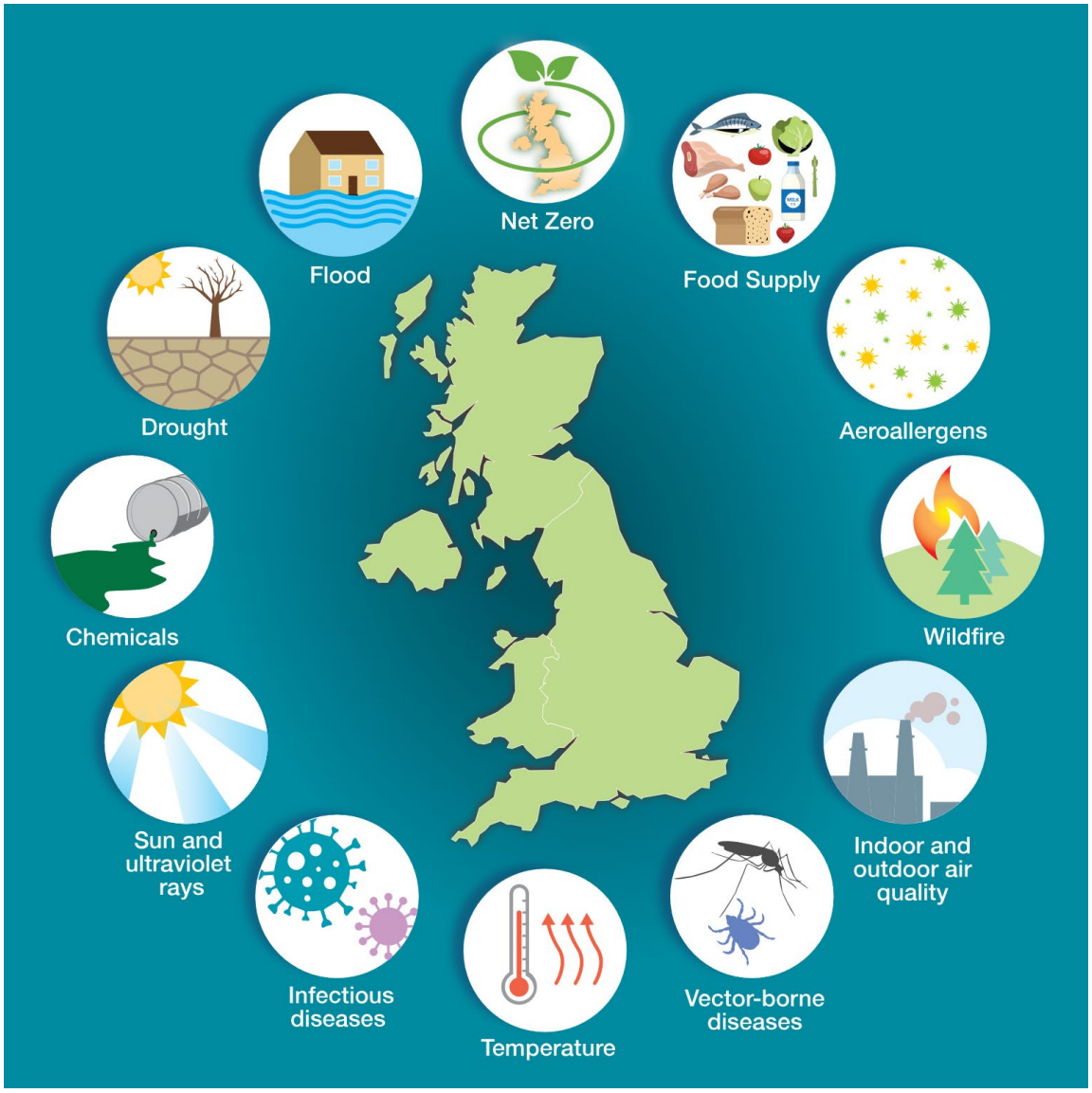
UK Health Security Agency

Health Effects of Climate Change (HECC) in the UK report: 2023 report

Chapter 15. Indicators for climate change and public health tracking



Summary

Robust indicators are needed for tracking the impact of climate change on health, monitor progress towards adaptation and mitigation, monitor progress with government commitments, and support policy development to build a climate resilient society. Despite the pressing need to assess impacts and progress in adaptation, the development of reliable and valid indicators has been slow and fragmented, with substantial and persistent gaps. Chapter 15 provides a review of current climate-health indicators for the UK (with many indicators developed for England but could be adapted to other countries), along with an evaluation of their suitability for monitoring public health outcomes. This chapter is based on the UK Health Security Agency (UKHSA) report 'Climate Change and Public Health Indicators: Scoping Review' and was led by experts from UKHSA and London School of Hygiene and Tropical Medicine.

Strong public health surveillance and tools that integrate data on environmental hazards, exposures and health outcomes are needed to guide decision-making and prioritise interventions. To date, health outcome indicators have predominantly focused on mortality and should be expanded to comprise morbidity, including mental health. Climate indicators, in contrast, have largely focused on climate hazards or vulnerability due to geographical proximity to those hazards (such as living near the coast or urban heat islands), but rarely include indicators suitable for evaluating interventions. Essential public health services such as preventive programmes, surveillance of disease and forecasting of future health risks are essential tools to build resilience against climate change. However, to protect health, actions must also extend beyond the health sector and should therefore include indicators of early warning system implementation and effectiveness, climate-resilient housing design, sustainable urban planning, sustainable water catchment management, transitions towards resilient food systems, and disaster preparedness.

This chapter highlights several research gaps and priorities relating to applying emerging evidence on adaptation processes and pathways to update and develop indicators, including the need to:

- improve the accuracy and reliability of indicators of climate-health adaptation progress
- advance indicators and metrics encompassing both direct and indirect effects of climate change on health with clear links to actions that can be taken by members of the public, private sector, and different levels of government
- develop indicators that allow the monitoring of health inequalities in climate and health to inform targeted policy and action

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Chapter 15. Indicators for climate change and public health tracking

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1. Introduction to climate change public health tracking

Climate resilient societies require a comprehensive intersectoral programme of climate action and a focus on public health to provide a strong indication of progress. As recommended by the World Health Organization (WHO) (1), this programme should address:

1. Health governance and policies tackling climate risks.
2. Health information, integrated surveillance, and climate early warning systems.
3. Preventive and curative services (water and sanitation, pest and vector control, food safety, disaster risk management for health, safe and environmentally sustainable health facilities, vaccination and child health services) (2, 3).

Indicators and metrics for tracking the impact of climate change on health are essential to monitor progress towards adaptation and mitigation at national, regional, and local levels. The need for indicators is increasingly recognised and European and North American countries are in the process of developing indicators to monitor impacts and progress on adaptation. Santé Publique France recently published a report that included indicators to monitor heat risks (4) and the European Environment Agency (EEA) has developed a set of indicators that largely relate to climate exposures but there is limited information that is relevant for public health planning (5). The United States Environment Protection Agency (EPA) regularly updates a small number of climate change indicators related to health, and highlights that this is still an emerging area (6).

The lack of established metrics to monitor health vulnerability, impacts and adaptation to climate change, has led to the development of multiple sets of indicators internationally, such as the European Climate Health Observatory, and the Lancet Countdown (7 to 9). For instance, the 24th Conference of Parties (COP24) special report on health and climate change recognised the need for indicators that would be globally consistent to ensure comparability between countries but also nationally relevant to inform strategic action (10). A step towards achieving this is publication of the region-specific Lancet Countdown reports, such as the Europe and South America versions (11, 12), which mirror the global version, but focus on regionally relevant indicators. This growing interest in tracking impacts and progress in adaptation and mitigation also stems from the need to hold governments accountable to their commitments in international treaties, and to galvanise populations into action by demonstrating the gap between what has already been achieved and how much still needs to be done to meet adaptation goals (13).

The development of national indicators is important to maximise the use of available data. The aim of the scoping review (14) was to identify the potential data sources within the UK that can be used to monitor vulnerability, impacts and adaptation progress, and to align with national policy priorities and environmental data sets.

Adapting to climate change requires intersectoral action that includes and extends beyond the health sector, such as:

- early warning systems
- climate-proof housing design
- urban planning
- sustainable water catchment management
- developing resilient food systems
- disaster preparedness

Nonetheless, essential public health services, including public education, preventive programmes, the surveillance of disease, and the forecasting of future health risks remain essential tools to address climate change (15, 16). In this context, a comprehensive public health surveillance system is pivotal to transition to societies resilient to climate change. The general framework for conducting environmental public health surveillance involves data from 3 points in the process by which an agent in the environment produces an adverse outcome on health status: hazards, exposures, and outcomes (17). Therefore, public health surveillance is not confined to monitoring health data, but includes monitoring of precursors, such as hazards and exposures, which can be seen within the context of societal and environmental drivers, pressures, and states, as well as actions needed to address the issue that is being monitored. This is illustrated by the drivers, pressures, state, exposures, effects, actions (DPSEEA) framework (18) and has been translated into an operational system of public health surveillance referred to as 'Environmental Public Health Tracking' (EPHT) (19). The relevance of EPHT for climate change and its risk for human health has been recognised by many countries (20). This approach fits local surveillance within a global framework to monitor progress on actions that aim to achieve adaptation, resilience, and sustainable development (21). This framework is already implemented in England as an EPHT programme, which is overseen by a board including representatives of groups providing many public health functions and delivers its climate surveillance tasks via a working group on Weather and Climate Data for surveillance.

Within this framework, which includes systematic access to environmental hazard and exposure data alongside health data, surveillance systems are paramount to guide action on all topics relevant to impacts of environmental change on health. These include detecting shifts in infectious disease patterns in relation to climate change and other environmental changes, as well as monitoring implementation in the built environment, food systems and response to extreme events. Importantly, surveillance systems should be vertically and horizontally integrated between health services and central and local government to ensure actions are aligned and synergistic in identifying and neutralising, or at least minimising, the risks posed by environmental change to population health. Although the actions required vary depending on the hazard, population, and setting, coordinated action is usually needed, including public health authorities and other sectors (for example food safety, transport, education, planning, housing, and so on).

Despite the pressing need to track progress in adaptation to environmental change to inform policy- and decision-making, development of reliable and valid indicators has been slow and patchy. Indeed, for most indicators across different domains of environmental change, such as heat and coastal change, feasible data is not available at national, regional, or local levels. In other cases where data exists, it still needs to be processed to derive health-relevant indicators.

The topic of indicators and monitoring is a new chapter topic for the 'Health Effects of Climate Change (HECC)' report series since neither the topic of indicators nor public health monitoring has been specifically included in any of the previous reports. In the 2012 report, however, there was a common theme of the need for increased and improved monitoring in most of the recommendation sections (22). This has also been highlighted in other chapters of this report.

This chapter summarises the main findings of a comprehensive review of indicators for climate change and health tracking that are either already in use or have been proposed by the UK Climate Change Committee (CCC) or other subject experts. New indicators are also suggested. The review follows the framework of the risks identified by in the UK Third Climate Change Risk Assessment technical report (23). The full version of this review can be found in (14), and a summary is provided in section 3.

2. Overview of ‘Climate Change and Public Health Indicators: Scoping Review’

2.1 Aim and method of the report

The aim of the scoping review was to provide a summary of the available information on indicators that map to the health risks of climate change in the UK, with a focus on England. It includes indicators that are already in use, and ones that have been suggested by advisory organisations, such as the CCC, or by subject experts contributing to the scoping review. The report aimed to cover a wide range of topics that have an influence on public health and where the impact might be altered by climate change. This spans from heatwaves and flooding, to changes in the food system and coastal change. Adaptation and mitigation activities are linked; therefore, the report also includes a small section on indicators for climate mitigation actions that are relevant to health and adaptation implementation.

The research on indicators was led by London School of Hygiene and Tropical Medicine (LSHTM) and UKHSA as part of the National Institute for Health and Care Research (NIHR) Health Protection Research Unit (HPRU) in Environmental Change and Health. A workshop with local authority stakeholders was held online on 18 May 2021 with 57 participants, including public health professionals, emergency planning leads and sustainability and adaptation officers from local authorities across England. Key messages from the workshop were that performance monitoring indicators were preferred, rather than exposure or outcome indicators. The importance of indicators relating to greenspace and blue space was identified, and that these needed to be related to other environmental goals, such as biodiversity.

Although the data sources listed for many of the indicators only cover England, a majority are applicable to the other UK nations if suitable data is collected. However, all indicators might not be relevant to all nations due to the difference in geography and climate, and indicators not included here could potentially be identified if a similar stakeholder workshop was held in the other nations.

2.2 Indicators included

Table 1 lists the indicators included in the scoping review, along with a short description and data availability, and references the HECC chapter where more information can be found about the topic (where applicable). In the scoping review, each indicator includes information about the sensitivity, that is, how accurate the indicator is at measuring the output of interest, available or potential data sources (focused on England), and the methods used to collect or process the data. It further includes comments on the feasibility and suitability of the indicator; that is, whether the suggested indicator is measuring what it is supposed to and, if it’s not already available, whether it is possible financially and practically to implement. Lastly, it includes information about the spatial scale (such as national or local level) the indicator is, or should be, available at, and if it is classified as an exposure, vulnerability, outcome, or action indicator.

Table 1. Summary of the indicators detailed in 'Climate change and Public Health Indicators: Scoping Review' report (14)

Key for letter colouring

The availability and suitability (A/S) of each indicator is indicated in column 2 with a coloured letter:

A green letter **A** indicates 'Yes, data available that could be used, or the indicator is currently in use'.
A blue letter **P** indicates 'Needs new processing of existing data'.
Red letters **NF** indicate 'No feasible data available'.
Grey letters **NR** indicate 'Indicator not recommended'.

Table 1a. Heatwaves and heat risk to health

Name of indicator	A/S	Short description	HECC chapter
H1. Exposure to solar ultraviolet (UV) radiation	A	Acute high or chronic exposure to sunlight increases the risk for a range of health impacts. UKHSA monitors UV radiation from 10 ground-based sites and displays near real-time UV index to the public. Forecasts of UV index is based on satellite data.	13
H2. Proportion of housing stock with overheating risk	P	Indoor overheating is qualitatively defined as the state at which occupants experience thermal discomfort due to the indoor environment, and vulnerability to this varies by location and type of dwelling. This indicator could be derived through empirical or modelling methods but is currently not possible due to lack of regular and frequent monitoring of indoor temperatures.	2
H3. Annual heat-related mortality	P	Health outcomes such as mortality increase above given temperature thresholds. UKHSA and partner agencies provide information on excess mortality that occurs during recognised heatwaves, which only captures a proportion of the heat-related mortality. This indicator is feasible but may be imprecise at local level due to small numbers.	2
H4. Annual heat illness	A	Hot weather has a range of effects on morbidity, even though mortality outcomes generally show stronger impact. UKHSA collects information related to illness (morbidity outcomes) on a real-time	2

Name of indicator	A/S	Short description	HECC chapter
		basis through syndromic surveillance systems, although it may not be good indicator of overall population impact.	
H5. Use of outdoor space for physical activity	A	Research shows a connection between time spent in greenspace and health improvements; use of outdoor space may change with increasing temperatures and changes in rainfall patterns due to climate change. The Natural England: People and Nature survey includes several questions linked to on this.	14
H6. Health impacts of wildfires	NF	Wildfire smoke includes both gases and particulate matter (PM) which can adversely impact on a range of health conditions. Significant increase in local PM due to wildfires can be monitored through the air quality monitoring system, and active wildfires through satellites. There is currently no monitoring of the risk of wildfires occurring or the health impacts of wildfires.	10
H7. Spatial planning measures for urban cooling	P	Green infrastructure (GI) offers sustainable low-cost cooling solutions, with a larger cooling effect from multiple layers compared to single layered trees. There is not an established indicator for cooling effects of GI components or characteristics, but an indicator could be derived regarding the increase in cooling-friendly greenspace. The Natural England GI Framework identifies several principles for the consideration of urban cooling, but work is still required to define the most useful indicator.	14
H8. Local heatwave plan	P	The ‘Adverse Weather and Health Plan (AWHP)’ triggers actions in the National Health Service (NHS), public health, social care and other community and voluntary organisations to support people who have vulnerability to heat. Several key parts of the plan are implemented locally and therefore a local strategy for addressing heatwaves would have benefits to health. Details on local area implementation are not centrally collected, hence this indicator is currently not available but would be feasible to achieve.	2

Name of indicator	A/S	Short description	HECC chapter
H9. Extreme heat in the local risk register	P	Local resilience forums (LRFs) are multi-agency partnerships made up of representatives from local public services, and each has a risk register to recognise and plan for the most important risks. Heatwaves are often not included but including it with a risk level associated would be a useful indicator of local preparedness for extreme heat. All risk registers are publicly available, so it would be possible to monitor if heatwaves are included and the risk assigned.	2

Table 1b. Cold and cold risks to health

Name of indicator	A/S	Short description	HECC chapter
C1. Proportion of housing stock with low indoor temperature	P	Indoor temperature in homes is important since people spend the majority of their time indoors during the winter, and elderly and vulnerable people spend a significant proportion of their time at home. Low standardised indoor temperatures (SIT) are considered as temperatures below 18°C in liveable rooms. This indicator is currently not possible due to lack of regular, widespread, and frequent monitoring of indoor temperatures.	2
C2. Fuel Poverty	A	Fuel poverty is a combination of fuel prices, household income and home energy efficiency. A household is considered fuel poor if the property has a fuel poverty energy efficiency rating band D-G (24) and would be under the poverty line if they bought the required amount of fuel to keep the home warm and functioning. This indicator is already available at national and local level.	14
C3. Annual cold-related mortality and morbidity	P	Cold-related mortality burden is significantly larger than heat-related in the UK. The currently available indicator is Excess Winter Deaths, but it is not fit for purpose due to its overly simplistic definition. An explicit assessment of cold-related mortality would be a much more suitable metric for cold-related mortality.	2
C4. Proportion of homes with	P	Certain energy efficiency upgrades such as insulation and double glazing are thought to result in more comfortable homes during winter, but potentially with greater risk of overheating in summer.	5

Name of indicator	A/S	Short description	HECC chapter
(retrofit) energy efficiency upgrades by type		Data on dwelling physical and energy efficiency state and energy efficiency measures is collected for parts of the housing stock, but not all.	

Table 1c. Flooding and flood risks to health

Name of indicator	A/S	Short description	HECC chapter
F1. Number of floods or populations flooded	P	Flooding is regularly occurring in the UK and is associated with a range of adverse social, health and economic impacts to households and communities. Rainfall data is consistently monitored, and a database of coastal flood events exists; however, to achieve this indicator, the current databases and monitoring of floods need to be updated to include more details such as number of households impacted by flood type and outcome for example mental health, loss of property, and injury.	3
F2. Flood warnings by populations affected	NR	Flood (fluvial, coastal) warnings in England and Wales are provided by a joint Flood Forecasting Centre between the Met Office and Environment Agency (EA). Data has been collected on all flood warnings since 2006. The data, however, is not robust enough to track long-term trends due to changes in area covered by the service and the increase in fine-scale, targeted warnings. Surface water flooding is not included in flood warnings.	3
F3. Populations with estimated frequency of flooding of more than a 1% chance in any year	P	The risk to people from flooding is present in most local areas, but with large regional differences in risk level. 10 local authorities account for 50% of the socially vulnerable people living in flood risk areas. Long-term flood risk maps are produced which could be used to annually report on ‘population at risk of flooding’ after additional processing, given that the maps are regularly updated to reflect changes to flood defence systems.	3

Name of indicator	A/S	Short description	HECC chapter
F4. New properties built on land with an estimated frequency of more than a 1.3% chance in any year	P	The National Planning Policy Framework states that local plans should consider the long-term implications for flood risk, however properties are still being built in areas prone to frequent flooding. The EA currently reports on properties built in areas prone to flooding on an annual basis. This indicator could be achieved by further processing of available flood risk and property data, but it is currently not possible to know if properties are built with flood protection measures.	3
F5. Proportion of households without flood insurance	P	Evidence shows that individuals without insurance have worse mental health outcomes from being flooded compared to those who have insurance. The current insurance scheme to provide affordable premiums in high-risk areas is delivered through private insurers, which hinders access to data necessary for this indicator. The Flood Re scheme may provide some relevant data for this indicator.	3
F6. Death or injury from flood events	P	Flooding events can cause injuries and deaths, both during the event from debris and fast flowing water, or during cleaning up. Deaths reported from drowning do not indicate the cause of drowning or if flooding was involved. Deaths from flooding events are collected locally, but not other health impacts. This indicator is feasible with improved monitoring systems.	3
F7. Estimated number of people suffering flood-related adverse mental health impacts	NF	The greatest burden of ill health from flooding is likely to be due to long-term negative impacts on mental health. Evidence shows that prevalence of negative mental health is still significant 3 years after the flooding event. The overall prevalence of mental health conditions can be derived from routine health data but are currently not possible to attribute to a flood event.	3
F8. Number of people displaced from home for more than 30 days	NF	Flooding can make homes unsafe to live in, leading to people being displaced from their homes for potentially a very long time if substantial repairs are required. Evacuation and displacement increase the risk of anxiety in individuals that have been flooded. It is not clear whether data is available for this indicator.	3

Name of indicator	A/S	Short description	HECC chapter
because of flood damage			
F9. Local Authority planning policy and guidance to minimise new dwellings and assets in flood risk areas	P	LRFs develop emergency plans on actions to take before, during and after a flood at the local level. Many local authorities have set up local flood risk management partnerships which bring together risk management authorities and others in their area to help with their local flood risk management strategies. It is not clear what available data exists for this indicator.	3
F10. Proportion of dwellings with property-level flood resilience	P	Property level resilience (PLR) measures can both reduce the risk of water getting into the property, and reduce the impact if the flood water does get in. The limited publicly available data provides an indication of the number of properties that implemented PLR through relevant schemes but does not include if households implemented it at their own cost. The proposed indicator is technically feasible but would require updates to the reporting system.	3
F11. Monitoring of the Flood and Coastal Erosion Risk Management Strategy implementation	P	The EA is required to produce a Flood and Coastal Erosion Risk Management (FCERM) report every year, which must incorporate application of the National FCERM strategy. The strategy strongly promotes resilience through a basket of measures. The proposed indicator is feasible as a comprehensive reporting system is established which tracks progress towards actions required by 2026 to ensure the country achieves the strategy vision by 2100.	3

Table 1d. Coastal change risks to health

Name of indicator	A/S	Short description	HECC chapter
E1. Rate of coastline loss due to coastal erosion	A	The coastal zone is one of the most vulnerable areas to climate change in the UK due to sea level rise and costal erosion. Coastal processes such as sediment movement and erosion exacerbate the risk threatening long-term sustainability of coastal communities. This data is currently provided by the National Coastal Erosion Risk Mapping (NCERM).	3
E2. Population at risk of inhabitability within 20 years because of coastal erosion	P	Costal erosion is already a risk to many properties and infrastructure, with some areas potentially becoming unsustainable in the long-term. The Department for the Environment, Food and Rural Affairs (Defra) has mapped properties at risk of costal erosion over the next 20 years, but this does not include caravans, and consistent national data on properties lost to coastal erosion is not collected. This indicator is feasible using the mapping data.	3
E3. Population at risk of coastal flooding or erosion without insurance or compensation scheme	NF	Insurance or compensation is not currently available to mitigate against the risk of losing properties to coastal erosion. Defra proposed an indicator which monitors community resilience to flooding and coastal erosion, and insurance or compensation schemes could form part of this. This is indicator is currently not feasible.	3
E4. Number of camping and caravan sites with evacuation flood or erosion plans in place	P	Temporary properties and beach huts have been lost as a result of coastal erosion, and more could have been lost if they had not been moved. The proposed indicator already exists for sites with evacuation or flood plans, which could be extended with erosion plans.	3
E5. Coastal risk management plans	P	Shoreline Management Plans (SMPs) are non-statutory documents that identify the most sustainable approach to managing flood and erosion risk in the short and long-term. The SMPs	3

Name of indicator	A/S	Short description	HECC chapter
		provide guidance on strategic and sustainable coastal defence policy options to reduce these risks for the local population. This indicator is feasible but will require criteria for the evaluation of individual local plans.	

Table 1e. Vector-borne disease

Name of indicator	A/S	Short description	HECC chapter
V1. Seasonal temperature profile compatible with survival of disease vectors	P	Seasonal temperatures and weather are strongly linked to climate patterns and may provide a suitable indicator of vector activity. Meteorological data is available, but research is required to identify the most appropriate climate-based index.	8
V2. Weekly tick activity	NF	Ticks respond directly to changes in temperature, humidity, and rainfall, and could therefore be used as indicators of climate change. However, field sampling of ticks can be time-consuming and expensive, and would therefore require an extensive network of volunteers. Notably, ticks are also strongly driven by local ecological conditions which confound the role of meteorological drivers. This data is currently not collected.	8
V3. Fortnightly mosquito activity	NF	Mosquito surveys are relatively less time-consuming since these can easily be collected using traps, which can then be correlated with weather data. However, often mosquito densities can relate to water management, so this would need to be considered. Data at this fine temporal scale is currently not collected. Improved surveillance would be required.	8
V4. Invasive species	NF	Detection of non-native vectors can provide an insight into emerging risks from climate change. Currently there are too few cases to enable this as a vulnerability indicator.	8

Name of indicator	A/S	Short description	HECC chapter
V5. Tick bite species at veterinary practices	NF	Data on inquiries at veterinary practices for tick bites on companion animals is available and is both spatially and temporally robust. There is, however, very limited data on the specific tick species being reported. Specific indicators and exceedance thresholds could be generated.	8
V6. Number (rate) of Lyme disease cases	P	Lyme disease is a notifiable disease, however only a low number of confirmed infections are reported and there is a lack of information about the onset of infection in time and space. Association between the number of cases with climate drivers remains underdeveloped.	8
V7. Autochthonous cases of vector-borne disease	P	Measuring the occurrence, incidence, and prevalence of a vector-borne disease in an animal population would provide information useful for managing climate risks to human health. Data for this indicator is reported through current surveillance systems or short-term research projects, but association with climate drivers remains underdeveloped.	8
V8. Implementation of monitoring and reporting system for vectors	P	Some local authorities undertake mosquito management, for example, specific biocidal control in salt marshes and flooded river systems, but these activities are ad-hoc rather than routine. Changes to local reporting systems would be needed to achieve this indicator.	8

Table 1f. Food systems and health impacts

Name of indicator	A/S	Short description	HECC chapter
FS1. Pollinator abundance	P	Some crops are dependent on pollinator insects to produce food, and climate change can impact the abundance of these pollinators. Regional losses of pollinators which alter delivery of crop pollination services may decrease the availability of some food products or increase economic costs of production. Monitoring of some of these species is currently done by voluntary organisations and is frequently not standardised or systematic. Long-term databases of confirmed bee and fly species	9

Name of indicator	A/S	Short description	HECC chapter
		records have been collected at different times by different recorders. Additional work would be required to collate this data.	
FS2. Yields per hectare and livestock or productivity by crop and livestock group	P	Both crops and livestock are sensitive to high temperatures and water availability. The UK imports a substantial proportion of its food and is therefore dependent on both domestic and international food production. A large number of metrics relating to this indicator are already monitored, both nationally and internationally. Revision to some of the reporting systems would be needed to obtain this indicator.	9
FS3. Food-borne outbreaks and or reported concerns and alerts	P	Agricultural response to climate impacts may involve increased use of pesticides, antibiotics, fertilisers and chemicals to maximise yields, however, this can lead to rising chemical contamination of crops and livestock. In the UK, there are 4 bacterial pathogens which cause the majority of food-borne outbreaks: *Campylobacter*, non-typhoidal *Salmonella*, STEC O157, and *Listeria monocytogenes*. Public health surveillance data exists for several infectious diseases related to food safety, and reports on this are routinely published. Food safety and compliance data on hazards detected in serious and widespread incidents also exists and is regularly published. There is however still very limited understanding of the potential connection to weather and climate.	7
FS4. Proportion of food waste along the value chain	P	Food waste is an economic and environmental loss, and potentially a factor in food security. Climate change may negatively impact on spoilage in the supply chain due to changing humidity and temperature. Monitoring of waste is already in place, but there are significant uncertainties associated with some components, such as primary production.	9
FS5. UK Food imports and exports by food group	P	The increase in agriculture trade has improved resilience from potential impacts on specific areas, but also increased the vulnerability to events disrupting the food system. Over 40% of food consumed in the UK is imported, with fruit and vegetables increasingly imported from climate-vulnerable countries. This indicator is feasible through the data already collected but should be complemented with an indicator on water availability.	9

Name of indicator	A/S	Short description	HECC chapter
FS6. Frequency and length of disruptions in supply by food group	NF	Both food production and transport routes can be disrupted by extreme events, which will become more frequent with climate change. The impact on the UK food supply chain is however unclear. Data is currently not available for this indicator.	9
FS7. Proportion of households that are food insecure	A	Food poverty is defined as when an individual does not have sufficient money for food, or they are unable to access food in their community. Climate-dependent food price and availability fluctuations may exacerbate existing health inequalities in food consumption by impacting dietary diversity and the nutritional quality of UK diets. Since 2019, data has been routinely collected.	9
FS8. Healthy (sustainable) diets and dietary diversity score	P	Food is responsible for a significant proportion of our greenhouse gas emissions, with a sizeable proportion stemming from red meat and dairy products. The Eatwell Guide moves people towards a more sustainable and healthier diet. Survey data is routinely collected each year but is primarily focused on nutrition rather than sustainability. Data is currently not available for this indicator but could be if question on sustainability was included in surveys.	9
FS9. Rate and frequency of foodbank use	P	The reliance on food banks has been rising consistently for nearly a decade and could potentially increase more with disruptions of the food supply chain. Both national survey data on food safety and issues, and distribution statistics from the main foodbank organisation are routinely published. This indicator could be available based on these data sets.	-
FS10. Food price change by food group	P	Economic shocks can adversely impact on product and consumption costs leading to spikes in food prices. This would particularly effect households already spending a large proportion of their income on food. Tracking food groups separately can help inform affordability of healthy diets. Data on real terms food prices for a selection of food groups is already collected and could be used to monitor the affordability of a healthy diet.	-

Name of indicator	A/S	Short description	HECC chapter
FS11. Incidence of food-borne diseases	P	Incidence of diseases from bacterial contamination is sensitive to temperature. Data on food-borne disease outbreaks is collected by UKHSA health surveillance systems, and the Food Standards Agency (FSA) estimates number of food-borne disease cases. This indicator is already in use, but association with climate drivers remains underdeveloped.	7
FS12. Development and implementation of national and or local food strategy	P	Managing the food system at a local level allows for location-relevant strategies, which can then feed into the national strategy. A national food strategy has been published, highlighting climate change as the biggest risk to food security. The National Food Strategy has been published, but an indicator for the implementation of the strategy would need to be developed in partnership with relevant organisations.	9
FS13. Development of dietary guidelines that embed climate change adaptation	NF	A climate-adapted food system would encompass foods that are not vulnerable to impacts of climate change. A diet aiming to be climate-resilient may not prioritise high consumption of plant-based foods due to it being highly weather dependent. No current dietary guidelines specifically consider climate resilience.	9, 14

Table 1g. Water quality and quantity and their health impacts

Name of indicator	A/S	Short description	HECC chapter
W1. Population affected by supply disruption	NF	Periods of reduced precipitation resulting from climate change will increase the likelihood of periods of water scarcity and droughts. Parts of the UK are already water stressed, and private water supplies are most vulnerable to climate hazards that affect water quality and quantity. Data on number of water usage bans is collected by the water companies, but it is currently not possible to monitor this with publicly available data.	11

Name of indicator	A/S	Short description	HECC chapter
W2. Population supplied by private wells	P	Private water supplies (PWS) are particularly at risk of contamination and vulnerable to dry and warm weather. Public Health England (PHE) undertook a survey of private wells in 2011 to 2013. There is currently no routine monitoring of the number or location of private wells, but replicating the data collection done by PHE could be done if information systems were put in place.	11
W3. Drinking water quality	P	Public water supplies are at risk of contamination from biological or chemical hazards caused by extreme weather events (flooding and drought). The quality of drinking water is regulated by the DWI and monitored by the individual water companies, or local authorities for PWS. Outbreaks in water supplies are reported, but the cause of the contamination and the role of weather is not routinely determined or reported.	7, 11
W4. Bathing water quality	P	Surface water (fresh or coastal) is at risk of contamination from biological or chemical hazards caused by extreme weather events (flooding and drought). Water quality at designated bathing water sites is monitored, and weekly assessments are done between May and September.	7, 11

Table 1h. Health services

Name of indicator	A/S	Short description	HECC chapter
HS1. Hospitals overheating incidents	A	UK summers are getting warmer with climate change, and a study found that up to 90% of hospital wards are vulnerable to overheating during periods of high temperatures due to the type and design of buildings. NHS England trusts are required to report instances of overheating as part of their estates return information collection, and new metrics are currently being developed to ascertain the extent of overheating impacts.	-
HS2. Health services flooded	P	Flood events can cause disruptions to health services and lead to increased healthcare backlogs. NHS England trusts are required to report major incidents which cause significant disruption to services or restrict service delivery and access, but lower impact events are not routinely reported.	3

Name of indicator	A/S	Short description	HECC chapter
HS3. Trust Green Plans that consider adaptation	P	All NHS trusts are required to complete Green Plans that describe plans and strategies to achieve their emission reduction and other environmental targets. Adaptation measures should be included in Green Plans by 2027; monitoring will be possible once an adaptation standard is developed since Green Plan reporting is a statutory requirement.	2, 3
HS4. Health care facilities adapted to be climate-proof	NF	To minimise distribution from severe weather such as overheating and flooding, most health care facilities need to undergo retrofitting. There is currently no system in place to monitor and evaluate if health care facilities are climate-proof (in terms of ability to mitigate adverse impacts from overheating, flooding and other extreme weather events), and criteria for classifying a facility as climate-proof have not been developed.	-

Table 1i. Social care services

Name of indicator	A/S	Short description	HECC chapter
SC1. Care home overheating incidents	NF	UK summers are getting warmer with climate change, and many buildings can experience overheating. Care home residents are particularly vulnerable to heat-related mortality and morbidity. Data on overheating is currently not routinely monitored by care homes.	2
SC2. Care homes flooded	P	Care homes are particularly at high risk from flooding due to the potential need to relocate vulnerable residents within a short timeframe. All organisations that the Care Quality Commission (CQC) regulates must report all service disruptions and a description of the trigger, but the database does not support extraction based on trigger cause. Updates to the reporting systems would be needed to achieve this indicator.	3

Table 1j. Health impacts from mitigation actions

Name of indicator	A/S	Short description	HECC chapter
M1. Mortality attributable to $PM_{2.5}$ by sector	NF	Air pollutants and greenhouse gases often have similar sources (for example, combustion processes, such as in vehicle engines, fossil fuelled power plants, or other energy generation). Outdoor air pollution constitutes of multiple types of pollutants, such as NO_2 and PM of various sizes. The Office for Health Improvement and Disparities (OHID) Public Health Outcomes Framework reports this indicator based on the anthropogenic fraction of $PM_{2.5}$, and is updated annually and calculated for each Local Authority in England. Currently it is not possible to portion pollutant exposures by sector in the UK.	4, 14
M2. Indoor air quality	NF	Changes in indoor air quality are important as people spend most of their time indoors. Increases in indoor air pollution may reflect a potential disbenefit from home energy efficiency measures that are needed to reduce carbon emissions. Indoor air quality in dwellings is not widely or systematically monitored, except radon on an as-requested basis This indicator is currently not possible due to lack of regular and frequent monitoring of indoor air quality.	5
M3. Active travel	A	Active travel is considered the most sustainable form of travel, but estimating the impacts of changes in active travel to transport related emissions are complex. Active travel can increase physical activity in the population, and policies for this exist in all devolved administrations in the UK. Annual surveys are carried out related to this and translated into indicators by multiple organisations at national and local level, however, there are some limitations to the currently available indicators.	14

3. Discussion

3.1 Legislation and policies to support monitoring

This section summarises UK and international legislation and policies relevant to the wider concept of monitoring adaptation, impact, and progress relating to climate change. A review of the policies relating to monitoring of specific areas (for example air pollution, water quality, and so on) will not be provided here since this is covered by other chapters.

The CCC has statutory obligations to monitor progress in responding to climate risks and opportunities, which includes, but is not limited to, risks to health and wellbeing. The Climate Change Act (2008) requires the Adaptation Committee to report on the progress in delivering the National Adaptation Programme every 2 years. The Climate Change (Scotland) Act 2009 also requires the CCC to report on progress on adaptation every 2 years. The Climate Change Act (Northern Ireland) 2022 only requires the CCC to provide an assessment no later than 3 years into each 5-year cycle. Wales does not have a fixed interval but can request a progress report. The monitoring framework was updated in 2023 to focus more on delivery and implementation, rather than just risk assessments and planning (25). This will potentially lead to some changes to the indicators currently used to assess health risks.

The Office for National Statistics (ONS) is responsible for collecting and publishing statistical data about the UK's society and population. This includes monitoring both the health care system and the health and well-being of the population and population sub-groups. Although some of the metrics monitored could potentially be used for monitoring impacts linked to climate change, this is not the purpose they were defined for, which limits their applicability to monitoring climate change adaptation. Currently ONS does not routinely monitor any of the indicators identified in this review. For ways to derive data for some of the identified indicators, such as combining multiple data sets, see the report in the annexe.

At the international level, the UK is required by the Paris Agreement of the UN Framework Convention on Climate Change (UNFCCC) to regularly update its Nationally Determined Contributions (NDCs) and implement measures to achieve the climate action goals. As part of this, the UK is also required to regularly report on the progress on implementing the NDCs. Including health aspects more broadly in the NDCs would lead to a mandatory monitoring of the progress on these aspects of health and climate change.

In relation to the COP process, there have been repeated requests for a more integrated and multisectoral reporting relating to health. In the COP24 special report on climate and health, the multisectoral approach used in The Lancet Countdown was highlighted since health risks feeds into nearly all sectors through the 'wider determinants of health'. It also pushed for the opportunity to incorporate health more widely into countries' NDCs, and the Sustainable

Development Goals (SDGs) as a framework to monitor advances in health and determinants of health (10).

Running up to COP27, a large number of health organisations put together a list of recommendations (26) which focused on the need to develop health metrics to measure progress towards the Global Goal on Adaptation (part of the 2015 Paris Agreement) since the health and wellbeing of populations is an outcome across all sectors. They also recommend standardised reporting on the effects on population health and wellbeing from climate finance responses to ensure impactful use of funding. This links to the statement in the COP24 report stating that the financial cost of mitigation would be more than covered if the gains for health was included in the evaluation (10).

3.2 Strengths and weaknesses of the indicators identified and issues with monitoring

There are limitations with the indicators identified and proposed in Table 1. One of the major issues is the discrepancy between what is identified as needed and what is feasible to monitor. For example, there is an urgent need for monitoring housing information to support the mitigation and adaptation policies required to reach net zero, which can only be achieved through systematic large-scale monitoring of indoor air quality to avoid unintended harms to health from home energy efficiency programmes (27).

Investment in widespread environmental monitoring is also required, and this should be focused on priorities for health and wellbeing as well as environmental impacts. The vector and food indicators require large areas of land to be monitored for ticks or pollinators by trained individuals to achieve consistent, high-quality data. Such surveys could combine a range of objectives to address several health and environmental policy goals.

Weather and environmental conditions, such as river levels or greenspace cover, are often monitored through remote sensors and satellites, and sent straight to a central database for analysis. Collecting this type of data is therefore significantly easier and cheaper compared to evaluating impacts on people or the state of their living environment. It also usually comes with the added benefit of high spatial coverage since many locations can be monitored at low cost. However, the value of remote and satellite monitoring needs to be assessed in collaboration with public health analysts to ensure relevance to health and wellbeing.

To derive their set of monitoring indicators, the Adaptation Sub-Committee of the CCC (ASC) first identified the relevant impacts to focus on and created a list of ‘ideal indicators’ without considering any practical constraints. The next step involved extracting a subset of ‘proposed indicators’ that could realistically be monitored, thus reflecting the difficulty of monitoring many indicators (28). This demonstrates a maturing process to define a set of indicators which can

capture the most important aspects and be collected over a longer period within a restricted budget.

When moving from research settings to the production of evaluations as part of public health service operations, the issue of governance for choice and use of indicators, and related data collection becomes crucial. An inclusive and well configured process is required to avoid duplication of effort and potentially confusing communication emerging from specific evaluations, such as attributable deaths or other model-based outcomes.

As highlighted in Table 1, most of the indicators identified are currently not available within current data systems. For some of the indicators this is due to the data currently not being collected (for example, indicators W1, V3, and HS3), or being available in a format that is not user-friendly (for example indicator F1, H8, FS2). This was also highlighted by the CCC, which noted the general issue of limited collection of health data which could be used to evaluate the impact from flooding, changes in the overall climate, and climate anxiety (29). Obtaining data in a user-friendly format would require a significant amount of time and resources but could be addressed if given priority and sufficient funding. Making the data openly accessible, however, is more difficult, especially if there are privacy concerns and or financial reasons that will impede making the data freely available. Data collected by public agencies can often be shared with other government departments through data sharing agreements, but without a common central database this can still prove difficult. An increasing amount of important data is also collected and stored by private companies (see for example indicator F5), which may have limited incentive to share.

The difference in data format and the need to download it from multiple platforms can also be a barrier for efficient working due to the time and skills required. The UKHSA Environmental Public Health Surveillance System (EPHSS) is a good starting point to address this issue; for example, by putting health outcomes and weather data on the same platform to support integrated research and monitoring. However, the need for a more integrated monitoring system is also highlighted in relation to the EPHSS system, since interventions in the housing, transport and energy sector have substantial public health implications, but are not monitored by UKHSA and therefore not yet available on the system (30).

Linked to these issues is the limited scope of the indicators listed in Table 1 for some exposures, with more indicators required on morbidity impacts from climate change associated with mental health and other health conditions. Stakeholder engagement has previously emphasised the important of action or process indicators. However, there is also limited scope in the action indicators (such as H8, F9, and E5), which so far are mainly focused on developing plans or guidelines, although developing a plan does not necessarily lead to a change in practice (31). This is partly because adaptation strategies and measures are at an early stage of development in some areas. Adding to this, only one of the action points identified is currently available (HS4; see Table 1) with the remaining requiring processing of existing data, updating reporting systems, or additional data being collected.

The issue of only having indicators for some areas of a monitoring framework (here exposure, vulnerability, outcome, action) has been noted for the framework used here and in the CCC's adaptation monitoring framework (25). The indicators summarised in Table 1 are mainly monitoring changes in hazards and vulnerability, but fewer measure action. In the CCC framework, by classifying all the indicators used (not specifically health focused) according to the 5 parts of the 'Theory of Change' framework, the CCC found that the vast majority of the indicators measured 'Action' (the input parameter) but very few measured 'Outcomes' which they deemed the essential part for adaptation monitoring (32). The CCC concluded that some indicators were initially designed for other purposes than to measure changes in risk vulnerability, which means that they are not the best to monitor adaptation progress. Similarly, indicators used in public health climate change monitoring were also designed for other purposes since environmental health monitoring has been in place for many years and therefore already has a time series of records. However, these indicators were designed to monitor the link between changes in the environment in a 'steady-state climate' and not under climate change (18).

Many national organisations are in the process of updating their reporting and monitoring to reflect already experienced or anticipated impacts from climate change. NHS England has been collecting data on overheating and already reports all major incidents causing significant disruption to services, such as major flooding events. New metrics are currently being developed by both Greener NHS and the regulatory body of care homes to collect data from weather events which have a negative impact on services without disrupting them, to better understand the changes in occurrence and frequency of such weather events. The EA published a collection of indicators for measuring resilience to flooding and coastal change in autumn 2022, including some of the topics listed here such as proportion of properties in 'at risk' areas without home, business and contents flood insurance coverage (33). Furthermore, the NCERM is being updated in the summer of 2024 to provide more in-depth information on coastal erosion risks. However, as highlighted in the review, there is a long way to go from initial development of an indicator until it is fully operational and enough data is collected to support a monitoring system.

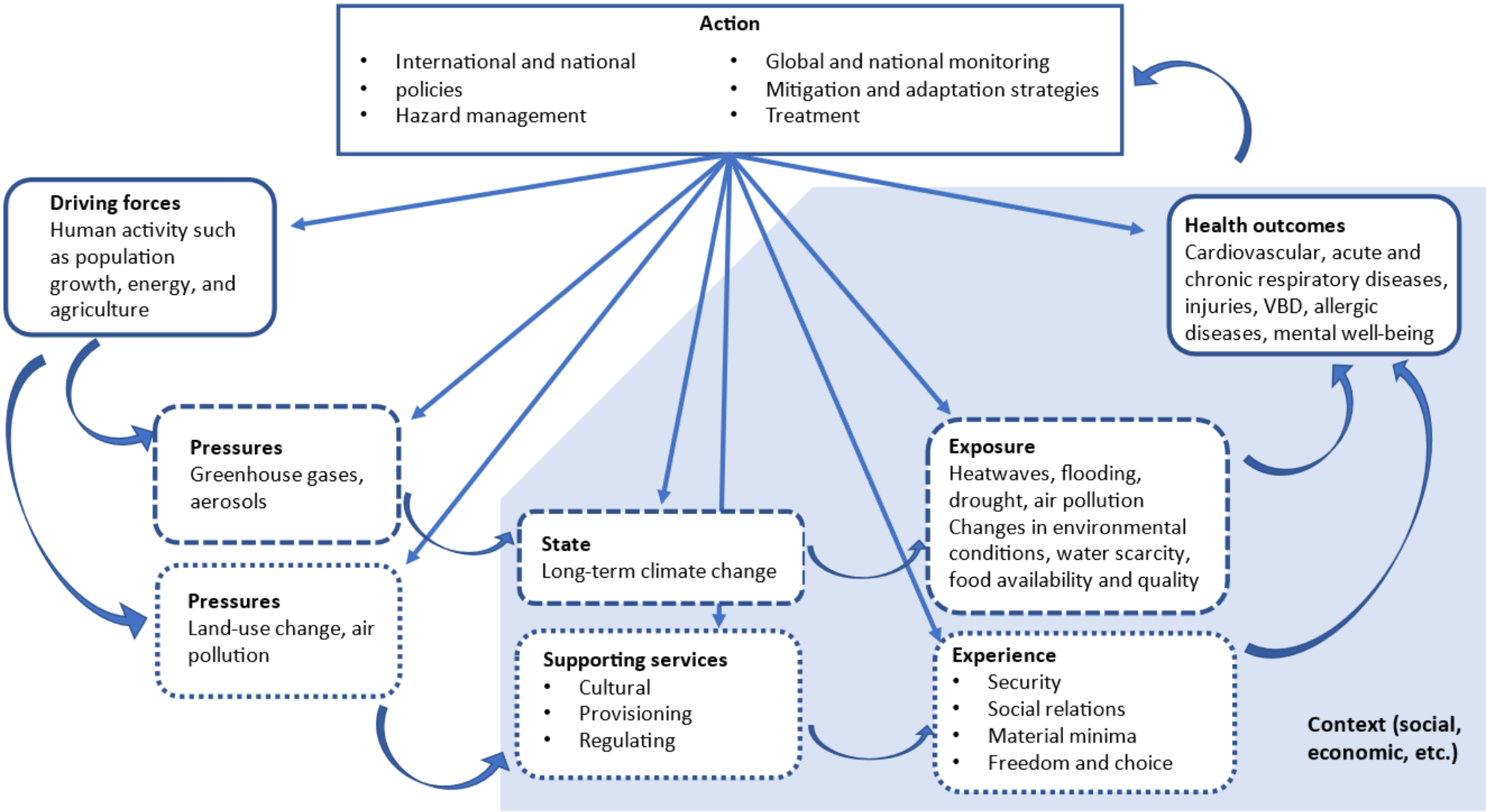
3.3 Framework to develop future indicators

Notwithstanding the comprehensive list of indicators already available, it is clear there are still important gaps in our ability to measure climate and health mitigation and adaptation. New indicators will be required to measure the full impact of climate on population health and the wider ecosystems on which it depends. The development of indicators in this report used the 'exposure, vulnerability, outcome and action' framework. However, in the process, the strengths and weaknesses of suitable indicator frameworks were also identified. Thus, arising from this process, future indicator development should take a broader approach. A review of possible broader frameworks for developing environmental health indicators for climate change and health identified several attributes that would characterise the value of any such framework (18). The review then considered several options for such framework, such as the burden of disease,

health impact assessment, or DPSEEA (drivers, pressures, state, exposures, effects, actions) approach, and concluded that DPSEEA was the only framework that can potentially address all attributes identified. Thus, the ecosystems enriched DPSEEA (eDPSEEA) framework (34) may be a good starting point to help extend the range of climate and health metrics and increase their value for monitoring progress toward adaptation and mitigation. This framework explicitly states how environmental health encompasses both the proximal environmental determinants of health and wellbeing as well as the ‘upstream’ drivers, pressures, and states of such determinants (see Figure 1 for examples). By broadening the scope for understanding the pathways to social and health impacts, the eDPSEEA framework makes it explicit that there are several levels at which interventions can be designed to reduce such impacts. This would broaden the scope for effective action. UKHSA and its partners could consider taking up the task of reviewing eDPSEEA alongside other broader framework for identification, development, delivery and use of environmental health indicators for climate change and health.

The breadth of indicators already available, albeit at different stages of development, together with the considerations of indicators currently missing, compellingly demonstrate the intersectoral nature of climate and health indicators. Mapping stakeholders and working across organisational and sectoral boundaries is at the core of public health. Therefore, public health professionals and agencies, including UKHSA, are well placed to lead this programme of work. In the first instance, there is a requirement to identify key stakeholders. For England, these would include ONS, Defra, EA, FSA, the Local Government Association, and the Met Office. These agencies have distinct remits and scope for intervention, and the scope for public health impacts of their activities in relation to climate change would need to be recognised before appropriate metrics could be defined, that are relevant to the requirements of public health analysis over time. These stakeholders collect different types of data that are critical to fully understand the extent of mitigation and adaptation and the effects on health. Therefore, a partnership of public health and other agencies will require development and resources to progress toward more effective indicators of climate change relevant to public health.

Figure 1. eDPSEEA framework applied to climate change, adapted from (18, 34)



Text version of Figure 1.

A list of climate change-related actions such as policies, hazard management and monitoring, which influence all other levels.

There are 2 routes, with both sharing the 2 levels: 1) driving forces (such as population growth and agriculture) and 2) health outcomes (both acute and chronic).

The climate route also includes pressures (greenhouse gases, aerosols), state (long-term climate change), and exposure (such as heatwaves, water scarcity, and quality of food).

The ecosystems route includes pressures (land-use change, air pollution), supporting services (cultural, provisioning and regulating), and experience (security, social relations, material minima, and freedom and choice).

End of text version of Figure 1.

4. Future priorities

4.1 Research priorities

The discussion clearly highlights the need for a wider span of indicators for monitoring impacts on health from climate change, whilst keeping the number of indicators manageable. There is also a strong need for improved accuracy and reliability of many of the indicators included in Table 1. Research to develop methods of defining the need for collecting and analysing comprehensive data to support the development of new indicators, and improving the accuracy and reliability of currently available indicators is therefore needed. There is further a need to develop indicators encompassing the areas in the eDPSEEA framework which are currently lacking available indicators. These are driving forces, pressures, and states with explicit links to available action by members of the public, private sector, and different levels of government. To promote action, from both the public and policymakers, research is needed to investigate how to effectively communicate indicators to diverse audiences.

More research is needed on the impact of climate change across population subgroups. For instance, those experiencing deprivation are more likely to lack the means and resources to adapt to extreme weather events and live in areas that lack access to green and blue spaces. They are also less likely to be able to take part in mitigation efforts due to lack of information and resources as, for example, plant-based diets and electric cars remain more expensive than meat-based diets and petrol cars. It is thus expected that climate change will exacerbate pre-existing health inequalities. Although most indicators currently available reflect population averages, this can hide important inequalities in exposure and outcomes across subgroups based on age, sex, deprivation, and ethnicity. Therefore, further research is needed to better understand these inequalities and hence inform targeted policy and action.

4.2 Implications for public health practice

Working across organisational and sectorial boundaries is a key component of public health. Public health professionals are therefore well placed to coordinate intersectoral and multidisciplinary action to promote and use new and wider-spanning indicators. They have a role in supporting policies that are expected to improve climate and health indicators.

Public health professionals could also use their contact with the public and other professionals to raise awareness on the critical importance of public health surveillance, that would monitor climate and health indicators to inform action towards adaptation and support related policies. They could also use their influence to raise awareness about the many routes climate change can impact on health, and the value of monitoring preventable exposures as well as observed health impacts.

Acronyms and abbreviations

Abbreviation	Meaning
CCC	Climate Change Committee
COP	Conference of Parties
Defra	Department for the Environment, Food and Rural Affairs
DPSEEA	drivers, pressures, state, exposures, effects, actions
EA	Environment Agency
eDPSEEA	ecosystems enriched DPSEEA
EPHT	Environmental Public Health Tracking
FSA	Food Standards Agency
GI	green infrastructure
HECC	Health Effects of Climate Change in the UK report
LRF	local resilience forum
NDCs	national determined contributions
ONS	Office for National Statistics
PM	particulate matter
UKHSA	UK Health Security Agency
UV	ultraviolet

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