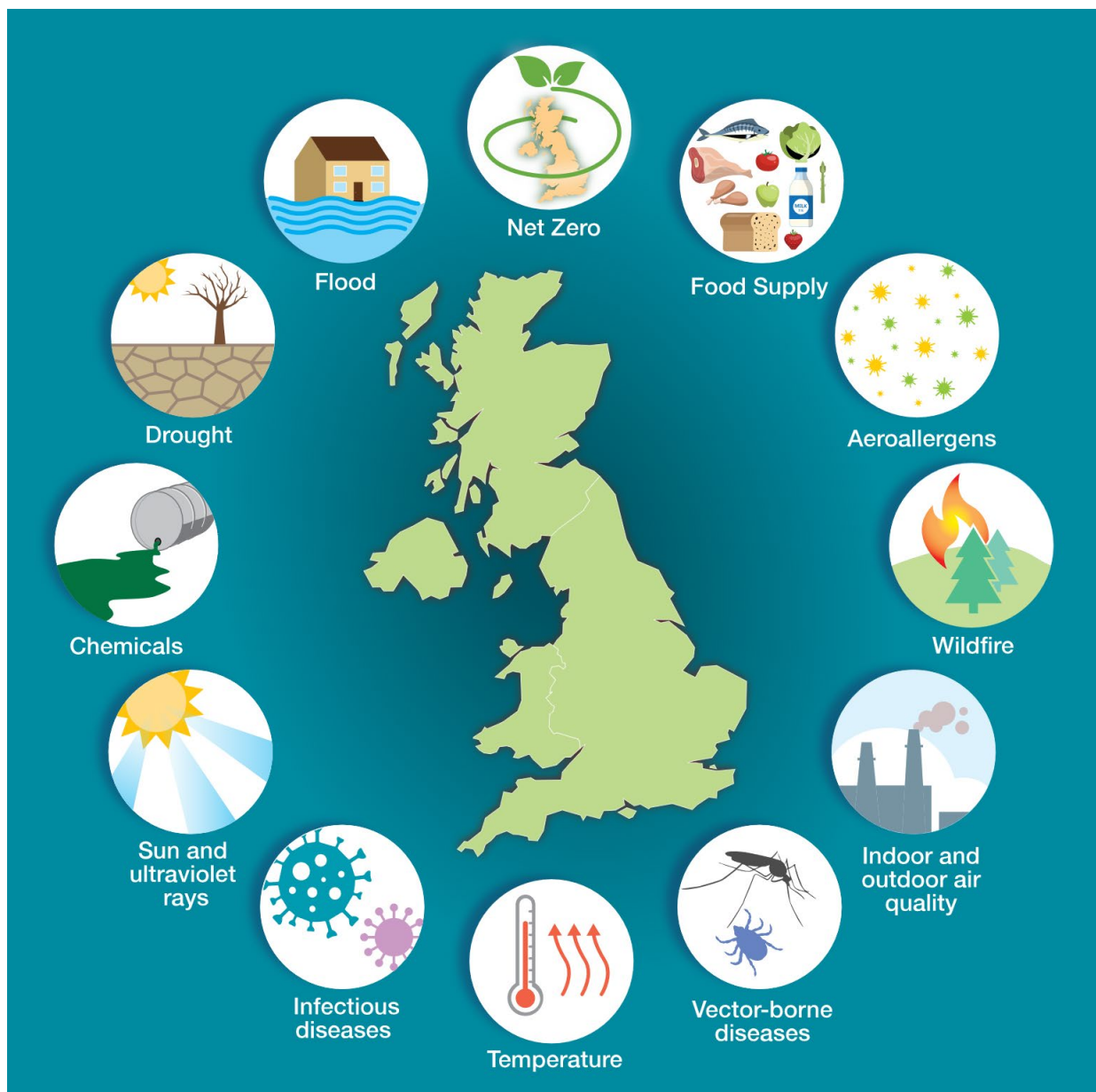




UK Health
Security
Agency

Health Effects of Climate Change (HECC) in the UK

State of the evidence 2023



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Foreword

Our changing climate poses one of the greatest health security and societal challenges, impacting everything from the air we breathe to the quality and availability of our food and water.

Climate change is increasing the frequency and intensity of environmental health threats like flooding and heatwaves and is creating conditions which heighten the risks from infectious diseases.

Climate change is now the context in which we will need to protect health from environmental hazards and infectious diseases and will determine future risks to health including new challenges such as wildfires and droughts and growing problems such as antimicrobial resistance or future pandemics.

And we must understand that whilst everyone will be at some risk from adverse health impacts from climate change, the impacts will vary at individual level and the most disadvantaged both here in the UK and around the world will be disproportionately affected.

While we are already experiencing some of these impacts, it is very important to understand that many of the anticipated adverse health impacts of climate change in the UK are still avoidable through mitigation and adaptation and that there are other benefits to health to be gained, therefore rapid action is critical to avoid the most severe potential scenarios outlined in this report and realise other benefits to health from mitigation and adaptation measures.

To secure health we need to understand both the impacts of climate change on health but also, importantly, effective interventions to protect health. The Health Effects of Climate Change in the UK report brings together up to date evidence to inform policies and actions to secure health. Since the last summary of evidence was published in 2012 there has been extensive growth in the evidence and this report collates it and provides the most up-to-date analyses using the most recent UK Climate Projections, published in 2018.

The UK Health Security Agency (UKHSA) is keeping the growing and harmful health impacts of climate change at the forefront of our preparedness efforts, and as part of our commitment under the UK Government's Second National Adaptation Plan (NAP), our Centre for Climate and Health Security (CCHS) has led on the development of this report, which brings together 15 independent chapters written by 90 experts from UK and international academic and research institutes, as well as teams from across UKHSA.

I would like to take this opportunity to thank the many people who have contributed to this report; our invaluable scientific and academic partners, and the co-ordinating team who worked tirelessly to bring the document together.

Whether you work in local or national government, health or social care, academia, the private or voluntary sectors, this report provides you with a synthesis of up-to-date scientific evidence that should inform future work around climate change, both from a policy and research perspective.

UKHSA has delivered a step-change in its preparedness through the establishment of the CCHS in October 2022, which will lead and coordinate efforts to protect health in the context of our changing climate both domestically and internationally. We are continuing to assess where we can have the greatest impact overseas, and the results of this engagement work will feed into our next business plan.

There is much we can do to avert and prevent the adverse health impacts from climate change on health, and action is needed now to adapt our policies, environments and our behaviours to secure health, wellbeing and livelihoods.

The establishment of the CCHS brings together the relevant fields of expertise across the Agency to address these issues, and we will continue to work closely with academia, local authorities, public sector organisations and international partners to strengthen the evidence base and take the necessary action.

Professor Isabel Oliver, Chief Scientific Officer, UKHSA

Overview chapter

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1. The climate crisis is a health crisis

1.1 Why climate change matters for health

Our changing climate will be the backdrop upon which our governments and health and social care organisations will need to ensure health security in the 21st century. This includes not only how to maintain and improve health as the UK decarbonises and transitions to net zero, but also how we will collectively prepare for, respond, and adapt to the health implications of increasing global temperatures.

Climate change affects most health determinants directly or indirectly by influencing the weather conditions we experience on a day-to-day basis. Climate change can increase risks to health directly through greater severity and frequency of extreme weather events such as flooding, drought, heatwaves or wildfires. Heatwaves, for example, have already led to excess deaths in England and they can increase burden on health and care services, increase strain on water, energy and transportation infrastructure and can have implications such as crop loss and reduced air quality that can also impact health. Many infectious diseases are highly climate sensitive, and with warmer temperatures we can expect an increased risk of new and emerging infectious diseases in the UK, including those transmitted through mosquito and tick bites. The impact of climate change on individuals will vary, with the worst effects on disadvantaged and vulnerable populations, which could widen health inequalities further.

Climate impacts outside of the UK can also affect our health. Weather extremes in the countries we import food from can disrupt food supply chains, the availability of foods highly sensitive to climate and potentially impact on food safety, while climate change impacts abroad may increase migration to the UK. The challenge for policy-makers and health and care professionals is understanding the extent to which climate change will affect different aspects of health as well as our health and care systems. All of the global health indicators monitored by the Lancet Countdown¹ are being undermined by climate change, increasing the fragility of the global systems that health depends on, and increasing the vulnerability of populations to coexisting geopolitical, energy, and cost-of-living crises (1). Climate change can result in political and social instability, leading to multi-region and cascading impacts across the globe, with implications for health security. Risks could also arise from low-probability, high-impact events such as climate tipping points (for example the collapse of the West Antarctic ice sheet and associated rapid sea-level rise).

In the UK, the impact of climate change will be costly to society and the NHS. The total costs of heat-related mortalities from climate change and related socio-economic change in England

¹ The Lancet Countdown is an international, multidisciplinary collaboration to monitor health and climate change. The annual Countdown report provides an independent assessment of progress towards the Paris Agreement goals.

have been estimated at approximately £6.8 billion per year in the 2020s, rising to £14.7 billion per year in the 2050s (using a medium-warming scenario and including treatment and resource costs, opportunity costs due to lost productivity and lost value of a life) (2).

1.2 A changing climate

Climate change is no longer a theoretical, future threat but an emerging reality, with impacts already being felt domestically and globally. The evidence indicates that extreme weather events are occurring more frequently due to warming global temperatures. These include recent severe flooding (Australia, Brazil, China, western Europe, Malaysia, Pakistan, South Africa, and South Sudan), wildfires (Canada, USA, Greece, Algeria, Italy, Spain, and Türkiye) and record temperatures (Australia, Canada, India, Italy, Oman, Türkiye, Pakistan, and the UK). Regardless of progress on global decarbonisation, temperatures will continue to rise because of the effects of greenhouse gases that have already been emitted. Under optimistic scenarios of low warming, temperatures will likely peak mid- to late-century, coinciding with the working age years of a child born today. The decisions made today will determine the severity and extent of climate impacts inherited by today's young people and their children.

The severity of climate change impacts will be highly dependent on how much warming occurs. The United Nations Framework Convention on Climate Change (UNFCCC) established the goal of limiting warming to below 1.5°C (no higher than 2°C) above the historic average. Beyond these temperatures, many ecological and human systems are expected to pass thresholds for unacceptable or irreversible impacts. The global average temperature passed 1°C above the pre-industrial average around 2017, with 1.5°C widely expected to be surpassed in the next 5 to 10 years. Current global actions and policies to reduce or remove greenhouse gases emitted into the atmosphere (termed 'decarbonisation') put us on a collective trajectory closer to 2°C to 3°C warming, with projections of over 4°C considered a plausible worst-case scenario.

In the UK, winters will become warmer and wetter, summers will become drier, and sea levels will continue to rise (Chapter 1). Although summers in the UK will become drier, the rain that does fall is more likely to occur in heavy rainfall events. There will still be cold snaps and cool summers or winters as weather varies between years and geographically, but these will be less common as climate change progresses. These trends are already underway: the current UK climate is warmer, wetter and sunnier than was typical during the 20th century.

1.3 Health co-benefits and opportunities

Many of the anticipated adverse health impacts of climate change in the UK are still avoidable through climate change mitigation measures and others are preventable at lower levels of warming through effective adaptation. In addition, there are some potential benefits and opportunities for health. Warmer winters will reduce health risks due to extreme cold (though risks from moderate cold remain) and there may be some benefits to agricultural production for certain crops. The extent to which health benefits can be gained from climate change will largely

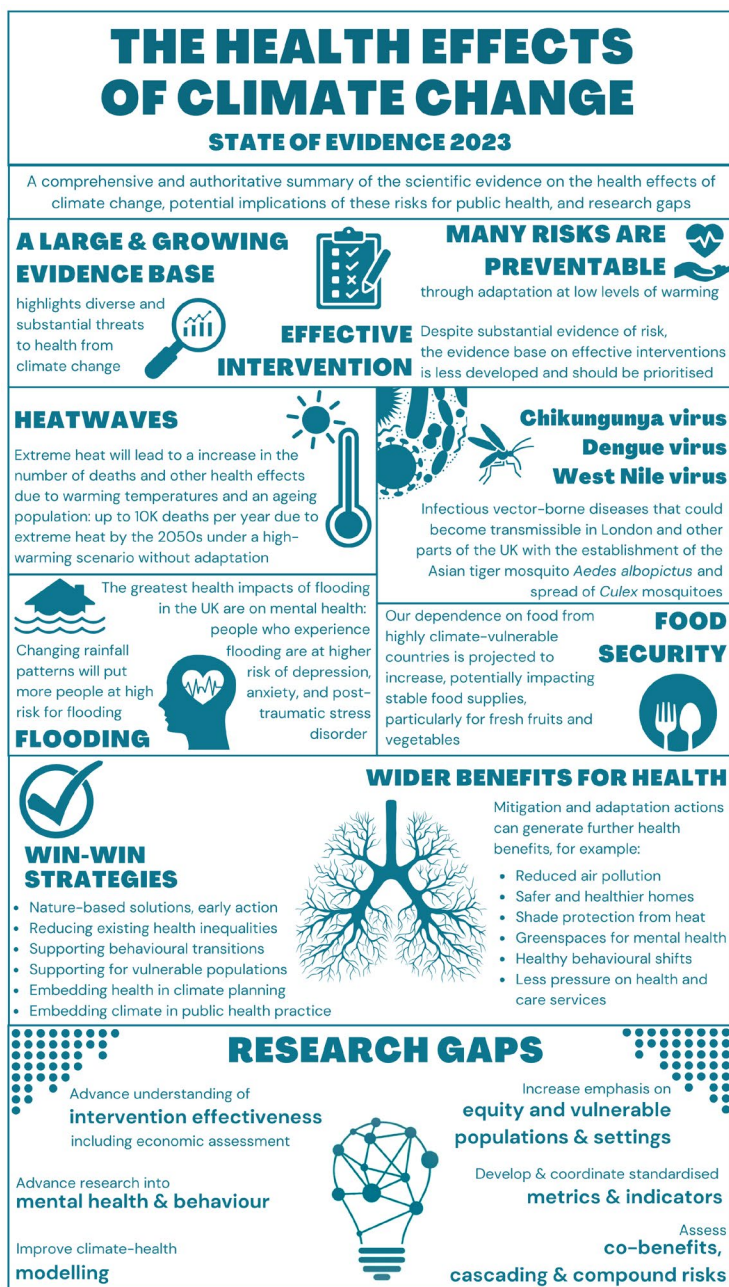
depend on if, how, and how fast the UK and its health and care systems adapt to changing temperatures.

However, the greatest opportunity for health benefits in the context of climate change comes from the potential to align health goals with the UK's decarbonisation agenda. If health considerations are embedded in decarbonisation strategies (such as through prioritisation and planning), there is the potential to generate a range of health benefits, particularly through air quality, food, housing, transport, green space, improved mental and physical health and reducing health inequalities (Chapter 14).

2. About this report

This report provides an authoritative summary of the scientific evidence on the health effects of climate change, potential implications for public health, and gaps in evidence. The report is primarily a scientific and technical document that collates up-to-date knowledge to inform policy and action in the UK. The report also acts as a resource for public health and other professional bodies and groups, government departments and authorities, science-facing civil society organisations, and interested stakeholders and partners with a role in securing health from the effects of climate change. Figure 1 provides an infographic summary showing the key elements and messages within this report.

Figure 1. Infographic summary of key messages within the report



Text version of Figure 1.

The 'Health Effects of Climate Change in the UK report' is a comprehensive and authoritative summary of the scientific evidence on the health effects of climate change, research gaps and potential implications of these risks for public health. There is a large and growing evidence base which highlights diverse and substantial threats to health from climate change. Many risks are preventable through adaptation at low levels of warming. Despite the substantial evidence of risk, the evidence base on effective interventions is less developed and should be prioritised.

Extreme heat will lead to an increase in the number of deaths and other health effects due to warming temperatures and an aging population. Up to 10,000 deaths per year due to extreme heat by the 2050s under a high-warming scenario without adaptation have been estimated.

Vector-borne diseases (such as chikungunya, dengue and Zika viruses) could become transmissible in London and other parts of the UK due to the establishment of *Aedes albopictus* and spread of *Culex* mosquitoes.

More people will be at high risk of flooding in future due to changing rainfall patterns. The greatest health impacts of flooding in the UK are on mental health: people who experience flooding are at higher risk of depression, anxiety and post-traumatic stress disorder.

Our dependence on food from highly climate-vulnerable countries is projected to increase, potentially impacting stable food supplies, particularly for fresh fruit and vegetables.

There are win-win strategies including nature-based solutions, reducing existing health inequalities, supporting behavioural transitions, supporting vulnerable populations, embedding health in climate planning and embedding climate in public health practice. There are also wider benefits to health of mitigation and adaptation actions, such as reduced air pollution, safer and healthier homes, shade protection from heat, greenspaces for mental health, healthy behaviour shifts and less pressure on health and care services.

The report highlights research gaps, including advancing understanding of intervention effectiveness (including economic assessment), advancing research into mental health and behaviour, improving climate-health modelling, increasing emphasis on equity and vulnerable population settings, developing and co-ordinating standardised metrics and indicators, and assess co-benefits and cascading and compound risks.

End of text version of Figure 1.

2.1 Previous reports

There have been 3 reports on the Health Effects of Climate Change in the UK (HECC) published in the past. The first report was published in 2002 (3), with an update published in

2008 (4). The 2012 edition used updated climate projections for the UK (UK Climate Projections 2009 (UKCP09)) (5). Since then, there has been extensive growth in the evidence of the health effects of climate change. This fourth report collates up-to-date evidence and analyses of the impact of climate change on public health within the UK, using the most recent climate change projections (UK Climate Projections 2018; UKCP18) (6) and scientific evidence and includes other emerging risks for the first time.

2.2 Legislative and jurisdictional context

Under the Climate Change Act (2008), 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, the second (CCRA2) in 2018 and the third (CCRA3) in 2023 (7). The National Adaptation Programme (NAP) sets out actions that the UK will take to adapt to climate change over the following 5 years; the third NAP was published in 2023 (8) and details the government's response to the risks and opportunities identified in the CCRA3. The third NAP "covers areas falling within scope of the UK government's responsibilities in relation to England, and its non-devolved functions in relation to the rest of the UK" (8).

The Climate Change Act and the Climate Change (Scotland) Act require the devolved governments to have their own plans for climate adaptation. Northern Ireland's second Climate Change Adaptation Programme (NICCAP2) was published in September 2019, covering a 5-year period (9). It responds to the risks and opportunities relevant to Northern Ireland in the CCRA2, with a focus on the most urgent risks. The second Scottish Climate Change Adaptation Programme (SCCAP2) was published in 2019 and also covers a 5-year period (10). It addresses the risks set out in CCRA2, and takes an outcomes-based approach, derived from both the UN Sustainable Development Goals and Scotland's National Performance Framework; a progress report is published each year (for example, 11, 12). The Welsh government published their climate change adaptation plan 'Prosperity for All: A Climate Conscious Wales' in 2019, which set out the actions to be taken during 2020 to 2025 (13). A progress report was published in 2022 including some additional sections in response to the increased risk levels identified in the third Climate Change Risk Assessment (CCRA3).

The 2023 HECC report delivers UKHSA's commitment under NAP2 to strengthen the evidence base for impacts of climate change on health using the most recent climate projections for the UK (UKCP18) (14). Within the UK, the devolved governments have produced resources related to climate change and health which are specific to their nations. In Scotland, the 'Place Standard with a Climate Lens' tool was published in 2022 (15), which is in support of the SCCAP2 outcome 'our communities are inclusive, empowered, resilient and safe in response to the changing climate' (12). The tool helps local communities understand how climate change and the net zero transition might affect them, as well as supporting people to design their future communities with climate in mind (15). The Welsh government published its climate change health impact assessment report in July 2023, which is a strategic and comprehensive appraisal of the potential impact of climate change on population health in Wales (16).

In the UK, health is a devolved responsibility, meaning that the structure of the health system, from national to local level, differs between the 4 nations that make up the UK. Therefore, evidence presented for England might not be applicable to the other nations, and this also applies to relevant legislation, policies and plans. This report covers the whole of the UK because the effects of climate change on public health will be broadly similar in England, Scotland, Wales and Northern Ireland. However, the research and public health considerations made at the end of each of the chapters are those of the authors and do not constitute a 4 nations policy statement. Whilst health and social care are devolved matters, climate risks are complex interactions. Some of the legislative and policy levers that can influence the wider determinants of population health, wellbeing and equity, that directly and indirectly influence climate exposures and vulnerabilities, for example macroeconomic and fiscal policy, trade and international trade, and energy, are matters reserved to the UK government. Other adaptation actions are the responsibility of regional or local authorities, industry or other sectors.

2.3 Developing the report

UKHSA has led on the development of this report which brings together 15 independent chapters written by 90 experts from UK and international academic and research institutions and UKHSA, covering a range of disciplines related to climate change and public health. The scope of the report was developed by UKHSA climate and health experts based on previous reports and emerging evidence. Reflecting a growing evidence base and a shift from a problem-based framing towards a solutions-based framing, 5 new chapters are included. Authors were invited to contribute to the report due to their expertise and experience in climate health impact assessment. All chapters were independently developed and written by author teams and have been peer-reviewed by at least 2 independent scientific topic experts.

The report was edited by leading scientists within the UKHSA's Centre for Climate and Health Security. All chapters are preceded by a summary written by the editors to provide a synthesis of evidence, main messages, key implications for public health and research needs. While each chapter presents independent scientific analysis from teams of expert authors, the chapter summaries are designed to provide a consistent and over-arching narrative across the report.

Whilst this is an updated version of 3 previous reports ([3 to 5](#)), this report is a stand-alone document. It provides a review, analysis, discussion and outline of implications of published scientific evidence on the health impacts of climate change in the UK. New evidence on direct and indirect effects of climate change on human health has become available through CCRA3 (a requirement of the Climate Change Act 2008) published in 2021 ([7](#)), and other independent research studies.

Chapters include a combination of new empirical analyses and synthesis of new evidence. Where climate projections are included in analyses, these are consistent in the use of the most updated climate data (UKCP18), using RCP8.5, a high-end warming scenario consistent with approximately 4.3°C of warming, or a 'worst-case scenario'. Ideally, analyses would consider a

range of warming scenarios, including +1.5°C, +2°C, and +3°C above pre-industrial temperatures to allow assessment of health impacts at different levels of warming. Unfortunately, climate projection data was not available at a sufficient resolution to support health impact assessment using multiple warming scenarios when analyses were conducted.

2.4 What is not in the report

As in previous iterations, the report does not attempt to rank health effects; instead, it investigates a predefined list of impacts, providing a summary of relevant health outcomes, research needs and public health implications. Where possible, chapters explore the geographical variability of health impacts, identify populations who are vulnerable, and outline adaptation options. The report excludes some important topics where there was insufficient evidence at the time of commissioning, or where topic experts were unavailable.

3. Key messages

3.1 There is substantial and growing evidence of the effects of climate change on health in the UK

The potential impacts of climate change on health will be significant and wide-ranging. The evidence is strongest for adverse impacts on health due to heat and cold (Chapter 2), flooding (Chapter 3), and vector-borne disease (VBD, Chapter 8) risks increasing under a warming climate. Heat and cold-related deaths are both projected to increase in the UK, although cold impacts will dominate until late century, largely due to an ageing and growing population. Increased risk of flooding will mean that people, properties, and infrastructure that were not previously at risk will become at risk of flooding. The UK will become more suitable for the survival of vectors of public health importance, notably *Aedes albopictus* mosquitoes. Transmission of dengue and chikungunya, and West Nile virus may be possible in the latter half of the century or sooner (Chapter 8). Food imports and prices, particularly for fruits and vegetables, will be more volatile due to high UK dependence upon foods from particularly climate-vulnerable countries (Chapter 9). Some risks that are not currently considered threats to health in the UK will emerge, including increased exposure to wildfires (Chapter 10) and drought (Chapter 11). In some areas, evidence on the health effects is mixed (as for aeroallergens, Chapter 6) or insufficient for full assessment (for example human exposure to chemicals, Chapter 12, and ultraviolet radiation, Chapter 13).

3.2 The health risks of climate change will not be distributed equally across the UK

There are clear geographical and sociodemographic differences in how climate risks to health will be felt. Some risks, such as emerging VBDs, drought, and wildfires, will likely emerge earliest in the southern regions of the UK. Other risks, such as sea-level rise and flooding, will be greatest in coastal towns, low-lying areas, and in or near floodplains. Urban areas may be particularly affected by extreme heat due to the urban heat island effect (Chapter 2). In the case of changing aeroallergen risk (Chapter 6), impacts will be highly localised across the country, with increasing risk emerging first in the Midlands. There is very strong evidence that older adults (over 65 years) and people with pre-existing health conditions will be at greatest risk from rising temperatures. An ageing UK population will be an important driver of national climate vulnerability in relation to health over the coming decades. Climate risks to health will map onto existing gradients in health and inequality. Those less able to control their environment, adapt their behaviours, or respond to new risks will be particularly vulnerable, including children, people with disabilities, people experiencing homelessness, and people in certain settings such as prisons, schools and social care, aligning closely with CORE20PLUS priorities (17). Similar patterns of inequality are seen across a range of health hazards in the UK and will underpin differential vulnerability to the health impacts of climate change.

3.3 The health risks of climate change will not be distributed equally across generations

The long-term trajectory of climate change means that there are inter-generational considerations. For an optimistic low-warming scenario, temperatures are likely to peak mid-century: current working age adults will be in their vulnerable retirement years and those who will be adults in the 2050s to 2080s will face the greatest burden of adaptation. A less optimistic scenario in line with the current trajectory of warming and global mitigation policies is consistent with temperatures that will either not decline after reaching a mid-century peak or will continue to rise (Chapter 1). In this case, current children and young people will experience increasingly severe warming and impacts into their retirement age, with impacts persisting or increasing also for their children. The health threats from climate change are thus high for current working age adults, particularly acute for current children and young people, and unknown but potentially severe for their children and grandchildren.

3.4 Health impacts will increase with progressive warming

The health risks from climate change that will evolve over the next century are highly dependent on the level and rate of global warming. Flood risk is projected to increase more steeply under high-warming scenarios, with the number of people in the UK significantly at risk of flooding projected to increase by 61% by 2050 under a modest warming scenario (+2°C) and 118% in a high warming scenario (+4°C) compared with current risk. Sea-level rises are highly sensitive to level of warming, with approximately one metre difference in projected sea-level rise between low and high warming scenarios (Chapters 1 and 3). Changing temperatures and human behaviours will likely cause increases in the importation and transmission of resistant organisms and therefore has the potential to increase the prevalence of resistant infections, posing a significant additional challenge to tackling antimicrobial resistance (AMR). Higher and more rapid warming will accelerate risks such as the likely emergence of *Ae. albopictus* mosquitoes into the UK and the spread of already established *Culex spp.* (Chapter 8). This in turn will heighten the risk of VBDs including dengue, chikungunya, and West Nile virus. Under a high-warming scenario, most of England will become suitable for the establishment of new domestic mosquitoes by the 2040s and 2050s. For most of Wales, Northern Ireland and parts of the Scottish Lowlands, new domestic mosquitoes may become established by the 2060s or 2070s. Slower and reduced warming is likely to delay these risks by decades or beyond this century. Decarbonisation to limit warming will thus reduce the severity of impacts and delay them, providing valuable time for society and health systems to prepare for and adapt to health risks.

3.5 Many adverse health impacts are avoidable with climate change mitigation and preventable at lower warming levels through effective adaptation

At lower levels of warming, there is strong evidence that targeted adaptations can save lives and reduce ill-health associated with climate change risks. There is good evidence that harms to health can be effectively reduced through multi-sectoral action, for example, by national heat and cold alert systems, improvements to housing including energy efficiency measures, shading, and greenspace. Whilst there will be interventions specific to particular climate risks, some interventions provide multiple health and societal benefits (so called ‘win-win’ or ‘co-benefits’ options), while others can create new or unintended risks (trade-offs) (Chapter 14). This is particularly important when considering approaches that meet multiple goals: such as protecting health in a changing climate, aligning to the UK’s decarbonisation commitments, and other societal goals. Measures to mitigate climate change, such as passive or low-carbon heating and cooling, energy efficient lighting, and solar energy will enable existing homes to become energy efficient, may help alleviate fuel poverty and improve thermal comfort in winter, for example, but without accompanying improvements in ventilation may reduce indoor air quality (Chapters 5 and 14). Similarly, air conditioning may be an effective measure for cooling buildings and protecting vulnerable people from extreme heat but is energy and carbon intensive. Minimising trade-offs and maximising benefits to health is thus a priority for policy and planning. The evidence base is strongest for diverse and multiple benefits from the following strategies:

3.5.1 Nature-based solutions

There is strong and growing evidence that interventions that harness or enhance natural systems and processes can provide numerous health benefits (Chapter 3). These include, for example, river or wetland restoration, greening of urban landscapes and infrastructure, and greening of rural landscapes. Such approaches can be effective in reducing flood risk, improve thermal regulation in cities and buildings, decrease energy costs, provide shade, improve air and water quality, and generate benefits for mental health. While such approaches have numerous potential benefits, health trade-offs may occur if interventions create or increase habitats suitable for vectors such as mosquitoes or ticks (Chapters 3 and 8). Implementation of nature-based solutions such as greening, restoration, or ‘rewilding’ should therefore be assessed on a case-by-case basis to maximise benefits and minimise trade-offs for health.

3.5.2 Mainstreaming climate-health considerations across sectors

Many of the interventions relevant to climate threats to health fall outside of the remit of the health and care sectors. Building retrofitting, urban and land-use planning, and transportation, for example, are key areas where policy and planning decisions will have implications for health risks due to climate change. Public health teams can play an important role in sharing evidence, applying evidence to specific scenarios, policies, and decisions, and contributing a health ‘voice’

working in partnership with these sectors. Health considerations should be incorporated into cross-sectoral planning, and climate considerations (such as decarbonisation goals) into health and care systems planning: a health-in-all-climate policies and climate-in-all-health-policies approach.

3.5.3 Interventions targeted for vulnerable populations and priority settings

Some health risks due to climate change will disproportionately affect some individuals, populations and settings. Protecting older adults during cold and hot weather periods is key to minimise heat risk and temperature-related mortality (Chapter 2). Some interventions would be most effective if targeted to settings where people are less able to self-regulate their temperature and environment, such as care homes, prisons, schools, workplaces, hospitals and public transport. Risks which are geographically focused would be suitable for targeted messaging, such as enhanced seasonal mosquito or tick alerting (Chapter 8), identification and support for flood-prone areas (Chapter 3) and promoting retrofitting schemes for buildings and homes in the most at-risk areas.

3.5.4 Early action

There are several areas where evidence supports the potential benefit of early action. Given the lead time needed for shifts in population behaviour, as well as policies, practices, and infrastructure, early planning will be necessary, and may be ineffective if delayed. Early implementation is also critical to ensure the effectiveness of surveillance and monitoring (Chapter 15). Strengthening surveillance to ensure rapid detection and effective response to incursions of vectors such as *Ae. albopictus* mosquitoes will be necessary to prevent the (largely irreversible) establishment of new vectors in the UK and the pathogens they can transmit.

3.5.5 Enhancing community resilience by addressing existing inequalities

As risks will manifest along existing social gradients in health, addressing current social and health inequities can help build resilience to a range of climate-health risks. This strategy has the benefit of improving resilience to a wider range of health risks and thus has strong evidence as a 'no-regrets' intervention approach.

3.5.6 Promoting adaptive behaviours

Individual behaviours will shift in response to growing climate risks, but professionals and organisations can play a role in communicating evidence to enable these transitions. For example, increasing levels of active travel is likely to reduce emissions and improve health across the population, with implications for transport and urban planning (Chapter 14). Healthier food and diets are also largely consistent with low-carbon emissions, adding to the evidence for healthy and sustainable dietary messaging (Chapter 14).

3.5.7 Embedding climate education into health, care and public health practice

Climate change will have widespread and potentially profound impacts on health, care and public health practice, with implications for the next generation of practitioners. Public health agencies and professionals can support emergency planning and response, undertake health impact assessments and advise on climate-health risks for their population, conduct needs assessments to highlight and address climate vulnerabilities, and contribute to long-term and coordinated planning in terms of infrastructure, emergency response, and continuity of health and social care services. Awareness of emerging localised VBD risks, growing health risks associated with extreme weather events, improved consumer education on food storage, handling and preparation practises and provision of information or evidence to food business operators in relation to food safety and security will be increasingly important considerations, as well as aligning public health practice with decarbonisation commitments.

4. Research gaps and needs

Individual chapters provide detailed topic-specific research priorities, but there are a number of themes that run throughout the report. These reflect common and cross-cutting priorities to improve and advance the evidence base supporting preparedness and response to climate risks to health in the UK.

4.1 Assessing future climate risks

4.1.1 Improved climate modelling to integrate multiple adaptation and warming scenarios

Current climate modelling and research has advanced substantially over the past decade but remains ill-equipped to incorporate measures to account for adaptation interventions, combining multiple mitigation and adaptation scenarios. There is urgent need for a new generation of climate and impact modelling methods that quantitatively integrates adaptation scenarios with multiple warming scenarios at high-resolution to enable health impact assessment, including improved estimation of uncertainties.

4.1.2 Improved epidemiological modelling for health impact assessment

Projecting future scenarios requires parameterisation of the links between climate-related hazards and health outcomes, and how these vary across contexts and over time. Understanding how these parameters or links vary is particularly critical for modelling of intervention and adaptation options. Development of improved frameworks and case-studies to support health impact assessment and projection modelling under a range of climate scenarios is needed. Additionally, a more diverse range of health outcomes should be assessed, complementing mortality estimates with consideration of morbidity and other metrics of ill-health such as years of life lost (YLL).

4.1.3 Improved understanding and assessment of cascading and compound risks and response options

Climate risks to health will not occur individually, but within the context of other challenges to health, and can impact multiple determinants of health. Research should explore the implications of scenarios involving cascading and compounding impacts associated with multiple interacting risks and challenges to health, for example a major flood event following a prolonged heatwave and drought, and associated adverse impacts on health and transport systems.

4.1.4 Improved understanding of the mental health impacts and behavioural determinants of health risks

Despite growing evidence of substantial impacts and risks to mental health posed by climate change, the evidence base lags behind other risks such as extreme heat and infectious disease. Similarly, attention to the behavioural contexts underpinning individual risk and barriers to behavioural change or uptake of interventions is growing but insufficient. Integration of relevant disciplines such as psychology, sociology, and relevant social sciences and humanities is needed to improve our understanding of climate vulnerability and risk, as well as underpin development of feasible and effective interventions. This is particularly important for health equity given in the context of vulnerable populations and those who may be at greatest risk but have the least ability to benefit from an intervention.

4.1.5 Econometric impact assessment for climate-health risks and intervention options

Development of appropriate tools and frameworks to estimate the economic implications of climate risks to health, and the economic case for health interventions, is needed. While methodologically challenging, providing estimates for cost-benefit analyses will be critical in supporting decision-making and prioritisation of investment in adaptation interventions. Limited studies in this area indicate the potential for substantial savings from interventions such as early warning systems, but further evidence is urgently needed.

4.2 Assessment of intervention options and effectiveness

4.2.1 Evaluation of adaptation interventions to protect UK populations from climate threats

As climate research progresses beyond assessment of risk towards consideration of responses and interventions, there is need for improved evidence on the effectiveness of alternative and combined interventions. Formal evaluation research should be applied to the needs of climate-health adaptation to inform the development of prioritisation frameworks for decision-makers.

4.2.2 Develop evidence on health co-benefits and trade-offs

Decision-makers need guidance and toolkits that support planning and prioritisation in the context of multiple, and sometimes conflicting, objectives. There is still relatively limited research that integrates these multiple priorities to provide evidence on how to understand and balance competing costs and benefits for health. Research should be prioritised to increase assessment and synthesis of the health benefits, co-benefits, inequalities, trade-offs and any potential harms to health associated with net zero actions, so that findings can be integrated into climate policies and actions to ensure health benefits are maximised and health harms are

avoided. This evidence should be explicitly developed with user accessibility and needs in mind to ensure that guidance is suitable in supporting decision-making.

4.2.3 Embedding equity across all climate-health research

Consistent with the Sustainable Development Goals framework, climate-health research should mainstream and standardise consideration of equity across research. This should include standard disaggregation of results by key determinants of equity (at the individual and population level). Equity consideration should be advanced to consider a more nuanced understanding of multiple dimensions of equity and justice (including procedural justice). Key areas of investigation should consider who is most exposed to climate hazards to health (for example, coastal communities or those in energy inefficient housing), who has pre-existing susceptibility to climate hazards to health (such as those with pre-existing health conditions, older adults), who has lower capacity to adapt to these risks or take advantage of adaptations (such as people with fewer social networks or experiencing deprivation), and who is less likely to be identified and prioritised by interventions due to social exclusion or marginalisation (for example, some ethnic or racial minorities, those with language difficulties). This should be informed by consideration of the CORE20PLUS framework (18), which is a UKHSA and NHS England approach to define the populations and communities to be routinely considered, inform action and reduce healthcare inequalities at national and system level.

4.2.4 Integrated research to support guidance for high priority settings

Research should focus on integrating evidence to inform guidance on transitions suitable for critical spaces and places, such as urban planning, the built environment, rural landscapes, and special settings (homes, transport, care home, hospitals, prisons, schools). Upgrades to the UK housing stock and infrastructure will need to balance ventilation, thermal regulation, and energy efficiency objectives, for example. Hospitals and care homes will need to similarly decarbonise whilst protecting a high proportion of vulnerable individuals from heat and protecting infrastructure from flooding. Transitions to rural landscapes such as 'rewilding' will need to balance trade-offs and priorities related to social, economic, health, environmental and cultural considerations. Research should support integrated assessment programmes to inform health risks, interventions, and opportunities for key sectors and settings.

4.3 Data integration and skills development

4.3.1 Coordination and standardisation of metrics and indicators of risk, vulnerability, and adaptation progress

Despite consistent calls for the development of metrics and indicators, efforts remain abundant but largely uncoordinated and lacking in coherence among research and public institutions. This constrains the ability of all organisations to effectively monitor and track risk and progress.

4.3.2 Coordination of data platforms and networks to integrate and curate climate-health data

Despite diverse and in some cases abundant relevant data, there is a substantial gap in leadership and coordination to link and integrate data sets and develop collective and standardised frameworks for metrics and indicators. There is significant potential to leverage existing data sets, data infrastructure, and initiatives to coordinate and advance data analytics to support climate and health research and decision-making.

4.3.3 Climate services for health and filling the climate-health skills gap

There is insufficient knowledge and skills within the health community to access relevant climate data, which in turn is often not translated, analysed, and produced in formats appropriate to the needs of public health practitioners and researchers. More generally, there is a skills gap in integrating climate sciences with health impact assessment. There is need for improved packaging of climate data, services, and training to respond to public health priorities. Climate services and data should be oriented towards the content and formatting needs of the public health community.

5. Next steps and moving forward

The chapters in this report provide an update on the growing evidence that climate change is an important determinant of health in the UK.

Many of the health risks from climate change are preventable. Therefore, it is key that the evidence in this report is used to inform policy and action. The extent to which climate risks can be avoided, however, will be largely determined by whether:

1. Climate change is limited to lower levels of warming (less than 2°C) as a result of concerted and rapid global decarbonisation.
2. Interventions are implemented early enough to have impact in line with projected risks.
3. Action is accompanied by a focus on existing gradients in health and equity to ensure that interventions do not exacerbate health inequalities. Higher rates of warming and delayed action translate to increasingly difficult and costly prevention of health impacts, with some interventions becoming infeasible or unsuitable.

The evidence base on the impact of climate change on health continues to grow and evolve but there is an urgent need to strengthen the evidence base on effective interventions to protect health from the adverse effects of climate change. However, it is already known that interventions to prepare for and respond to the health risks of climate change are in many ways consistent with broader health objectives and represent 'win-win' or 'no-regrets' actions.

There are several emerging areas of research that were not included in this report but should be considered a priority for future assessments. First, there is emerging evidence of numerous biological, ecological, health systems and policy intersections between climate change and AMR that have until recently been overlooked and may have important implications for alignment of policy across these 2 major global health challenges. The health risks of AMR alone are predicted to cause 10 million deaths worldwide per year by 2050, but the impact of climate change has the potential to increase these mortality rates still further and faster. Second, there is growing attention and evidence on the implications of climate change for mental health, which would benefit from formal assessment. Third, more distal pathways by which climate change can impact health, including impacts on migration, remain poorly understood but the evidence base is developing.

6. What UKHSA is doing

UKHSA preparedness has delivered a step-change through the establishment of the Centre for Climate and Health Security in October 2022 to lead and coordinate efforts to protect health in the context of our changing climate, working in partnership with academia to improve our understanding of the health effects of climate change and effective interventions to secure health. The establishment of the CCHS brings together the relevant fields of expertise across the Agency to address the climate challenge and gives further momentum to help minimise the effects of climate change on health and reduce health inequalities.

UKHSA partners across government in England to ensure a joined-up and aligned approach to preparedness and response to environmental hazards. This includes collaboration with local authorities, the Environment Agency (EA), the Department for Health and Social Care (DHSC), the Office for Health Improvement and Disparities (OHID), NHS England, the Department for Food, Environment and Rural Affairs (Defra), the Met Office, the Department for Levelling Up, Housing and Communities (DLUHC), the Department for Education (DfE), the Ministry of Justice (MoJ), the Department for Science, Innovation and Technology (DSIT), Department for Culture, Media and Sport (DCMS), the Department for Transport (DfT), Foreign, Commonwealth and Development Office (FCDO), Department for Energy Security and Net Zero (DESNZ) and Cabinet Office. Engagement with these partners is a core remit and objective of the new climate centre, for example. The Centre remains committed to working closely with devolved governments and their associated public health agencies.

Since the early 1990s, the UK has developed its own sets of national climate projections based on the latest developments in climate science. UKHSA works closely with the Met Office to integrate climate science and modelling into health impact assessments and launched an impact-based weather-health alerts system in 2023 to help local responders understand what actions they may need to take, based on the impacts expected because of the weather. UKHSA launched the 'Adverse Weather and Health Plan (AWHP)' for England in April 2023 ([19](#)). The AWHP outlines areas where different sectors (including public, independent, voluntary, health and social care organisations and local communities) can work together to maintain and improve integrated arrangements for planning and response to deliver the best outcomes possible during adverse weather.

The UKHSA Real-time Syndromic Surveillance Team currently support the AWHP through the provision and interpretation of real-time health data (syndromic surveillance). Throughout the year, but particularly during periods of extreme weather, the syndromic surveillance team monitor a suite of national surveillance systems of NHS activity, including NHS 111 calls and emergency department (ED) attendances. The team report on events such as increases in heatstroke visits to EDs, to inform the work of incident response teams. Further work is planned to improve current syndromic indicators for monitoring the health impact of extreme weather and climate change, including the use of machine learning and artificial intelligence to improve the sensitivity of the syndromic systems.

UKHSA undertakes surveillance of new, emerging and endemic infectious diseases and monitors the UK tick and mosquito populations through both passive and active surveillance activities, and monitors for non-native vectors. UKHSA has contributed to developing a cross-government contingency plan following the detection of invasive mosquitoes in England ([20](#)), which involves a network of invasive mosquito trapping locations coordinated by UKHSA.

UKHSA health protection experts work to identify and control infectious diseases and environmental hazards responding to outbreaks and incidents to protect health. Health Protection teams are engaged in collaborative work on climate change and environmental sustainability locally and with partners looking at the broader aspects, such as future water resource and the potential for coastal flooding. Teams ensure that local systems are aware of information published nationally and help in its interpretation and implementation of any action required.

UKHSA works with partners within and outside government to understand and tackle AMR. The UK's next 5-year national action plan on AMR will be published in 2024 and will capture challenging ambitions and actions to respond to this existential threat, including working with UK Research and Innovation (UKRI) through their AMR Transdisciplinary Networks to strengthen the evidence base and pursuing climate-secure interventions to address AMR.

UKHSA contributes to advancing the evidence on the health effects of climate change by working with the National Institute for Health and Care Research (NIHR) Health Protection Research Units and other academic partners. UKHSA is establishing work programmes focused on increasing understanding of co-benefits and building the evidence base for healthy greening. UKHSA's Behavioural Science and Insights Unit supports research to improve understanding of the barriers and opportunities for 'win-win' behavioural shifts that provide both health and decarbonisation benefits. We work in partnership with national and local government to translate the evidence into policy, guidance and advice.

Abbreviations and acronyms

Abbreviation	Meaning
AMR	antimicrobial resistance
AWHP	Adverse Weather and Health Plan
CCHS	Centre for Climate and Health Security
CCRA	Climate Change Risk Assessment
EDs	emergency departments
GHGs	greenhouse gases
HECC	Health Effects of Climate Change in the UK
NAP	National Adaptation Programme
SCCAP2	Second Scottish Climate Change Adaptation Programme
UKCP09	UK Climate Projections 2009
UKCP18	UK Climate Projections 2018
UKHSA	UK Health Security Agency
VBD	vector-borne diseases

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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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