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

1. There is a strong body of evidence that excess heat is extremely detrimental to human health. The European heatwave of 2003 saw an estimated 70,000 excess deaths[i]. Similar numbers have been found for the more recent 2022 European heatwave, with one study published in the prestigious journal Nature estimating 61,672 heat-related deaths in Europe between 30 May and 4 September 2022[ii]. The 1995 Chicago heatwave officially claimed over 700 lives in the city, although the figure is likely to be higher[iii].

2. The mechanisms through which excess heat leads to increased morbidity and mortality are also well-established. When body temperature rises above 38 degrees Celsius, a person is at risk of heat exhaustion which impairs their physical and cognitive functioning; when body temperature rises to 40.6 degrees Celsius, a person experiences heat stroke – a life-threatening illness that leads to organ damage and loss of consciousness[iv]. Excess temperatures also increase the risk of dehydration, which has its own health impacts, and can also have harmful impacts on mental health and well-being[v].

3. Three groups are known to be particularly sensitive to the harmful effects of excess heat should they encounter it [iii, v, vi]:
    (1) those with pre-existing health conditions, particularly those relating to the respiratory or circulatory systems;
    (2) older people (>75); and
    (3) children, due to a decreased bodily capacity for thermal regulation.

4. The study on the 2022 European heatwave found that there were 56% more heat-related deaths in women than men[ii], although it is not clear whether this is due to biological differences in the susceptibility to high temperatures, or to greater exposure to extreme heat (e.g. due to socially-constructed gender norms that see women spend a greater proportion of time indoors at a time when homes are overheating).

## Question 2: How can sustainable cooling solutions and adaptation strategies be implemented in such a way as to minimise overheating, reduce energy consumption and prevent overloading of the electricity grid during peak demand?

1. As a general principle, "passive cooling" solutions (those which require no artificial energy input) should be prioritised and used as far as practical and possible.

2. Air conditioning or other artificial cooling systems can exacerbate local "heat islands" and worsen heatwave conditions locally as they are essentially warming up the air outside to cool temperatures indoors. Therefore, their widespread usage will exacerbate heatwave conditions locally, which may be particularly problematic for lower-income groups who would be less likely to afford and use air conditioning in their homes. Air conditioning can also contribute to wider climate change (through increasing energy consumption and so potentially burning of fossil fuels, heightened the risk of overloading the electrical grid.

3. There are two scales at which passive cooling solutions can be adopted:
    a. **In the design of individual homes**[v]
        i. Shading devices (ideally external such as shutters, awnings and pergolas, or shading from trees) over south- and west- facing windows can play a key role reducing direct sunlight exposure inside a home, thus minimising the greenhouse effect and reducing temperatures significantly.
        ii. Increasing ventilation, by incorporating windows that open sufficiently and across multiple aspects.
        iii. Cool-coloured coatings or surface treatments buildings and roofs to reflect a larger proportion of solar radiation (as is common in many southern Mediterranean counties, where homes are painted white). The Cool Roofs initiative in New York City, which has involved painting the roofs of buildings a highly reflective white, has been found to reduce indoor temperatures by up to 30%[vii];
        iv. Installing insulation in the walls and roof space of a home. Insulation is not only highly effective and keeping heat inside a home during the winter but can also keep excess heat *outside* during periods of high temperatures.[viii]
    b. **Beyond the home**, it is also crucial take measures at the wider neighbourhood level to reduce overheating and build resilience. This can include:
        i. <u>Adaptation of the built environment to reduce localised heat islands.</u> Adaptations here can include lighter coloured buildings, pavements, and other surfaces - currently, materials used for these are often darker colours which absorb high proportion of solar radiation before releasing this as heat. Lighter coloured surfaces can reduce temperatures by several degrees. This can be achieved either by using building materials that are lighter in colour (e.g., cement concrete rather than asphalt), or ideally cool-coloured coatings or surface treatments to existing surfaces. One piece of research at the Berkeley

Lab in California[ix] has found that "cool pavements" can increase solar reflectance to between 30-50%, compared to only 5% for a traditional asphalt surface, making important reductions in the temperatures of urban neighbourhoods and thus reducing heatwave risks. Another study in Los Angeles found that painting pavements with a light-coloured coating cooled the streets by 1-2C.[x]

ii. Other research has also emphasised the important role that <u>vegetation and green space</u> can play in reducing urban temperatures.[xi] [,xii, xiii] Trees and other vegetation cool temperatures by providing shading from direct sunlight, and by releasing water vapour into the air through evapotranspiration. This can involve both dedicated parks and green spaces, which provide important cool spaces during heat waves, but also "green infrastructure" that is integrated into the built environment - such as street trees, green roofs and walls. One study found that neighbourhoods within a 10-minute walk of a park are as much as 3C cooler than areas outside that range[ix]. Another study mapping land surface temperatures during heatwaves among 10 cities across the globe found that areas with high proportions of trees and water cover correspond to cooler temperatures, by up to 12C in some places[xi].

iii. <u>Community-based cool spaces and buildings</u>, which are open and accessible as public spaces during heatwaves, can offer people an escape from an overheating home. Cool spaces can be air-conditioned buildings or centres, such as churches, schools, libraries, shopping centres, or other civic/communal buildings. Because only a single space requires air conditioning, this is many times more efficient and less energy-demanding than using air conditioning on multiple individual homes. These spaces can also offer water and other protective services and facilities to assist people during heatwaves. They would effectively operate in a similar way to existing “Warm Banks” that have recently be used during the winter months to help people keep warm.[xiv]

iv. <u>Reducing car use and car dependency</u>, because cars are a key contributor to local urban heat islands and so exacerbate heatwave conditions.[xv] They do this by releasing latent heat from engines and by causing particulate pollutants that "trap" heat within the urban environment. Reducing car use and promoting alternative transport modes is thus an important part of reducing heatwave vulnerability, as well as contributing to broader climate change and net zero targets.

v. <u>Investing in the “social infrastructure” of cities, towns and neighbourhoods.</u> Research by Professor Eric Klinenberg at the University of Chicago has demonstrated the central importance of "social infrastructure" and community cohesion in protecting the most vulnerable during heatwaves [iii]. Social infrastructure refers to the shared physical spaces that influence how people interact and allow bonds to develop. His research powerfully demonstrates that a

community's resilience strongly correlates with the robustness of its social infrastructure. Healthy and high-quality social infrastructure fosters contact, social ties and networks of mutual support that can be drawn upon in times of crisis – including during heatwaves or other disasters.[xvi] In contrast, degraded, run-down and disinvested social infrastructure discourages and inhibits social activity, leaving households and individuals to fend for themselves. This is particularly important for protecting the most vulnerable during heatwave events. Among the most vulnerable people are those who are socially isolated and feel unable to escape an overheating home, and whom do not have contacts of support that can assist them or check on their wellbeing. Healthy social infrastructure can reduce social isolation and thus vulnerability among such groups[ix].

## Question 3: What actions can be taken to protect those most vulnerable to the impacts of extreme heat?

1. Those most vulnerable to extreme heat could be prioritised for home retrofits of cooling measures, including both passive measures (e.g. shutters, awnings, ventilation) and the installation of reverse cycle Air-Source Heat Pumps that can be used for energy-efficient heating and cooling. This prioritisation could include, for example:
    a. guidelines or mandates for social housing providers regarding the installation of cooling measures, since this sector houses a high proportion of people who might be deemed vulnerable.
    b. making grants or low-interest loans available to low-income and vulnerable homeowners that fund the purchase and installation of cooling measures. This could be accompanied by a national advice programme, potentially integrated with existing fuel poverty advice schemes, that inform people of the measures that can be taken to reduce overheating risks in their home.

2. Beyond individual homes, steps could also be taken to prioritise the most vulnerable when making changes at the wider neighbourhood level. For example, the development of community cooling centres, the provision of green infrastructure and green space, plans to reduce car dependency, and investments in "social infrastructure" could all be designed to initially target and prioritise neighbourhoods with a known high proportion of vulnerable residents.

3. In particular, we would argue that improving the provision of green space for low-income and vulnerable communities is crucially important. There is evidence suggesting that green space provision is often worse in low-income neighbourhoods, either because there is less green space available or that green space in such areas is (perceived as) poor quality or unsafe.[xvii] Furthermore, people with disabilities[xviii], children, and women[xix] can face additional barriers that can discourage them from green space usage. Improving green space provision and quality is essential for enabling vulnerable populations can access them during heatwave periods.

## Question 5: 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?

1. Trends towards steel and glass particularly in dense urban areas are unhelpful in this regard, presenting challenges to cooling the interior and exterior environment.[xx] Air conditioning is often assumed as standard and favoured over more passive cooling measures such as planting (around and up buildings), window shades, less heat absorbing materials and natural ventilation.[xxi]

## Question 6: 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?

1. Overheating is a very real and growing concern in both new build and retrofit projects.

2. Overheating prevention is only covered by Part O of the Building Regulations for new build properties which requires limited glazing. Overheating can be exacerbated by high indoor humidity, which in winter causes dangerous mould outbreaks, therefore maintaining ventilation all year round is vital.

3. Those who have mechanical ventilation must be discouraged from turning this off due to energy affordability concerns or blocking up vents to avoid draughts and thus cutting off ventilation or disrupting cross- ventilation. See the important work of Jenny Brierley (2021) in relation to this behavioural issue[xxii] Brierley, J (2021), Fresh air and low carbon: a practice approach to maintaining home ventilation. White Rose etheses. https://etheses.whiterose.ac.uk/29017/

## Question 7: What role might reversible heat pumps (which can act as both heating and cooling systems) and other emerging technological solutions, such as the development of smart materials, play in meeting future cooling demands?

1. Where a fabric first option (minimising glazing, maximising passive cooling) is not sufficient, reverse cycle heat pumps could provide a vital safety net. Options to consider here include mandating heat pumps capable of cooling through the Building Regulations and in relation to social housing providers.

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