Written evidence submitted by the Met Office Academic Partnership (MOAP) cross-institutional working group on Climate Change and Health

The Met Office Academic Partnership (MOAP), brings together research excellence from the Met Office and leading UK universities, while reaching scientists in other sectors including health, technology, artificial intelligence, and the social sciences, to advance weather and climate science.

MOAP institutions involved in this submission: University of Bristol (lead for Climate Change and Health), University of Birmingham, University of Edinburgh, University of Leeds, University of Oxford, UCL and the Met Office

This submission draws on research expertise in weather and climate science, epidemiology and social science, and includes both the current evidence base and ongoing research. Contributors would welcome the opportunity to provide further evidence to the committee. Further details of individual expertise are provided following the inquiry responses.

Executive Summary

Extensive evidence exists for the negative impact of extreme and moderate heat on UK health, both mortality and morbidity. Although extreme heat causes more serious health outcomes, the health outcomes of moderate heat are also considerable. Future UK climate projections show increases in the frequency of extremely hot days and nights and the UK has more days in the year of moderate heat therefore **a dedicated UK Heat Resilience Strategy to facilitate adaptation to both extreme and moderate heat would be beneficial for future UK health outcomes.**

Older people and those with underlying health conditions are most at risk from extreme and moderate heat, as are groups spending significant time outside (e.g. construction workers or the homeless). Further **research and evaluation of heat-health warning systems, responsible messaging from traditional and social media, and cooling strategies are needed** to identify the most effective approaches to reduce heat mortality.

Heat risk and vulnerability also vary across geographic scales, notably higher in urban compared to rural areas. **Data informed decision-making tools can support government and local authorities** to identify high risk groups and areas and plan effective adaptation and mitigation measures.

Effective urban planning and design, along with building regulation, can mitigate overheating risk and support communities to adapt to increasing temperatures. Green infrastructure is highly effective in minimising overheating risk and should be more widely adopted in urban planning and design. Heat resilience is regulated in new building design, however, retrofitting existing building stock must address overheating and ventilation risks in conjunction with winter energy efficiency.

This document will lay out responses to the following questions which are of interest to the committee:

1. What evidence exists on the relationship between heat and human health (mortality and morbidity), and which communities are worst affected?
2. What actions can be taken to protect those most vulnerable to the impacts of extreme heat?
3. Does the current planning framework do enough to encourage heat resilience measures such as cooling shelters, water bodies, green infrastructure and shading to be integrated into urban planning? Where such measures are incorporated, how accessible and successful are they?
4. What can be done to protect the UK's existing public and private sector housing stock from the impacts of extreme heat while ensuring that homes are sufficiently warm in the winter months?
5. Does the Government's Future Homes Standard adequately consider overheating in homes? If not, what additional elements should it include?
6. How effectively is the Government working across departments and with local authorities to ensure a coordinated approach is taken to heat resilience?
7. Does the UK need a dedicated Heat Resilience Strategy? What lessons can be learned from other nations when it comes to national strategies for heat resilience?

Inquiry Responses

1. What evidence exists on the relationship between heat and human health (mortality and morbidity), and which communities are worst affected?

1.1 Evidence between heat and human health

Most UK summers result in 1,000-3,000 heat-related deaths (Lo et al, 2022), 8,000-9,000 heat-related emergency hospital admissions (Rizmie et al, 2022), and an increase in accident and emergency department attendances (Corcuera Hotz & Hajat, 2020). In England and Wales, for each 1°C rise in temperature, a 2% increase in mortality has been reported (Gasparrini et al, 2012). These deaths are predominantly from cardiovascular failure and respiratory problems; both from overwhelming the thermoregulation within the body.

The effects of heat on morbidity can range from acute to medium and long-term. While extreme heat causes more serious health outcomes, moderate heat can also have serious negative impacts and the UK has more days in the year in moderate heat conditions (Jenkins et al, 2022). A determinantal heat-health link has been found in all administrative regions of the UK, even in the coldest UK climates like Scotland (Wan et al, 2022).

Heat 'stress' also amplifies mental health problems, including those related to domestic violence, alcoholism, sleep disorders, and concentration and accidents. In England and Wales, some evidence of an increased risk of suicide has been found (Page et al, 2007). The highest increase in injury risk is from drowning and assaults. There is also evidence for adverse pregnancy and birth outcomes with heat extremes (Chersich et al, 2020). Longer-term exposures of heat on health and compound heat-pollution effects are less studied, but there is some evidence of association with respiratory outcomes and comorbidities (Zafeiratou et al, 2021, Warkentin et al, 2023). Examples where there is a known link, but not accurate estimates of the change in risk with climate change, are related to long-term renal (kidney) problems, sleep-related risks such as dementia, and cancer-related risks, such as behavioural changes that lead to more UV exposure, although the latter is highly uncertain.

This MOAP cross-institutional working group on Climate and Health are currently reviewing published evidence and performing novel research through analysis of expert opinion data regarding UK weather and climate hazards, including heat and cold, and health outcomes that lead to mortality. We expect to publish this review over the next six months and experts from across the working-group would be pleased to offer further insight to the committee.

1.2 Which communities are worst affected?

Specific communities that are at greater risk during both moderate and extreme heat events include older people, young children and those with underlying health conditions (Arbuthnott & Hajat, 2017). Older people, often considered as over 65 years of age in the literature, are far more at-risk than younger generations, with 1 in every 2,000 over 85's dying from heat every year (Jenkins et al, 2022) . During the 2003 and 2013 UK heatwaves, a moderate increase in the number of NHS direct calls was seen for the younger age groups (0-4 and 4-14 years) (Smith et al, 2016), and an 11% increase in paediatric trauma admissions was found for every 5°C rise in temperature (Parsons et al, 2011). Those with underlying health conditions, also present increased risk during high heat events. Notable parts of this community that are most effected are those in care homes, physiatry hospitals, and prisons, although some of this evidence comes from countries outside the UK (Arbuthnott & Hajat, 2017). Research from the UK and elsewhere highlights that 'outdoor' communities, such as homeless people, the military, sports players and construction workers, have higher exposure to heat, and are therefore more commonly affected through negative health outcomes, normally related to heat stroke which leads to loss in productivity, morbidity, and mortality (Flouris et al, 2018). Some individuals who are at risk may not consider themselves to be so. Culturally, people living in the UK have a tendency to stick to habits and routines, so adaptation strategies, such as exercising at cooler times of the day, are often not adopted. Studies have shown heat to have physiological impacts on the study participants, despite them self-reporting to be broadly comfortable (Waldock et al, 2018; Gupta et al, 2021).

Geographic variation

The trapping of heat in cities, known as the urban heat island effect, means that city mortality and morbidity is higher than rural mortality and morbidity, even when normalised by the local population. Estimates during one of the most extreme UK heatwaves (2003) suggest this city heat trapping effect could account for around 50% of the total mortality (Heaviside et al, 2016). Heat risk also varies across geographic communities shown in studies at both city (Met Office et al, 2022) and UK (Kennedy-Asser et al, 2022) scales. Across all 376 districts in England and Wales, those in London and south/southeast England were found to have an increased risk of cardiovascular heat-death for a 1 °C rise in temperature as compared to districts in the far north (Bennett et al, 2014).

2. What actions can be taken to protect those most vulnerable to the impacts of extreme heat?

2.1 Communication of health-risks

In the UK, the policy-level healthcare response to heat is in the form of heat warning systems (HWS). In 2022, the hottest summer recorded in England, the first ever Level 4 Heat-Health Alert (HHA) was issued for a record number of days. 2022 also observed the highest heat mortality since the introduction of the Heatwave Plan for England, and the HHA system in 2004, with 2,985 excess deaths (UKHSA and ONS, 2023).

Many UK residents have positive or ambivalent feelings towards the prospect of hot summers that can suppress the effectiveness of heat health protection messaging and diminish uptake of heat protection behaviours (Lefevre et al, 2015), though there is evidence that concern about hot summers is increasing (Steentjes et al, 2020). Messaging highlighting the unpleasant aspects of hot weather have been found to increase intention to engage in heat protection behaviours (Bruine de Bruin et al, 2016).

Despite being most at risk, older people were least likely to take some personal or home protective measures during the 2013 heatwave (Khare et al, 2015). An Australian study characterised six sub-groups or 'thermal personalities' within older people, based on factors including personal characteristics, beliefs and house type, which were used to communicate potential adaptation options (University of Adelaide, 2021).

Encouraging behavioural changes during extreme heat events can provide low or no cost solutions to some risk factors. For example, in many UK houses, bedrooms are not the coolest rooms in the house, and during extreme events, sleeping in a cooler 'safe haven' room can offer respite (Drury et al. 2021).

Reducing misinformation can also save lives. The 2022 UK heatwave was a clear example of this, where, although well-informed and timely advice provided by the UK Government and trusted sources such as the Met Office and UK Health Security Agency were critical to keeping the population safe, some influential traditional media outlets and social media influencers accused meteorologists of being alarmist 'harbingers of doom', downplaying ill health from heat, and causing confusion in the general public (Mitchell and Lo, 2022).

A global review of heat-mortality attributed decreased heat sensitivity to factors including implementation of heat warning systems, increased awareness, and improved cooling strategies (Sheridan & Allen, 2018). However, evidence of the effectiveness of these systems and strategies, is limited and ambivalent. Further research and evaluation is warranted to understand their impact on heat-mortality and morbidity reduction.

2.2 Guidance for workplaces, care settings, and schools

Current UK health and safety guidance for workplace temperatures provides advice for minimum limits but not maximums. For employers it is important that extra precautions and provisions are made during moderate as well as extreme heat events, particularly for sectors where staff are physically active, working outside or wearing personal protective equipment (PPE).

In care settings precautions are required for both staff and residents (case study: Kennedy-Asser, 2022). Managers reported ensuring staff took longer breaks and spent time outside on hot days. Although this may represent a drop in productivity, it is likely more cost effective than installing cooling systems. Fluids taken in by residents are closely monitored and during periods of extreme heat drinks can substituted for ice lollies or other frozen drinks to ensure they are taking enough fluids and to keep them cool.

Ongoing projects from the UK Climate Resilience (UKCR) Programme (UKRI and Met Office) are quantifying climate risks to build resilience and generate usable outputs to directly support decision-making:

i) ClimaCare: Climate Resilience of Care Settings

People aged over 65 years spend more than 80% of their time in residential environments or care settings, and people aged over 85 years more than 90% therefore, the indoor environment is a huge moderator of heat exposure in older populations. The ClimaCare project is developing methods to assess future overheating risk and the potential of passive strategies to reduce these risks (UKCR ClimaCare project, UCL).

ii) Overheating in Schools

As part of their current annual climate risk assessment and adaptation strategy, the Department for Education (DfE) are considering the impact of heat on loss of learning in schools. A novel Met Office framework using the CLIMADA open-source climate risk assessment platform (Dawkins et al, 2023) is being applied to school building stock modelling (UKCR ARID project, UCL) and combined with DfE building condition data (Condition Data Collection 2 (CDC2)), to assess current and future indoor temperature risk in schools and inform DfE policy planning.

2.3 Urban planning and design

Heat vulnerability is not routinely considered within urban planning and design. Consequently, new homes are built in neighbourhoods that may be prone to overheating, with inadequate public realm spaces that do not provide thermal regulation, using building materials that do not offer cooling. In Birmingham, the local authority and the University of Birmingham have co-developed a Climate Risk and Vulnerability Assessment (CRVA) mapping tool that identifies those areas of the city which are at higher risk of overheating (along with other climate risks). The CRVA is currently being used to understand whether ongoing and proposed developments increase or decrease the climate (and therefore overheating) risk and vulnerability of an area. In the future it will be used to target interventions in areas experiencing greater climate risk and ensure developments are more climate resilient. The CRVA approach uses open access datasets and can be replicated by local authorities in England using the same datasets, or more broadly using locally relevant datasets (Greenham et al, 2023; Ferranti et al, in review).

Street trees and urban green spaces can provide areas of respite from the heat and contribute to the overall lowering of temperatures within a city. Estimates for European cities suggest increasing tree coverage to 30% would reduce temperatures by 0·4°C and prevent 2,644 premature deaths (Iungman et al, 2023). Further evidence of green infrastructure for heat resilience is provided in section 3.

2.4 Public cool spaces

In London (Cool Spaces Initiative, 2023), and Madrid (Climate Shelters, 2023) designated and publicised ‘cool spaces’ including indoor spaces (some air conditioned) and outdoor areas with tree cover or alongside waterways, provide opportunity for refuge during heat events. In parts of Australia, local councils provided free travel for residents to local swimming pools (Dufty, 2022).

3. **Does the current planning framework do enough to encourage heat resilience measures such as cooling shelters, water bodies, green infrastructure and shading to be integrated into urban planning? Where such measures are incorporated, how accessible and successful are they?**

Spatial development plans set by devolved regional governments contain policies directly relating to heat resilience measures, including provision of shade, green spaces, and use of preferred cooling strategies. Local plans typically do mention adaptation to climate change, and heat as a risk, but are less likely to identify specific measures that may need to be taken.

Green infrastructure, including trees, green roofs, parks, gardens, within public and private settings, provides cooling in several ways (Vaz Monterio et al, 2019):

- Shade: trees provide ground-level shade for people, reducing mean radiant temperatures by ~ 4°C (Armson et al, 2013) and thereby improving thermal comfort. They can also cool lower stories of building reducing cooling demand (Zhao et al, 2017) and improving indoor thermal comfort (Taleghani et al, 2019).
- Increasing the sky view factor: whilst open parkland and gardens are hot in the direct sunlight, these open spaces cool more effectively at nighttime as heat is lost via radiative cooling (loss of long-wave radiation). Green spaces >0.5ha provide cooling; to provide cooling on an urban scale, green spaces need to be close together – modelling suggests greenspaces of 3–5 ha need to be placed about 100–150 m apart (Vaz Monterio et al, 2019).
- Evapotranspiration turns heat energy into water providing cooling. Sufficient access to water is essential for vegetation to provide cooling by evapotranspiration. Modelling of urban trees in Zurich indicated the cooling effect by evapotranspiration alone to be in the order of 1°C (Meili et al, 2019).
- Lower heat storage: Vegetation has a lower heat capacity than other objects in urban areas (e.g. buildings) and therefore stores less heat during the daytime, and consequently has less heat to release at night, when the urban heat island effect is most pronounced.

Green space and trees, and consequently cooling benefits, are not equally distributed across urban areas; more deprived areas have less green space (Chakraborty et al, 2019). The Trees and Design Action Group (TDAG) suggests practical steps to assess heat within urban planning and design, with a focus on the role of trees and green infrastructure (Ferranti et al. 2021).

Cool roofs, made from more reflective surfaces or as a green roof, are estimated to cool urban outdoor temperatures by 0.5 °C on average (Macintyre and Heaviside, 2019). Building energy modelling suggests that reflective roof surfaces make a large difference to indoor summer temperatures or cooling demand when added to poorly insulated roofs, but a well-insulated roof with a reflective coating appears to be most effective overall (Virk et al, 2015). However, reflected solar radiation can also reduce thermal comfort, particularly in the early-to-mid afternoon hours, implying that they cannot substitute for vegetation, green infrastructure or shade as a single urban cooling solution (Middel et al, 2020). Built structures providing shade are also effective (Turner et al, 2023).

4. What can be done to protect the UK's existing public and private sector housing stock from the impacts of extreme heat while ensuring that homes are sufficiently warm in the winter months?

Retrofitting to improve winter energy efficiency raises concern about the impacts on summertime overheating risk and unintended consequences of newly airtight buildings where sufficient ventilation is not maintained. Lower rates of air exchange coupled with solar gain can lead to a rise in overheating, humidity, mould and allergen prevalence, and infectious disease (Bouzarovski and Robinson, 2022), and these health problems may emerge in the future as critical for the UK population (MOAP, unpublished review). Retrofitting of homes should be holistic, considering how insulation can be improved whilst maintaining or improving ventilation, for example mechanical ventilation with heat recovery systems (Centre for Sustainable Justice, 2022).

For existing buildings, a simple and effective retrofit is to add external shutters to windows. A modelling study of the residential housing stock in the West Midlands estimated that external shutters could reduce the risk of heat mortality by around 40% (Taylor et al, 2018).

Air-conditioning provides a similar level of heat mortality reduction (Francesco et al, 2020) but is less likely to be sufficient to mitigate building-related heat stress as it is unaffordable to many households, especially in the context of high energy bills. Air conditioning also negates one of the overarching goals of energy efficiency policies, which is to reduce overall energy demand.

5. Does the Government's Future Homes Standard adequately consider overheating in homes? If not, what additional elements should it include?

Overheating cannot be considered in isolation. If homes are tightly insulated and not well ventilated then other risks arise: such as mould and poor indoor air quality. A consultation on the Future Homes Standard led to proposals for a Future Buildings Standard (2021) which includes mitigation against overheating in residential buildings. Supporting documentation addresses overheating and also covers ventilation and limiting solar gains. However, requirements apply only to new residential buildings and most existing buildings do not meet the new standards (Climate Change Committee/ARUP, 2022). Existing buildings are largely not addressed by current policy.

Cooling needs are only included in the Standard Assessment Procedure (SAP) ratings for buildings that have fixed cooling systems. This means that the SAP does not address cooling needs for most buildings.

6. How effectively is the Government working across departments and with local authorities to ensure a coordinated approach is taken to heat resilience?

Enhancing heat resilience requires timely, reliable and accessible evidence to provide nuanced information about risks and resilience according to individual and household characteristics and indoor and outdoor exposure factors. Interactive web tools providing information on future changes to indicators of climate risk across the UK to supporting decision making are exemplars of co-ordination across sectors to tackle heat resilience.

i. Climate Risk Indicators (University of Reading & Met Office) provides information at scales ranging from the district to the four nations of the UK. Users can plot maps showing the variation in indicators across the UK and can plot and download time series for specific locations.

ii. Climate Risk and Vulnerability Assessment (CRVA) (University of Birmingham & Birmingham City Council) identifies those areas of the city which are at higher risk of overheating (along with other climate risks).

iii. Keep Bristol Cool Mapping Tool (Met Office, University of Manchester & Bristol City Council)

7. Does the UK need a dedicated Heat Resilience Strategy? What lessons can be learned from other nations when it comes to national strategies for heat resilience?

A dedicated UK Heat Resilience Strategy would support reducing mortality and morbidity associated with both extreme and moderate heat.

The latest UK climate projections show increases in the frequency of extremely hot days and nights, with a UK increase in hot days of between 5 and 39 days per year (Hanlon et al, 2021). Extremely hot nights, which are currently rare, are emerging as more common occurrences and the frequency of high daily temperatures increases systematically. Scotland, where high temperatures above 30°C are historically rare have substantially increased risk of such high temperatures (Undorf et al, 2020). Research in China suggests that combined hot day and nights have greater mortality then either individually (Wang et al, 2021) with such events becoming more common as global temperatures increase (Wang et al, 2020) suggesting the need to prepare for, as yet, unseen temperature extremes. A global analysis of county's that are most 'at-risk' to extreme heat showed that we are often under-estimating the most extreme heatwaves in our climate analysis. In that study, led by the University of Bristol, it was showed that the UK has had one of the most exceptional events, the 2022 summer heatwave, so has a good 'working memory' of extreme heat (Thomson et al, 2023). Even stabilisation of global temperatures at 2°C above pre-industrial values will cause a substantial increase in the risk of extreme heatwaves, with estimates suggesting heat-related mortality of 3,000-4,000 being an average UK summer (Jenkins et al, 2022).

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