indoor and outdoor spaces with key amenities for coping with hot weather, such as shade and drinking water. Cool spaces include for instance libraries and community centres.

anticipated to increase.[237] The Green Plan of NHS property services, managing ~10% of NHS estates, does not address heat risks.[238]

The NHS Net Zero Buildings Standard (2023) requires that newly built facilities and major refurbishments are assessed for thermal comfort and avoid overheating.[239] [a]

Academic and healthcare stakeholders note the importance of better education of health and social care professionals about heat-health impacts. This includes awareness of high risk groups, including interactions of heat with medication. In the Third Health and Care Adaptation report, the NHS recognises this educational need, and states it is beginning to develop education material.[240]

Occupational settings

The UK follows international standards for occupations involving exposure to extreme temperatures.[241] However, there is no guidance on a maximum temperature for general workers in the UK.[242b] Some academics advocate setting a maximum working temperature[c] to protect employees. However, evidence upon which to establish a maximum indoor temperature is limited.[243]

Another suggestion is introducing employee health checks in heat-risk occupations (for example agricultural workers), and a system to recognise employees' heat vulnerabilities.[244]

Public perception and education on heat

Many stakeholders note the need for a cultural shift in the perception of heat.[175] Research shows that people are not sufficiently aware of the dangers and the protective actions they can take.[245] This particularly applies to high-risk groups, such as older people, who may not perceive themselves at risk.

Stakeholders suggest public communication on heat risks should be paired with education on heat and climate change.[246]

Research collaborations and funding

While further research on health effects of heat is seen as important, stakeholders note action is needed urgently and should not be delayed.[175]

Multidisciplinary research initiatives seek to explore climate change impacts on public health and address knowledge gaps (Table 5):

[a] It encourages the use of passive cooling.

[b] A minimum temperature of 16°C is set in legal guidelines.

[c] A maximum temperature above which work either needs to be stopped or special measures to alleviate heat stress need to be put in place (for instance, work-rest cycles, cooling stations).

Table 5 Selected examples of current research initiatives and funding	
Wellcome Trust	A new scheme funds research on climate change impacts on health.[247] Projects include research on the impact of heat on mental health in London and heat effects on pregnancy outcomes in deprived areas of England and Wales.[248]
UK Research and Innovation (UKRI)	UKRI funds transdisciplinary research hubs working towards realising health co-benefits of the UK transition to net zero.[249] UKRI further provides funding to multiple research projects related to heat impacts on public health.[250–252]
National Institute for Health and Care Research (NIHR)	The NIHR funds Health Protection Research Units (HPRUs) in England. HPRU are partnerships between universities and the UKHSA. The NIHR set climate change and health security as a priority area for HPRUs. A NIHR HPRU on Environmental Change and Health is led by the London School of Hygiene and Tropical Medicine, collaborating with the Met Office, UKHSA and University College London.[253]
Multi-Country Multi-City (MCC) Collaborative Research Network	The MCC Collaborative Research Network is an international research collaboration on associations between environmental stressors, climate and health.[254]
HEAT-SHIELD	HEAT-SHIELD is an international collaboration between European universities, including UK universities. HEAT-SHIELD aims to improve health and work productivity in the context of global warming.[168]
RECLAIM	RECLAIM is a network led by the University of Surrey, focused on the use of green and blue infrastructure to make cities healthier.[255]

The need for a joint approach

Heat affects public health through multiple areas, and interactions mean impacts on one area cascade elsewhere. Interventions realised in one sector may trickle down to benefit another.[a]

These complex interdependencies between sectors requires a joint, interdisciplinary approach, involving different governmental departments and agencies.[165,175,256] The third National Adaptation Programme supports a whole-government approach.[257]

The EAC has recommended appointing a Minister for Heat Resilience.[175] In the Government's response to the EAC, details on a Climate Resilience Steering Board were set out.[258] Similarly, academics suggest a single government department should be responsible for orchestrating the cross-sector response to heat risks.[165]

Governmental stakeholders state the UKHSA Centre for Climate and Health Security will provide strategic leadership in the response to health impacts of heat.[259]

[a] For instance, implementing buildings regulations that reduce the risk of building overheating can benefit people's health and reduce demand on healthcare services.

References

1. Zachariah, M. *et al.* (2023). Extreme heat in North America, Europe and China in July 2023 made much more likely by climate change. World Weather Attribution.
2. Zachariah, M. *et al.* (2022). *Without human-caused climate change temperatures of 40oC in the UK would have been extremely unlikely*. World Weather Attribution.
3. Philip, S. *et al.* (2023). Extreme April heat in Spain, Portugal, Morocco & Algeria almost impossible without climate change. *11*. World Weather Attribution.
4. What is a heatwave? *Met Office*.
5. Excess mortality during heat-periods. *Office for National Statistics*.
6. Howarth, C. (2024). Preparing for heat risk is complex: Aligning adaptation and mitigation is essential. *PLOS Clim.*, Vol 3, e0000371. Public Library of Science.
7. Oxby, J. *et al.* (2024). Demand side response: A tool for lowering household energy bills.
8. Grub, H. *et al.* (2024). What is a just transition for environmental targets?
9. Collins, A. *et al.* (2024). Local area energy planning: achieving net zero locally.
10. Wolmuth-Gordon, H. *et al.* (2024). Public health and climate change: a One Health approach.
11. Kendon, M. *et al.* (2023). State of the UK Climate 2022. *Int. J. Climatol.*, Vol 43, 1–83.
12. Top ten UK's hottest years all since 2002. *Met Office*.
13. New record from July heat. *Met Office*.
14. Christidis, N. *et al.* (2020). The increasing likelihood of temperatures above 30 to 40 °C in the United Kingdom. *Nat. Commun.*, Vol 11, 3093. Nature Publishing Group.
15. Hanlon, H. M. *et al.* (2021). Future changes to high impact weather in the UK. *Clim. Change*, Vol 166, 50.
16. IPCC — Intergovernmental Panel on Climate Change.
17. Masson-Delmotte, V. *et al.* (2023). IPCC, 2021: Summary for Policymakers. Cambridge University Press.
18. Kenny, G. P. *et al.* (2013). Thermometry, calorimetry, and mean body temperature during heat stress. *Compr. Physiol.*, Vol 3, 1689–1719.
19. Baldwin, J. W. *et al.* (2023). Humidity's Role in Heat-Related Health Outcomes: A Heated Debate. *Environ. Health Perspect.*, Vol 131, 055001. Environmental Health Perspectives.
20. (2023). Red Alert: Developing a Human-centred Heat Resilience Strategy. The Physiological Society.
21. Ebi, K. L. *et al.* (2021). Hot weather and heat extremes: health risks. *The Lancet*, Vol 398, 698–708.
22. Flouris, A. D. *et al.* (2018). Workers' health and productivity under occupational heat strain: a systematic review and meta-analysis. *Lancet Planet. Health*, Vol 2, e521–e531.
23. Watts, N. *et al.* (2021). The 2020 report of The Lancet Countdown on health and climate change: responding to converging crises. *Data Explorer*.

24. Hajat, S. *et al.* (2014). Climate change effects on human health: projections of temperature-related mortality for the UK during the 2020s, 2050s and 2080s. *J. Epidemiol. Community Health*, Vol 68, 641–648.
25. Vardoulakis, S. *et al.* (2014). Comparative Assessment of the Effects of Climate Change on Heat- and Cold-Related Mortality in the United Kingdom and Australia. *Environ. Health Perspect.*, Vol 122, 1285–1292. Environmental Health Perspectives.
26. Jenkins, K. *et al.* (2022). Updated projections of UK heat-related mortality using policy-relevant global warming levels and socio-economic scenarios. *Environ. Res. Lett.*, Vol 17, 114036. IOP Publishing.
27. Huang, W. T. K. *et al.* (2022). Non-linear response of temperature-related mortality risk to global warming in England and Wales. *Environ. Res. Lett.*, Vol 17, 034017. IOP Publishing.
28. Cole, R. *et al.* (2023). The contribution of demographic changes to future heat-related health burdens under climate change scenarios. *Environ. Int.*, Vol 173, 107836.
29. (2023). *Health Effects of Climate Change (HECC) in the UK: 2023 report Chapter 2. Temperature effects on mortality in a changing climate*. UKHSA.
30. Williams, L. *et al.* (2019). *Evaluation of the Heatwave Plan for England*. Policy innovation and evaluation reserach unit.
31. *Weather-health alerting system - user guide*. UKHSA, Met Office.
32. Heat mortality monitoring report: 2022. UK Health Security Agency.
33. Excess mortality during heat-periods - Office for National Statistics.
34. Climate-related mortality, England and Wales: 1988 to 2022. *Office for National Statistics*.
35. Climate-related mortality and hospital admissions, England and Wales: 2001 to 2020. *Office for National Statistics*.
36. Smith, S. *et al.* (2016). Estimating the burden of heat illness in England during the 2013 summer heatwave using syndromic surveillance. *J Epidemiol Community Health*, Vol 70, 459–465. BMJ Publishing Group Ltd.
37. Syndromic surveillance summary: 28 July 2022 week 29. *GOV.UK*.
38. Brooks, K. *et al.* (2023). Heatwaves, hospitals and health system resilience in England: a qualitative assessment of frontline perspectives from the hot summer of 2019. *BMJ Open*, Vol 13, e068298.
39. Davey, S. L. *et al.* (2024). Prevalence of occupational heat stress across the seasons and its management amongst healthcare professionals in the UK. *Appl. Ergon.*, Vol 118, 104281.
40. Rizmie, D. *et al.* (2022). Impact of extreme temperatures on emergency hospital admissions by age and socio-economic deprivation in England. *Soc. Sci. Med.*, Vol 308, 115193.
41. Thornes, J. E. *et al.* (2014). Ambulance call-outs and response times in Birmingham and the impact of extreme weather and climate change. *Emerg. Med. J. EMJ*, Vol 31, 220–228.
42. GreenSurg Collaborative (2023). Elective surgical services need to start planning for summer pressures. *Br. J. Surg.*, Vol 110, 508–510.
43. Guy's and St Thomas' NHS Foundation Trust (2023). *Review of the Guy's and St Thomas' IT critical incident final report from the deputy Chief Executive Officer*.
44. Lawrance, E. *et al.* (2023). Ambient temperature and mental health: a systematic review and meta analysis. *e589*, Elsevier.

45. Malcolm, R. A. *et al.* (2018). Passive Heat Exposure Alters Perception and Executive Function. *Front. Physiol.*, Vol 9, Frontiers.
46. Buguet, A. *et al.* (2023). Heatwaves and human sleep: Stress response versus adaptation. *J. Neurol. Sci.*, Vol 454, 120862.
47. Metropolitan Police Data.
48. (2018). Heatwave: Is there more crime in hot weather? *BBC News*.
49. Mahendran, R. *et al.* (2021). Interpersonal violence associated with hot weather. *Lancet Planet. Health*, Vol 5, e571–e572. Elsevier.
50. Heo, S. *et al.* (2024). A nationwide time-series analysis for short-term effects of ambient temperature on violent crime in South Korea. *Sci. Rep.*, Vol 14, 3210. Nature Publishing Group.
51. Kubo, R. *et al.* (2021). Association between ambient temperature and intentional injuries: A case-crossover analysis using ambulance transport records in Japan. *Sci. Total Environ.*, Vol 774, 145511.
52. Tiihonen, J. *et al.* (2017). The Association of Ambient Temperature and Violent Crime. *Sci. Rep.*, Vol 7, 6543. Nature Publishing Group.
53. Stevens, H. R. *et al.* (2024). Associations between violent crime inside and outside, air temperature, urban heat island magnitude and urban green space. *Int. J. Biometeorol.*, Vol 68, 661–673.
54. Heilmann, K. *et al.* (2021). The urban crime and heat gradient in high and low poverty areas. *J. Public Econ.*, Vol 197, 104408.
55. Jonescu, E. *et al.* (2023). How Urban Heat Islands Effect Crime: Understanding the Implications of Temperature, Population Density, and Green Canopy Cover in Shaping Built Environments. in
56. Gamble, J. L. *et al.* (2012). Temperature and violent crime in dallas, Texas: relationships and implications of climate change. *West. J. Emerg. Med.*, Vol 13, 239–246.
57. Hipp, J. R. *et al.* (2004). Crimes of Opportunity or Crimes of Emotion? Testing Two Explanations of Seasonal Change in Crime*. *Soc. Forces*, Vol 82, 1333–1372.
58. Otte im Kampe, E. *et al.* (2016). Impact of high ambient temperature on unintentional injuries in high-income countries: a narrative systematic literature review. *BMJ Open*, Vol 6, e010399.
59. Parsons, N. *et al.* (2011). Modelling the effects of the weather on admissions to UK trauma units: a cross-sectional study. *Emerg. Med. J.*, Vol 28, 851–855. BMJ Publishing Group Ltd and the British Association for Accident & Emergency Medicine.
60. Hills, S. P. *et al.* (2024). Association between air temperature and unintentional drowning risk in the United Kingdom 2012-2019: A nationwide case-crossover study. *Prev. Med.*, Vol 179, 107832.
61. (2023). Public Urged to 'Respect the Water' as Latest Statistics Show 226 Accidental Drownings in 2022, with More Dying at Inland Water than at the Coast. *Royal Life Saving Society UK (RLSS UK)*.
62. Millyard, A. *et al.* (2020). Impairments to Thermoregulation in the Elderly During Heat Exposure Events. *Gerontol. Geriatr. Med.*, Vol 6, 2333721420932432.
63. Smith, C. J. *et al.* (2013). Nonuniform, age-related decrements in regional sweating and skin blood flow. *Am. J. Physiol.-Regul. Integr. Comp. Physiol.*, Vol 305, R877–R885. American Physiological Society.
64. Yu, W. *et al.* (2012). Daily average temperature and mortality among the elderly: a meta-analysis and systematic review of epidemiological evidence. *Int. J. Biometeorol.*, Vol 56, 569–581.

65. Waldock, K. A. M. *et al.* (2018). Physiological and perceptual responses in the elderly to simulated daily living activities in UK summer climatic conditions. *Public Health*, Vol 161, 163–170.
66. Takamata, A. *et al.* (1999). Effect of an exercise-heat acclimation program on body fluid regulatory responses to dehydration in older men. *Am. J. Physiol. - Regul. Integr. Comp. Physiol.*, Vol 277, R1041–R1050.
67. Tsuzuki-Hayakawa, K. *et al.* (1995). Thermoregulation during heat exposure of young children compared to their mothers. *Eur. J. Appl. Physiol.*, Vol 72, 12–17.
68. Tochihara, Y. *et al.* (1995). Thermal responses of 6- to 8-year-old children during immersion of their legs in a hot water bath. *Appl. Hum. Sci. J. Physiol. Anthropol.*, Vol 14, 23–28.
69. Shibasaki, M. *et al.* (1997). Mechanisms of underdeveloped sweating responses in prepubertal boys. *Eur. J. Appl. Physiol.*, Vol 76, 340–345.
70. Shibasaki, M. *et al.* (1999). Relationship between skin blood flow and sweating rate in prepubertal boys and young men. *Acta Physiol. Scand.*, Vol 167, 105–110.
71. Inbar, O. *et al.* (2004). Comparison of thermoregulatory responses to exercise in dry heat among prepubertal boys, young adults and older males. *Exp. Physiol.*, Vol 89, 691–700.
72. Basagaña, X. *et al.* (2011). Heat Waves and Cause-specific Mortality at all Ages. *Epidemiology*, Vol 22, 765.
73. Xu, Z. *et al.* (2014). The impact of heat waves on children's health: a systematic review. *Int. J. Biometeorol.*, Vol 58, 239–247.
74. Berko, J. *et al.* (2014). Deaths attributed to heat, cold, and other weather events in the United States, 2006-2010. *Natl. Health Stat. Rep.*, 1–15.
75. Basu, R. *et al.* (2008). A multicounty analysis identifying the populations vulnerable to mortality associated with high ambient temperature in California. *Am. J. Epidemiol.*, Vol 168, 632–637.
76. Kenny, G. P. *et al.* (2010). Heat stress in older individuals and patients with common chronic diseases. *CMAJ Can. Med. Assoc. J.*, Vol 182, 1053–1060.
77. Bunker, A. *et al.* (2016). Effects of Air Temperature on Climate-Sensitive Mortality and Morbidity Outcomes in the Elderly; a Systematic Review and Meta-analysis of Epidemiological Evidence. *EBioMedicine*, Vol 6, 258–268.
78. José, G.-A. *et al.* (1997). Dehydration markedly impairs cardiovascular function in hyperthermic endurance athletes during exercise. *J. Appl. Physiol.*, Vol 82, 1229–1236. American Physiological Society.
79. Liu, J. *et al.* (2021). Hot weather as a risk factor for kidney disease outcomes: A systematic review and meta-analysis of epidemiological evidence. *Sci. Total Environ.*, Vol 801, 149806.
80. Jankowski, J. *et al.* (2021). Cardiovascular Disease in Chronic Kidney Disease. *Circulation*, Vol 143, 1157–1172.
81. Stansberry, K. B. *et al.* (1997). Impairment of peripheral blood flow responses in diabetes resembles an enhanced aging effect. *Diabetes Care*, Vol 20, 1711–1716.
82. Wick, D. E. *et al.* (2006). Delayed threshold for active cutaneous vasodilation in patients with Type 2 diabetes mellitus. *J. Appl. Physiol. Bethesda Md 1985*, Vol 100, 637–641.
83. Song, X. *et al.* (2021). Impact of short-term exposure to extreme temperatures on diabetes mellitus

morbidity and mortality? A systematic review and meta-analysis. *Environ. Sci. Pollut. Res.*, Vol 28, 58035–58049.
84. Miyamura, K. *et al.* (2022). Association between heat exposure and hospitalization for diabetic ketoacidosis, hyperosmolar hyperglycemic state, and hypoglycemia in Japan. *Environ. Int.*, Vol 167, 107410.
85. (2020). Seizures and hot summers. *Epilepsy Society*.
86. Sisodiya, S. M. *et al.* (2019). Climate change and epilepsy: Time to take action. *Epilepsia Open*, Vol 4, 524–536.
87. Gulcebi, M. I. *et al.* (2021). Climate change and epilepsy: Insights from clinical and basic science studies. *Epilepsy Behav.*, Vol 116, 107791.
88. Gulcebi, M. I. *et al.* (2021). Climate change and epilepsy: Insights from clinical and basic science studies. *Epilepsy Behav.*, Vol 116, 107791.
89. Ferlisi, M. *et al.* (2014). Seizure precipitants (triggering factors) in patients with epilepsy. *Epilepsy Behav.*, Vol 33, 101–105.
90. Hämäläinen, P. *et al.* (2012). The effects of heat stress on cognition in persons with multiple sclerosis. *Mult. Scler. J.*, Vol 18, 489–497. SAGE Publications Ltd STM.
91. Marino, F. E. (2009). Heat reactions in multiple sclerosis: an overlooked paradigm in the study of comparative fatigue. *Int. J. Hyperth. Off. J. Eur. Soc. Hyperthermic Oncol. North Am. Hyperth. Group*, Vol 25, 34–40.
92. Flensner, G. *et al.* (2011). Sensitivity to heat in MS patients: a factor strongly influencing symptomology - an explorative survey. *BMC Neurol.*, Vol 11, 27.
93. Petrilli, S. *et al.* (2004). [Influence of temperature changes on clinical symptoms in multiple sclerosis: an epidemiologic study]. *Ann. Readaptation Med. Phys. Rev. Sci. Soc. Francaise Reeducation Fonct. Readaptation Med. Phys.*, Vol 47, 204–208.
94. Zammit, C. *et al.* (2021). Neurological disorders vis-à-vis climate change. *Early Hum. Dev.*, Vol 155, 105217.
95. Stella, A. B. *et al.* (2023). Climate Change and Global Warming: Are Individuals with Dementia - Including Alzheimer's Disease - At a Higher Risk? *Curr. Alzheimer Res.*, Vol 20, 209–212.
96. Leta, V. *et al.* (2019). Sweating and other thermoregulatory abnormalities in Parkinson's disease: A review. *Ann. Mov. Disord.*, Vol 2, 39.
97. Hunt, A. P. *et al.* (2024). Evidence of heat sensitivity in people with Parkinson's disease. *Int. J. Biometeorol.*,
98. Wee, J. *et al.* (2023). Effects of medications on heat loss capacity in chronic disease patients: health implications amidst global warming. *Pharmacol. Rev.*, American Society for Pharmacology and Experimental Therapeutics.
99. Cheshire, W. P. *et al.* (2008). Drug-Induced Hyperhidrosis and Hypohidrosis. *Drug Saf.*, Vol 31, 109–126.
100. Layton, J. B. *et al.* (2020). Heatwaves, medications, and heat-related hospitalization in older Medicare beneficiaries with chronic conditions. *PLoS ONE*, Vol 15, e0243665.
101. Kenny, G. P. *et al.* (2010). Heat stress in older individuals and patients with common chronic diseases. *CMAJ Can. Med. Assoc. J.*, Vol 182, 1053–1060.
102. Westaway, K. *et al.* (2015). Medicines can affect thermoregulation and accentuate the risk of dehydration and heat-related illness during hot weather. *J. Clin. Pharm. Ther.*, Vol 40, 363–367.
103. Meadows, J. *et al.* (2024). Mental illness and increased vulnerability to negative health effects from

extreme heat events: a systematic review. *Psychiatry Res.*, Vol 332, 115678.
104. Bélanger, D. *et al.* (2014). Perceived Adverse Health Effects of Heat and Their Determinants in Deprived Neighbourhoods: A Cross-Sectional Survey of Nine Cities in Canada. *Int. J. Environ. Res. Public. Health*, Vol 11, 11028–11053. Multidisciplinary Digital Publishing Institute.
105. Larrieu, S. *et al.* (2008). Factors associated with morbidity during the 2003 heat wave in two population-based cohorts of elderly subjects: PAQUID and Three City. *Eur. J. Epidemiol.*, Vol 23, 295–302.
106. Kim, S.-H. *et al.* (2014). The effect of pre-existing medical conditions on heat stroke during hot weather in South Korea. *Environ. Res.*, Vol 133, 246–252.
107. Nitschke, M. *et al.* (2013). Risk Factors, Health Effects and Behaviour in Older People during Extreme Heat: A Survey in South Australia. *Int. J. Environ. Res. Public. Health*, Vol 10, 6721–6733. Multidisciplinary Digital Publishing Institute.
108. Woodland, L. *et al.* (2023). Investigating the Health Impacts of Climate Change among People with Pre-Existing Mental Health Problems: A Scoping Review. *Int. J. Environ. Res. Public. Health*, Vol 20, 5563.
109. Rocklöv, J. *et al.* (2014). Susceptibility to mortality related to temperature and heat and cold wave duration in the population of Stockholm County, Sweden. *Glob. Health Action*, Vol 7, 22737. Taylor & Francis.
110. Zhang, Y. *et al.* (2017). Risk factors for deaths during the 2009 heat wave in Adelaide, Australia: a matched case-control study. *Int. J. Biometeorol.*, Vol 61, 35–47.
111. Vandentorren, S. *et al.* (2006). August 2003 Heat Wave in France: Risk Factors for Death of Elderly People Living at Home. *Eur. J. Public Health*, Vol 16, 583–591.
112. Oudin Åström, D. *et al.* (2015). The effect of heat waves on mortality in susceptible groups: a cohort study of a mediterranean and a northern European City. *Environ. Health*, Vol 14, 30.
113. Stivanello, E. *et al.* (2020). Mental Health Disorders and Summer Temperature-Related Mortality: A Case Crossover Study. *Int. J. Environ. Res. Public. Health*, Vol 17, 9122. Multidisciplinary Digital Publishing Institute.
114. Stafoggia, M. *et al.* (2006). Vulnerability to Heat-Related Mortality: A Multicity, Population-Based, Case-Crossover Analysis. *Epidemiology*, Vol 17, 315.
115. Lee, M. J. *et al.* (2023). Chronic Diseases Associated With Mortality in British Columbia, Canada During the 2021 Western North America Extreme Heat Event. *GeoHealth*, Vol 7, e2022GH000729.
116. Page, L. A. *et al.* (2012). Temperature-related deaths in people with psychosis, dementia and substance misuse. *Br. J. Psychiatry J. Ment. Sci.*, Vol 200, 485–490.
117. Holstein, J. *et al.* (2005). Were less disabled patients the most affected by 2003 heat wave in nursing homes in Paris, France? *J. Public Health*, Vol 27, 359–365.
118. Kovats, R. S. *et al.* (2008). Heat Stress and Public Health: A Critical Review. *Annu. Rev. Public Health*, Vol 29, 41–55. Annual Reviews.
119. Lõhmus, M. (2018). Possible Biological Mechanisms Linking Mental Health and Heat—A Contemplative Review. *Int. J. Environ. Res. Public. Health*, Vol 15, 1515. Multidisciplinary Digital Publishing Institute.
120. Pevalin, D. J. *et al.* (2017). The impact of persistent poor housing conditions on mental health: A

longitudinal population-based study. *Prev. Med.*, Vol 105, 304–310.
121. Gao, J. *et al.* (2019). Ambient temperature, sunlight duration, and suicide: A systematic review and meta-analysis. *Sci. Total Environ.*, Vol 646, 1021–1029.
122. Thompson, R. *et al.* (2018). Associations between high ambient temperatures and heat waves with mental health outcomes: a systematic review. *Public Health*, Vol 161, 171–191.
123. Heo, S. *et al.* (2021). Suicide and Associations with Air Pollution and Ambient Temperature: A Systematic Review and Meta-Analysis. *Int. J. Environ. Res. Public. Health*, Vol 18, 7699. Multidisciplinary Digital Publishing Institute.
124. Frangione, B. *et al.* (2022). Short-term changes in meteorological conditions and suicide: A systematic review and meta-analysis. *Environ. Res.*, Vol 207, 112230.
125. Cornelius, S. L. *et al.* (2021). The Effect of Meteorological, Pollution, and Geographic Exposures on Death by Suicide: A Scoping Review. *Int. J. Environ. Res. Public. Health*, Vol 18, 7809. Multidisciplinary Digital Publishing Institute.
126. Page, L. A. *et al.* (2007). Relationship between daily suicide counts and temperature in England and Wales. *Br. J. Psychiatry J. Ment. Sci.*, Vol 191, 106–112.
127. Thompson, R. *et al.* (2018). Associations between high ambient temperatures and heat waves with mental health outcomes: a systematic review. *Public Health*, Vol 161, 171–191.
128. Liu, J. *et al.* (2021). Is there an association between hot weather and poor mental health outcomes? A systematic review and meta-analysis. *Environ. Int.*, Vol 153, 106533.
129. Lee, H.-C. *et al.* (2007). Seasonal variations in bipolar disorder admissions and the association with climate: A population-based study. *J. Affect. Disord.*, Vol 97, 61–69.
130. Shapira, A. *et al.* (2004). Admission rates of bipolar depressed patients increase during spring/summer and correlate with maximal environmental temperature. *Bipolar Disord.*, Vol 6, 90–93.
131. Sung, T.-I. *et al.* (2013). A positive relationship between ambient temperature and bipolar disorder identified using a national cohort of psychiatric inpatients. *Soc. Psychiatry Psychiatr. Epidemiol.*, Vol 48, 295–302.
132. Hansen, A. L. *et al.* (2008). The Effect of Heatwaves on Mental Health in a Temperate Australian City. *Epidemiology*, Vol 19, S85.
133. Shiloh, R. *et al.* (2005). Effects of climate on admission rates of schizophrenia patients to psychiatric hospitals. *Eur. Psychiatry*, Vol 20, 61–64.
134. McWilliams, S. *et al.* (2014). Daily weather variables and affective disorder admissions to psychiatric hospitals. *Int. J. Biometeorol.*, Vol 58, 2045–2057.
135. Berry, H. L. *et al.* (2010). Climate change and mental health: a causal pathways framework. *Int. J. Public Health*, Vol 55, 123–132.
136. Preterm birth. *World Health Organization*.
137. Bonell, A. *et al.* (2024). An expert review of environmental heat exposure and stillbirth in the face of climate change: Clinical implications and priority issues. *BJOG Int. J. Obstet. Gynaecol.*, Vol 131, 623–631.
138. Chersich, M. F. *et al.* (2020). Associations between high temperatures in pregnancy and risk of preterm birth, low birth weight, and stillbirths: systematic review and meta-analysis. *BMJ*, Vol 371, m3811. British Medical Journal Publishing Group.
139. Bekkar, B. *et al.* (2020). Association of Air Pollution and Heat Exposure

With Preterm Birth, Low Birth Weight, and Stillbirth in the US: A Systematic Review. *JAMA Netw. Open*, Vol 3, e208243.
140. Syed, S. *et al.* (2022). Extreme Heat and Pregnancy Outcomes: A Scoping Review of the Epidemiological Evidence. *Int. J. Environ. Res. Public. Health*, Vol 19, 2412. Multidisciplinary Digital Publishing Institute.
141. Kuehn, L. *et al.* (2017). Heat Exposure and Maternal Health in the Face of Climate Change. *Int. J. Environ. Res. Public. Health*, Vol 14, 853. Multidisciplinary Digital Publishing Institute.
142. Sexton, J. *et al.* (2021). Systematic review of ambient temperature exposure during pregnancy and stillbirth: Methods and evidence. *Environ. Res.*, Vol 197, 111037.
143. Baharav, Y. *et al.* (2023). The Impact of Extreme Heat Exposure on Pregnant People and Neonates: A State of the Science Review. *J. Midwifery Womens Health*, Vol 68, 324–332.
144. Part, C. *et al.* (2022). Ambient temperature during pregnancy and risk of maternal hypertensive disorders: A time-to-event study in Johannesburg, South Africa. *Environ. Res.*, Vol 212, 113596.
145. Smallcombe, J. W. *et al.* (2021). Thermoregulation During Pregnancy: a Controlled Trial Investigating the Risk of Maternal Hyperthermia During Exercise in the Heat. *Sports Med.*, Vol 51, 2655–2664.
146. Samuels, L. *et al.* (2022). Physiological mechanisms of the impact of heat during pregnancy and the clinical implications: review of the evidence from an expert group meeting. *Int. J. Biometeorol.*, Vol 66, 1505–1513.
147. Garcia, C. K. *et al.* (2022). Exertional heat stroke: pathophysiology and risk factors. *BMJ Med.*, Vol 1, e000239.
148. Bouchama, A. *et al.* (2022). Classic and exertional heatstroke. *Nat. Rev. Dis. Primer*, Vol 8, 1–23. Nature Publishing Group.
149. Stacey, M. J. *et al.* (2015). Susceptibility to exertional heat illness and hospitalisation risk in UK military personnel. *BMJ Open Sport Exerc. Med.*, Vol 1, e000055. BMJ Specialist Journals.
150. Moore, A. C. *et al.* (2016). Risk factors for heat illness among British soldiers in the hot Collective Training Environment. *J. R. Army Med. Corps*, Vol 162, 434–439.
151. Yoda, T. *et al.* (2005). Effects of alcohol on thermoregulation during mild heat exposure in humans. *Alcohol Fayettev. N*, Vol 36, 195–200.
152. Allison, T. G. *et al.* (1992). Thermoregulatory, cardiovascular, and psychophysical response to alcohol in men in 40 degrees C water. *J. Appl. Physiol. Bethesda Md 1985*, Vol 72, 2099–2107.
153. Cusack, L. *et al.* (2011). Heatwaves and their impact on people with alcohol, drug and mental health conditions: a discussion paper on clinical practice considerations. *J. Adv. Nurs.*, Vol 67, 915–922.
154. Crandall, C. G. *et al.* (2002). Mechanism of cocaine-induced hyperthermia in humans. *Ann. Intern. Med.*, Vol 136, 785–791.
155. Levine, M. *et al.* (2012). Influence of Drug Use on Morbidity and Mortality in Heatstroke. *J. Med. Toxicol.*, Vol 8, 252–257.
156. (2021). *Statistical Digest of Rural England: Population*. Department for Environment, Food & Rural Affairs.
157. United Nations (2018). World Urbanization Prospects - Population Division.
158. Oke, T. R. (1982). The energetic basis of the urban heat island. *Q. J. R. Meteorol. Soc.*, Vol 108, 1–24.
159. Met Office (2022). How can we respond to the dangers of extreme

heat in UK cities? *Official blog of the Met Office news team*.
160. Arnfield, A. J. (2003). Two decades of urban climate research: a review of turbulence, exchanges of energy and water, and the urban heat island. *Int. J. Climatol.*, Vol 23, 1–26.
161. Smith, C. L. *et al.* (2011). Fine-scale spatial temperature patterns across a UK conurbation. *Clim. Change*, Vol 109, 269–286.
162. Heaviside, C. *et al.* (2017). The Urban Heat Island: Implications for Health in a Changing Environment. *Curr. Environ. Health Rep.*, Vol 4, 296–305.
163. Li, D. *et al.* (2013). Synergistic Interactions between Urban Heat Islands and Heat Waves: The Impact in Cities Is Larger than the Sum of Its Parts. *J. Appl. Meteorol. Climatol.*, Vol 52, 2051–2064. American Meteorological Society.
164. Heaviside, C. *et al.* (2016). Attribution of mortality to the urban heat island during heatwaves in the West Midlands, UK. *Environ. Health*, Vol 15, S27.
165. Turning up the heat: learning from the summer 2022 heatwaves in England to inform UK policy on extreme heat.
166. Bouhi, N. *et al.* (2022). *Addressing overheating risk in existing UK homes*. Arup.
167. Lomas, K. *et al.* (2021). Dwelling and household characteristics' influence on reported and measured summertime overheating: a glimpse of a mild climate in the 2050's. Loughborough University.
168. Morris, N. B. *et al.* (2021). The HEAT-SHIELD project — Perspectives from an inter-sectoral approach to occupational heat stress. *J. Sci. Med. Sport*, Vol 24, 747–755.
169. Kovats, S. *et al.* (2021). *The Third UK Climate Change Risk Assessment Technical Report: Health, Communities and the Built Environment*.
170. Oikonomou, E. *et al.* (2012). Modelling the relative importance of the urban heat island and the thermal quality of dwellings for overheating in London. *Build. Environ.*, Vol 57, 223–238.
171. Vardoulakis, S. *et al.* (2015). Impact of climate change on the domestic indoor environment and associated health risks in the UK. *Environ. Int.*, Vol 85, 299–313.
172. Mavrogianni, A. *et al.* (2012). Building characteristics as determinants of propensity to high indoor summer temperatures in London dwellings. *Build. Environ.*, Vol 55, 117–130.
173. (2021). *Energy Follow Up Survey: thermal comfort, damp and ventilation*. Department for Business Energy and Industrial Strategy.
174. Gupta, R. *et al.* (2019). Meta-analysis of summertime indoor temperatures in new-build, retrofitted, and existing UK dwellings. *Sci. Technol. Built Environ.*, Vol 25, 1212–1225. Taylor & Francis.
175. (2024). Heat resilience and sustainable cooling. Environmental Audit Committee.
176. Mavrogianni, A. *et al.* (2017). Inhabitant actions and summer overheating risk in London dwellings. *Build. Res. Inf.*, Vol 45, 119–142.
177. Gupta, R. *et al.* (2017). Overheating in care settings: magnitude, causes, preparedness and remedies. *Build. Res. Inf.*, Vol 45, 83–101. Routledge.
178. Yi, C. yoon *et al.* (2022). Thermal comfort modelling of older people living in care homes: An evaluation of heat balance, adaptive comfort, and thermographic methods. *Build. Environ.*, Vol 207, 108550.
179. Thompson, R. *et al.* (2022). Heatwave Mortality in Summer 2020 in England: An Observational Study.

Int. J. Environ. Res. Public. Health, Vol 19, 6123.
180. Kovats, R. S. *et al.* (2006). Mortality in southern England during the 2003 heat wave by place of death. *Health Stat. Q.*, 6–8.
181. London City Hall (2020). How Schools and Early Years Settings can Adapt to Climate Change.
182. Park, R. J. *et al.* (2021). Learning is inhibited by heat exposure, both internationally and within the United States. *Nat. Hum. Behav.*, Vol 5, 19–27. Nature Publishing Group.
183. The Ministry of Justice: Environmental Sustainability. Environmental Audit Committee - House of Commons.
184. Marí-Dell'Olmo, M. *et al.* (2019). Social inequalities in the association between temperature and mortality in a South European context. *Int. J. Public Health*, Vol 64, 27–37.
185. Ellena, M. *et al.* (2020). Social inequalities in heat-attributable mortality in the city of Turin, northwest of Italy: a time series analysis from 1982 to 2018. *Environ. Health*, Vol 19, 116.
186. Luanaigh, C. O. *et al.* (2008). Loneliness and the health of older people. *Int. J. Geriatr. Psychiatry*, Vol 23, 1213–1221.
187. Orlando, S. *et al.* (2021). The Effectiveness of Intervening on Social Isolation to Reduce Mortality during Heat Waves in Aged Population: A Retrospective Ecological Study. *Int. J. Environ. Res. Public. Health*, Vol 18, 11587.
188. Lloyd, S. J. *et al.* (2023). The Direct and Indirect Influences of Interrelated Regional-Level Sociodemographic Factors on Heat-Attributable Mortality in Europe: Insights for Adaptation Strategies. *Environ. Health Perspect.*, Vol 131, 087013.
189. What Are Health Inequalities? *The King's Fund*.
190. Blake, E. *et al.* (2024). Urban outdoor air quality.
191. (2017). Chapter 5: inequality in health. *GOV.UK*.
192. State of the environment: health, people and the environment. *GOV.UK*.
193. Rizmie, D. *et al.* (2022). Impact of extreme temperatures on emergency hospital admissions by age and socio-economic deprivation in England. *Soc. Sci. Med.*, Vol 308, 115193.
194. Murage, P. *et al.* (2020). What individual and neighbourhood-level factors increase the risk of heat-related mortality? A case-crossover study of over 185,000 deaths in London using high-resolution climate datasets. *Environ. Int.*, Vol 134, 105292.
195. Wan, K. *et al.* (2022). Temperature-related mortality and associated vulnerabilities: evidence from Scotland using extended time-series datasets. *Environ. Health*, Vol 21, 99.
196. Gasparrini, A. *et al.* (2022). Small-area assessment of temperature-related mortality risks in England and Wales: a case time series analysis. *Lancet Planet. Health*, Vol 6, e557–e564. Elsevier.
197. Son, J.-Y. *et al.* (2019). Temperature-related mortality: a systematic review and investigation of effect modifiers. *Environ. Res. Lett.*, Vol 14, 073004. IOP Publishing.
198. Kidd, S. A. *et al.* (2023). A response framework for addressing the risks of climate change for homeless populations. *Clim. Policy*, Vol 23, 623–636.
199. Hajat, S. *et al.* (2023). Ambient Temperature and Emergency Hospital Admissions in People Experiencing Homelessness: London, United Kingdom, 2011-2019. *Am. J. Public Health*, Vol 113, 981–984.
200. Red Cross (2020). Heat wave guide for cities.

201. (2023). *Adverse Weather Health Plan*. UK Health Security Agency.
202. (2023). The Third National Adaptation Programme (NAP3) and the Fourth Strategy for Climate Adaptation Reporting.
203. (2022). UK Climate Change Risk Assessment 2022.
204. (2023). *Health Effects of Climate Change (HECC) in the UK: 2023 report*. UK Health Security Agency.
205. Paul Watkiss Associates (2021). *Monetary Valuation of Risks and Opportunities in CCRA3*.
206. What are the National Severe Weather Warning Service Impact tables? *Met Office*.
207. Heat-health Alert service. *Met Office*.
208. Yi, C. *et al.* (2023). Modelling urban dwellers' indoor heat stress to enhance heat-health warning and planning. *Build. Environ.*, Vol 243, 110623.
209. (2024). Beat the heat: hot weather advice. *GOV.UK*.
210. McLoughlin, N. *et al.* (2023). Changing behavioral responses to heat risk in a warming world: How can communication approaches be improved? *WIREs Clim. Change*, Vol 14, e819.
211. UK heatwave risk report. *British Red Cross*.
212. Met Office should name heatwaves to convey their dangers. *Grantham Research Institute on climate change and the environment*.
213. Name heatwaves as part of early warning system to save lives. *The Physiological Society*.
214. (2022). WMO has no immediate plans to name heatwaves. *World Meteorological Organization*.
215. The Keep Bristol Cool mapping tool. *Bristol City Council*.
216. (2019). UK housing: Fit for the future? Committee on Climate Change.
217. (2021). Heat and buildings strategy. Department for Energy Security and Net Zero and Department for Business, Energy & Industrial Strategy.
218. (2021). Overheating: Approved Document O.
219. (2022). Independent Assessment: The UK's Heat and Buildings Strategy.
220. Climate Change Mitigation. *UKGBC*.
221. The Future Homes and Buildings Standards: 2023 consultation. *GOV.UK*.
222. (2018). *Energy Assessment Guidance*. Mayor of London.
223. (2021). *Cooling in the UK*. Department for Business Energy and Industrial Strategy.
224. Caio, A. *et al.* (2024). Sustainable cooling.
225. (2023). How nature can help cities fend off record-smashing heat. *UNEP*.
226. (2023). Nature-based solutions play crucial role in building Europe's climate resilience.
227. Sahani, J. *et al.* (2023). Efficacy assessment of green-blue nature-based solutions against environmental heat mitigation. *Environ. Int.*, Vol 179, 108187.
228. (2023). Progress in adapting to climate change - 2023 Report to Parliament. Climate Change Committee.
229. (2023). Environmental Improvement Plan 2023. Department for Environment, Food & Rural Affairs.
230. (2019). Urban Tree Challenge Fund. Forestry Commission.
231. (2021). Launch of the England Trees Action Plan – Forestry Commission.
232. Natural England (2023). Green Infrastructure.
233. (2023). Urban Green Spaces.
234. London City Hall Cool Spaces.
235. NHS England (2022). Emergency preparedness, resilience and response: core standards.
236. Heat-Health Alert action card for health and social care providers. *GOV.UK*.

237. NHS England (2021). How to produce a Green Plan: A three year strategy towards net-zero.
238. (2022). *The NHSPS Green Plan*. NHS Property Services.
239. NHS England (2023). NHS Net Zero Building Standard.
240. NHS England (2021). Health and care adaptation reports.
241. (2024). Recommendations for health and safety amidst heatwaves | International Labour Organization.
242. (2019). *Health & Safety Guidance - Temperature at Work*. Unite the Union.
243. Tham, S. *et al.* (2020). Indoor temperature and health: a global systematic review. *Public Health*, Vol 179, 9–17.
244. 14:00-17:00 ISO 8025:2024. *ISO*.
245. UK heatwave risk report. *British Red Cross*.
246. First phase of Heat-Cool initiative successfully completed | University of Surrey.
247. Climate Impacts Awards. *Wellcome*.
248. Find grants awarded | Grant Funding. *Wellcome*.
249. (2024). Realising the health co-benefits of the transition to net zero: invited stage two.
250. (2023). Addressing environmental challenges: NERC highlight topics 2023.
251. (2023). Maximising UK adaptation to climate change hub.
252. (2024). Maximising UK adaptation to climate change research projects.
253. The NIHR Health Protection Research Unit in Environmental Change and Health | LSHTM.
254. MCC Collaborative Research Network. *MCC Collaborative Research Network*.
255. RECLAIM - Reclaiming Forgotten Cities - Turning cities from vulnerable spaces to healthy places for people. *RECLAIM*.
256. Howarth, C. (2024). Preparing for heat risk is complex: Aligning adaptation and mitigation is essential. *PLOS Clim.*, Vol 3, e0000371. Public Library of Science.
257. (2024). Third National Adaptation Programme (NAP3). *GOV.UK*.
258. Heat resilience and sustainable cooling: Government Response to the Committee's Fifth Report - Environmental Audit Committee.
259. (2023). Climate and health security: Looking ahead to 2023 – UK Health Security Agency.

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