Heat and Preventable Deaths in the Health and Social care System

Summary

Key Policy messages

This case study considers how climate change (specifically, the hazards to health from increased heat) could affect a current NHS outcome of preventing people from dying prematurely. It also considers the existing emergency response plan in England for severe heat and heatwaves - the Heatwave Plan – and its purpose of reducing summer and spring deaths for such events. The study notes that heat-related fatalities in England are projected to increase with climate change, especially under higher warming scenarios: this would have a major impact on these outcomes/goals, making them more difficult to achieve. These fatalities have high economic costs, estimated in this study as a range from £323 million to £9.9 billion per year by the 2050s.

The Heatwave Plan, which includes the Heat-Health Watch System (HHWS), should have some impact in reducing these future risks, although its effectiveness is currently being evaluated. Based on similar international schemes, the plausible benefits of the heat alert system could be around an average 40% reduction in fatalities during heat extremes. This means there although the heatwave plan could reduce deaths, there will still be rising numbers of residual heat-related deaths because of climate change. Furthermore, climate change will increase the costs of delivering the HHWS, as the scheme will be triggered more frequently (unless the threshold triggers are changed upwards). This study has also identified a risk of short-term lock-in, associated with the additional numbers of elderly people requiring care (estimated to be 71,000 by 2025 and 190,000 by 2035 on top of 410,000 now). A failure to plan heat management in new care homes / care in the home could lock-in large numbers of people to heat risks, and a similar issue arises with new build hospital design.

The conclusion is that even with the current heatwave plan, there is a major adaptation gap in the health and social care system. This is a key concern because there is a rising risk of an unprecedented heatwave event in the future. Based on the latest science, an extreme heatwave with temperatures exceeding 40°C in England could well be experienced in the next few years, and there should be planning for this now. This study has undertaken an initial scoping of additional adaptation options for health and social care organisations. We identify no and low-options from other countries (that experience extreme heat more routinely). These offer a targeted set of possible options for reducing heat-related mortality in vulnerable groups and have high benefit to cost ratios - it is therefore recommended that further analysis of health and social care options/lessons from other countries would be beneficial (especially if the forthcoming evaluation of the Heatwave Plan shows low evidence of benefits). The study also highlights the need for greater early action to address heat and health risks in care homes and hospitals (to avoid lock-in), and action to start iterative adaptation planning for major heat extremes.

What is the outcome?

The focus of the case study is on England only. The study initially identified the NHS outcomes on preventing people from dying prematurely (reducing the number of preventable deaths), in this case from heat. This is focused on people dying while in NHS care (following hospitalisation), but the case study has considered all premature deaths from heat. The case study has also looked at a related climate-relevant outcome set out in the current Heatwave Plan for England (PHE, 2018), for 'protecting health and reducing harm from severe heat and heatwaves'. The heatwave plan has a broad aim to reduce spring and summer deaths and illness by raising public awareness and triggering actions in the NHS, public health, social care and other community and voluntary organisations. The plan is underpinned by a heatwave alert early warning, the heat health watch system (HHWS) in England.

This study has assessed if climate change could make both outcomes (NHS and the Heatwave Plan outcomes) more difficult to achieve. It has:

- Assessed the current and future risks of climate change and how these might affect the outcome of preventing premature deaths (with a focus on heat-related premature deaths);
- Assessed the benefits of current extreme weather and adaptation measures in the health and social care system (the Heatwave Plan and HHWS) in reducing current and future heat-related deaths, and benefits for the Government outcome (preventing premature deaths) and the adaptation-related outcome in the Heatwave Plan (reducing spring and summer deaths);
- Investigated if further adaptation would be justified, beyond current adaptation plans, focusing on health and social care organisations (and other public agencies and professionals who interact with those most at risk) and potential benefits and costs.

It is stressed that this case study is challenging because the policy landscape for managing heat-related health risks involves shared institutional responsibilities across Government. Public Health England (PHE) is the operational lead for the current Heatwave Plan. More generally, health-related responsibilities sit with the NHS and the overall healthcare system, while the management of relevant heat risks (risk reduction) for the built environment sits with MHCLG, and to a lesser extent, BEIS. These organisations have a shared responsibility for adaptation.

For this case study, we have focused on adaptation in the health and social care system, rather than the built environment, but we do include consideration of built environment responsibilities within the health system (e.g. care homes and hospitals).

What is the challenge of meeting the outcome in a 2 and 4°C world?

<u>Current</u>. Daily deaths increase with average outdoor temperature, above certain thresholds, and can lead to large number of additional fatalities during warm periods, including (but not limited to) heatwaves. There were major heatwaves in England in 2003 and 2006, which were both attributed with causing over excess 2000 fatalities (PHE, 2018a: 2018b) and there have also been heatwaves in recent years, in 2016 (908 excess deaths), 2017 (778 excess deaths), and 2018 (863 excess deaths overall) (PHE, 2018c). However, many heat-related excess deaths arise outside of heatwaves. It is difficult to estimate the total number of heat-related deaths each year as many of these occur outside of heatwave events and at relatively moderate temperatures but current estimates suggest that there are around 2000 heat-related deaths per year in the UK (Hajat et al., 2014: Kovats and Osborn., 2016).

<u>Future</u>. Future climate change is estimated (Hajat et al.,2014) to increase heat- related fatalities to potentially 3000 per year by the 2020s, and to 5000 per year by the 2050s (if the additional effects of climate only are considered). However, the total number of heat-related fatalities is projected to increase to 7000 per year by the 2050s when population and age distribution changes are also considered (i.e. the combined effect of climate and socio-economic change acting together). These central values (Hajat et al., 2014) are based on a medium emission scenario only. However, there is uncertainty around these estimates, reflecting different emission pathways (2°C vs 4°C pathways) and climate model uncertainty. The Hajat study does consider the latter and reports a range of 2000 to 5000 deaths in the 2020s (mid estimate of 3000 including climate and population change) and 3000 to 13000 in the 2050s (mid estimate of 7000). These estimates may not fully capture future extreme temperature impacts or urban heat island effects, which might increase these impacts. However, they do not include the effects of natural acclimatisation or existing adaptation policy (including the Heatwave plan and HHWS), which could reduce these impacts, potentially significantly.

<u>Thresholds</u>. One of the additional issues in this case study is to consider if there are potential thresholds involved with the impacts. There are several different types of thresholds for heat-related mortality.

- The threshold for heat-related mortality, i.e. the 17-20°C range (daily average temperature) reported in Hajat et al. at which mortality starts to increase, and the threshold of approximately 25°C (daily maximum temperature) for excess summer deaths reported by PHE (2018). Some heat-mortality curves also show increases in mortality rates at higher temperatures.
- The HHWS threshold temperatures (maximum day and night temperatures), and the triggering of HHWS responses (PHE, 2018), noting these vary by English region.
- Threshold indoor temperatures for buildings for overheating and comfort levels (daytime and night-time), as well as occupational standards, which are relevant for hospitals and care homes.
- The potential for a policy threshold, i.e. a major event that is considered an unacceptable policy risk (e.g. a major Paris 2003 type event), noting such a threshold has not been set at present.

It is noted that the recent update of the UK climate projections, UKCP18 (Lowe et al., 2018), reports that hot summers are expected to become more common, with the probability of seeing a summer as hot as 2018 of the order of 50% by mid-century, regardless of the future emissions trajectory. UKCP18 appears to project greater heat extremes than the previous UKCP09 projections. This has important implications for threshold exceedances.

<u>Lock-in.</u> There is also a potential lock-in issue. For the health system, these include the building of hospitals and care homes (CCC, 2014: CCC, 2017), noting there is a wider lock-in for new buildings and overheating risk more generally. There is therefore a need to ensure new hospitals are designed for the future climate. For care homes, there is a major issue because of the changing age distribution of England, and the high projected increase in the numbers of older people requiring care (>75 and especially >85 years, i.e. those most vulnerable to heat). In the UK, there are currently 410,000 residents in care homes (CMA, 2017). The number of additional people projected to become dependent is another 71,000 by 2025 and 190,000 by 2035 (Kingston et al., 2018): this implies a large increase in the number of vulnerable people in the care sector [care homes or care in the home]. If early action is not taken to consider heat risks for this emerging group, there is a risk of locking in future exposure and health risks. This also means that future care policy could have important lock-in risks, e.g. a policy towards greater independent care in the home might actually increase future risks.

What are the potential economic costs of not achieving the outcome?

This study has estimated the economic costs of the additional heat-related mortality cases. We use the Hajat et al. estimates and values, and the standard approach in UK Government appraisal for valuing changes in fatality risk (the value of a prevented fatality, VPF) (DfT, 2019). This captures the total effect on society's welfare, assessing resource costs i.e. medical treatment costs; opportunity costs, e.g. lost productivity; and dis-utility i.e. pain or suffering. However, there is some debate on the applicability of these values to the heat mortality context, because a proportion of people affected are old or have existing health conditions and/or lower life expectancy, and thus the fatalities may reflect a death brought forward (displaced) by only a short period of time (Watkiss and Hunt, 2012). There is uncertainty in the evidence base about how strong an effect this is. For this reason, a sensitivity analysis with an adjusted value is also used (as commonly used in the air pollution context, where similar issues exist). With the use of the full Value of a Prevented Fatality, the estimated economic costs from the increase in heat-related mortality from climate change are very large, with costs of £2.5 billion/year (combined effect of climate and population change) in the 2020s, rising to £9.9 billion/year (climate and population change) in the 2050s. However, the sensitivity analysis that takes account of a short period of life lost (using a Quality Adjusted Life Year value, and 1 year of life lost on average) reduces these economic costs significantly, to £58 million to £83 million in the 2020s (climate / climate and population) and £213 million to £323 million in the 2050s. In practice, the economic cost may lie between these two values. It is stressed that these numbers do not include existing adaptation policy (including the HHWS) or physiological acclimatisation.

What are the benefits of existing adaptation on the achievability of the outcome?

The next step is to consider the potential benefits of current adaptation (the current Heatwave Plan, including the HHWS (PHE, 2018a), plus additional announced adaptation policy in NAP2 (Defra, 2018)) in reducing the current and future climate related risks set out above. This aims to assess how much current policy in the health and social care system could help to achieve the Government outcome (of reducing preventable premature deaths) and adaptation outcome (of reducing spring and summer deaths). The Heatwave Plan sets out what should happen before and during periods of severe heat in England, focusing on how health and social care organisations can raise awareness of risks and what preparations to make to reduce them. The main focus is on short-term measures, centred on actions around the HHWS. This has been the focus of the analysis. The Heatwave Plan also includes a set of long-term measures that extend towards the built environment and extend outside the health and social care responsibility, which are not included in this analysis. However, the analysis here has considered built environment aspects that are relevant for health and social care organisations.

It is stressed that most of the evidence on effectiveness comes from heatwave events (rather than the total heat-related mortality burden), and this only captures a proportion of the burden in England. For this case study, the analysis applied the effectiveness of heatwave responses to the overall heat-related mortality burden. This study has analysed the potential effectiveness, and estimated costs and benefits of the HHWS, now and in the future with climate change, noting that CCRA 1 and 2 did not assess the potential impact of the scheme in reducing risks (Kovats and Osborn., 2016). There is currently no published data on the effectiveness of the Heatwave Plan and HHWS in England, although an evaluation led by PHE is expected to be published soon. There is some evidence that suggests that the scheme has had some benefits in reducing mortality for temperatures above the HHWS thresholds (Green et al., 2016), but that heat-related mortality below the thresholds has not changed significantly. There is also evidence from other countries with heatwave plans (Tooloo et al., 2013: Chiabai et al., 2018), that report a wide range of estimated benefits, which indicate effectiveness of an average 40%, though with some plans reporting a 90% benefit (noting most, but not all of these benefits are associated with heatwave events).

To explore the potential benefits, we use a sensitivity range with a lower value of 0% and an upper value of 40% (i.e. we assume the Heatwave plan, including year-round actions, prevents up to 40% of potential premature fatalities). This estimate was based on information from heatwave plans from other countries, from Tooloo et al., 2013. We applied this effectiveness level to the total number of heat-related fatalities estimates above, as there is no data on the proportion of fatalities that occur during and outside heatwaves (although we acknowledge that the Heatwave plan is likely to primarily reduce excess deaths primarily during heatwaves). This analysis was based on the method used in Hunt et al., 2016. The analysis also assumes a similar level of effectiveness under future climate change (as a %). The analysis finds that the economic benefits of the Heatwave Plan and HHWS – at the upper level – could be very large (plausibly as much as £1 billion/year by the 2020s, based on the full VPF). However, climate change will increase the increase the resource costs (Hunt et al., 2016) of operating the HP and HHWS, as it is triggered more frequently, reflecting a higher incidence of heatwaves (unless trigger levels are changed). The study has estimated the indicative increase in resource costs of the HP and HHWS under future climate change, using the estimated health staff resource costs associated with different trigger levels (again based on Hunt et al., 2016). This finds the increases are modest (£million/year), but rise more strongly under higher warming scenarios. Overall, the analysis indicates a potentially high benefit to cost ratio for the current scheme (for the upper values) now and in the future. As an example (for London, see Hunt et al, 2016), the marginal benefit to cost ratio would range from 10:1 to 30:1 for the 2040s (for low and high warming scenarios, respectively). Note that the BCR may be much lower, pending the results of the HHWS evaluation.

However, even with the Heatwave Plan and HHWS, there will be high residual impacts, and these are projected to increase (in absolute numbers) over time. There is therefore a large adaptation gap. Even under an optimistic scenario with the upper effectiveness value used above, residual economic costs would be £1.3 billion/year in the 2020s, rising to £4.9 billion/year by the 2050s (central estimates). Furthermore, the likelihood of a major unprecedented heatwave event in the next decade is considered high. This could have large policy impacts. Therefore, we consider that current policy outcomes (to reduce premature deaths, and reduce heat-related fatalities) are likely to be missed. There are therefore further opportunities for additional options that would provide additional adaptation to reduce current and future risks and help achieve the outcomes.

What are the potential additional adaptation options to address residual impacts?
The next step is to consider the potential additional adaptation options that could reduce heat-related mortality risks, and help achieve the original outcomes (preventable premature deaths, and deaths during spring and summer). This is focused on reducing future climate change risks and fatalities in the health domain, while noting that there is a wider set of adaptation actions for reducing heat exposure in buildings in general (residential) and the urban environment.

There are some additional adaptation actions to address heat-related health risks in the 2nd NAP for England (Defra, 2018). This list of actions is quite comprehensive, but they are primarily focused on monitoring and process-based outcomes (the production of adaptation plans). This makes it very difficult to know what adaptation is planned, and how effective it will be. Nevertheless, there is a need for additional adaptation (not least to specify what should be in plans). A review of the literature has found that most of the current focus is on the built environment and urban environment. However, while this has many benefits, it is not targeted at heat-related mortality (rather it includes a set of outcomes, including overheating and comfort, building energy use and health), and there are likely to be health system responses, including behavioural change among the public and for health and social care workers, that could achieve high cost-effectiveness in reducing these risks. To explore this, the analysis has looked at three types of options for early priorities in a high-level adaptation pathway.

<u>No- and low-regret measures.</u> A number of low-regret measures could enhance the effectiveness of the Heatwave Plan, HHWS and actions, notably drawing on lessons from current (hotter) countries that report much higher effectiveness levels (in reducing summer deaths) from similar heat warning systems. Indeed, some studies report effectiveness levels of 80 to 90% (Tooloo et al., 2013). A key priority is therefore to understand the success factors in these other countries, and identify additional cost-effective measures for the UK. Contingency planning for an unprecedented heatwave event (>40°C) is also highlighted.

<u>For lock-in risks</u>, there are important climate smart priorities on the design of new hospitals (Giridharan et al., 2013: Fifield et al., 2018) and care homes (JRF, 2016), the latter including the support from Government needed to create the awareness and enabling environment for the private sector.

<u>For early planning to address long-term risks</u>, there is a priority to develop iterative adaptation pathways for public health and social care options for heat and health (and not assume that these future problems will be addressed adequately by the built environment), especially given the projected change in heatwave frequency and severity with the new UCKP18 projections.

What are the benefits and potential costs of additional adaptation?
Research on the costs and benefits of adaptation to heat risks from climate change has overwhelmingly focussed on heat wave warning systems, or the built environment (see ECONADAPT, 2017): little quantitative analysis has been undertaken on other measures, particularly those tailored to health and social care. In the absence of such data, the study has looked at a qualitative indication of the possible scale of costs (low, medium, high) and effectiveness (low, medium, high). These indicate potentially promising additional options with high benefit to cost ratios, that are likely to be more cost-effective (than general built environment options) for targeting heat-related fatalities.

Step 1. What is the outcome?

This outcome is initially based on the NHS outcomes framework on preventing people from dying prematurely (i.e. reduction in the number of preventable deaths). This draws on the Quality Accounts, which are annual reports about the quality of services provided by an NHS healthcare service. They are published by each NHS healthcare provider, including the independent sector and are made available to the public. The Quality Accounts are split into 5 domains, the first being 'preventing people from dying prematurely'. Therefore, the first Government outcome is the NHS outcome framework on preventing people from dying prematurely (i.e. reduction in the number of preventable deaths). For this case study, the focus is on preventing people dying prematurely from heat.

The Summary Hospital-level Mortality Indicator (SHMI) reports on mortality at trust level across the NHS in England. The SHMI is the ratio between the actual number of patients who die following hospitalisation at the trust and the number that would be expected to die on the basis of average England figures, given the characteristics of the patients treated. It covers patients admitted to non-specialist acute trusts in England who died either while in hospital or within 30 days of discharge. However, there are no numbers for heat-related hospitalisation and fatalities. Therefore, the study has focused on all estimated heat-related premature deaths. Further work to estimate the heat-related component of the SHMI is recommended.

The case study has focused on premature deaths from heat (as a key climate driver of premature deaths) and widened the analysis to consider all people (not just those in hospitalisation), but with a focus on those who are the responsibility of the overall health care system (NHS and social care). Note that the focus of this case study is on England only.

Alongside this, there is a relevant climate related outcome set out in the current Heatwave plan for England (PHE/NHS England (2018)) - for protecting health and reducing harm from severe heat and heatwaves. This is an emergency plan intended to protect the population from heat-related harm to health. It aims to prepare for, alert people to, and prevent, the major avoidable effects on health during periods of severe heat in England. The purpose of the Heatwave Plan is to reduce summer deaths and illness (during severe heat and heatwaves) by raising public awareness and triggering actions in the NHS, public health, social care and other community and voluntary organisations to support people who have health, housing or economic circumstances that increase their vulnerability to heat (this is also highlighted in NAP2, which reports [p52] 'the Heatwave Plan for England aims to reduce summer deaths and illness by raising public awareness and triggering actions'. The plan is updated each year. The plan comprises sections on:

- The Alert system;
- Heatwave and summer preparedness;
- Communicating with the public;
- Working with service providers;
- Engaging the community;
- Strategic planning;

The plan is underpinned by a system of heatwave alerts, developed with the Met Office, the heat-health watch system (HHWS) in England, which forecasts and provide warnings for heatwaves to help prevent mortality and morbidity from heat.

The Heatwave Plan also includes a long-term planning component:

- Co-ordinated long-term planning between agencies to protect people and infrastructure from the effects of severe hot weather and thus reduce excess summer illness and death;

- Long-term multi-agency planning to adapt to and reduce the impact of climate change, including 'greening the built environment', building design (e.g. increasing shading around and insulation of buildings), increasing energy efficiency (e.g. reducing carbon emissions); and transport policies.

It is highlighted that much of this long-term planning sits outside of the control of the health sector. The Heatwave plan strongly recommends that these long-term planning issues are considered by Health and Wellbeing Boards and included in joint strategic needs assessments (JSNAs) and Joint Health and Wellbeing Strategies (JHWSs), in order to inform commissioning.

Theory of Change / Logic Model

This case study is slightly different to many of the others considered in this report, and has a more complicated theory of change/logic model. The case study considers how a climate-related risk could affect the current Government outcome (preventing premature deaths, with a focus on heat). However, there is already an emergency response plan in place to help manage these risks, with its own relevant climate-related outcome (the Heatwave plan purpose of reducing summer and spring deaths, noting as set out above that this is focused on severe heat and heatwaves). The case study has therefore considered these aspects as two related outcomes, and assessed whether climate change could make both of these more difficult to achieve. The steps are:

- To assess the current and future risks of climate change and how these might affect the outcome of preventing premature deaths (with a focus on heat-related premature deaths);
- To assess the benefits of current adaptation plans (the Heatwave Plan and HHWS) in reducing current and future heat-related deaths, and thus helping to meet the main Government outcome (preventing premature deaths), but also to deliver the outcome in the Heatwave Plan outcome (reducing spring and summer deaths (from severe heat and heatwaves);
- To investigate if further adaptation would be justified, beyond current the Heatwave plan and NAP2 adaptation actions, and to assess their potential benefits towards achieving the Government and Heatwave Plan outcomes, as well as potential costs.

The focus on adaptation in this case study is centred on the short-term responses in the Heatwave Plan (see above), and its potential benefit in reducing heat-related mortality, but it also considers the long-term planning components in the Plan. The focus is to look at additional measures of relevance for health and social care organisations (and other public agencies and professionals who interact with those most at risk). This includes some built environment aspects that sit within the health and social care landscape. The relationships in the logic models are shown below.

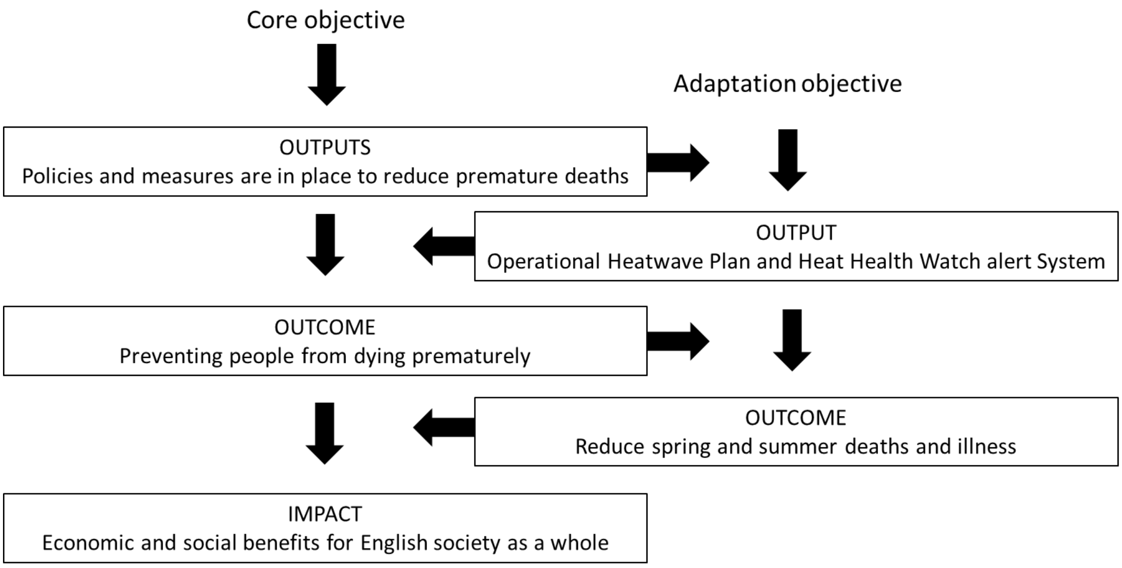


Figure 1 Outcome map of the primary objective and adaptation objective.

It is also noted that there is an issue that climate change may reduce cold-related mortality, and thus may have benefits for the NHS outcomes above. This will also affect the delivery of the outcome, but we have not considered cold-related benefits, as the focus on adaptation here is on heat-related effects.

Policy landscape

The policy landscape for managing heat and health risks is complex. While the health-related responsibilities sit with the NHS and the overall health care system, the management of relevant heat risks extend to the built environment. This also applies to the responsibility for the adaptation responses that can address heat risks. For this case study, we have focused on risks and adaptation within the context of the health system.

Previous work illustrates the complexity of the institutional responsibility and governance. A social network mapping analysis (Bharwini and Watkiss, 2012) found a very large number of organisations need to act to address the overall risk pathway for heat and health, with major differences in the adaptation actions and responsible departments in the short-term (heat alert, concentred in the Health domain) as compared to the long-term (a housing stock that is resilient to the challenges of the future, warmer climate, focused on the building and land use domains).

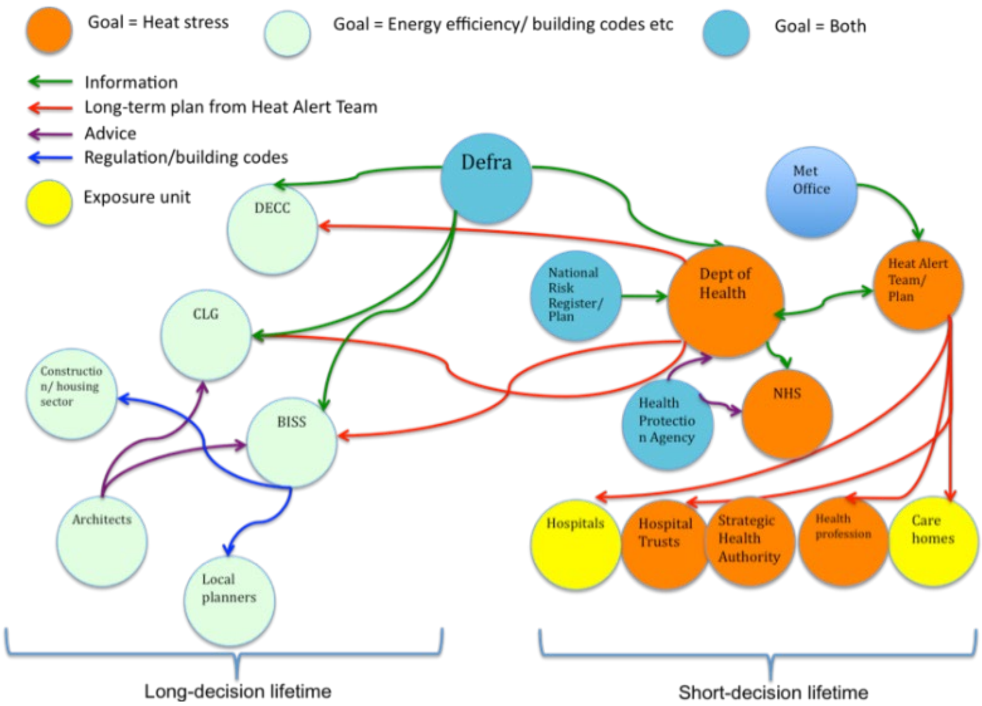


Figure 2 Social Network Mapping of Managing Heat and Health Risks in the UK. Source Bharwini and Watkiss, 2012.

The health landscape has changed significantly since this earlier mapping, although the broad division between short- and long-term aspects remain split between the health and built environment remains. For the health landscape (the focus of this case study), the relevant actors are:

- NHS England;
- Public Health England;
- Directors of Public Health in local authorities.

Public Health England (PHE) is the operational lead for the current Heatwave Plan in England.

As reported in the Heatwave Plan for England (2018) the implementation of the Health and Social Care Act 2012 has seen the abolition of Primary Care Trusts and Strategic Health Authorities and the creation of a number of new bodies including Public Health England (PHE), NHS England and clinical commissioning groups (CCGs). At a local level, responsibility for public health has transferred to local authorities. Responsibility for preparing and publishing the Heatwave Plan for England has passed to PHE. Further, the Department of Health & Social Care (DHSC) is responsible for strategic leadership of both health and social care systems, but no longer has direct management of most NHS systems. NHS England provides national leadership for improving health care outcomes, directly commissions general practice services, some specialist services, and oversees clinical commissioning groups. CCGs now commission planned hospital care, rehabilitative care, urgent and emergency care, most community health services and mental health and learning disability services. Directors of Public Health in local authorities are responsible for population health outcomes, supported by Public Health England (PHE), which provides national leadership and expert services to support public health.

As in the figure, however, much of the broader landscape on management of heat sits outside the health system, sitting with the Department for Business, Energy and Industrial Strategy (BEIS) and the Ministry of Housing, Communities and Local Government (MHCLG).

Step 2. What is the challenge of meeting the outcome in a 2 and 4°C world?

The first analytical step is to estimate the impact of climate change on meeting the outcome. This has started first with an analysis of the future impacts <u>without</u> current adaptation plans.

Current impacts

There is a well-established literature and existing epidemiological relationships between temperature and mortality. These typically show a U or J shaped curve, with rising mortality with increasing temperature, above a threshold. The exact shape of the relationship and the threshold varies with country (and even city) (see Baccini et al., 2008). There is, however, a further discussion on the degree to which the relationships from these studies capture extreme heat (heatwave) events, especially in major urban conglomerations, because risk may be exacerbated by the urban heat island effect.

There are some further issues due to other factors involved: part of the rise in mortality seen – particularly for heatwaves - may be attributable to air pollution, which makes respiratory symptoms worse (PHE/NHS England, 2018b). This is also the subject of considerable analysis in the literature. Furthermore, air pollution may be affected by climate change as well, i.e. climate change could affect air quality levels. This case study has not looked at these factors, but acknowledges these are important issues.

The average daily outdoor temperature thresholds in England at which populations begin to show heat-related mortality vary regionally from around 17°C to 20°C (CCC, 2014, based on Hajat et al., 2014). As highlighted above, daily deaths increase above this level, and the majority of heat-related mortality cases occur outside of heatwaves. It is noted that that the English Heatwave Plan reports different numbers, reporting that increasing temperatures in excess of approximately 25ºC are associated with excess summer deaths, with higher temperatures associated with greater numbers of excess deaths (PHE/NHS England, 2018b).

Hajat et al (2014) estimated <u>current</u> heat-related mortality at 2000 fatalities/year on average in the UK. This was reported by the Adaptation Committee in the 2014 progress report (2014) and the CCRA2 (Kovats and Osborn., 2016). This was based on analysis of deaths in the period 1993 – 2006.

While the number of fatalities increase above relatively low levels, the focus in public health has on heatwaves. There have been previous major heatwaves that have affected England, which resulted in major numbers of additional fatalities, notably in 2003, 2006 and 2016-2018.

The 2003 heatwave event was attributed with 2234 excess deaths (PHE, 2018) – although there were much higher fatalities across Europe, with an estimated 75000 excess deaths, with particularly high numbers in France (and Paris) (EEA, 2008). The 2006 summer heatwave was associated with an estimated 2323 extra deaths (PHE, 2018). Note that the HHWS was introduced in 2004.

The series of heatwaves in England in the summer of 2018 is estimated to have led to an 863 additional deaths (PHE, 2018c). The summer of 2018 saw 4 heatwaves (3 Level-3 heatwave alerts). The first heatwave occurred from 25 June to 27June 2018 when there were an estimated 188 excess deaths above baseline in the 65+ year olds. The second heatwave occurred from 30 June to 10 July 2018 when an estimated 266 excess deaths observed above baseline in 65+ year olds. The third heatwave occurred from 21 July to 29 July 2018, where there were an estimated 409 excess deaths observed above baseline in the 65+ year olds. The impact on mortality of 863 excess deaths was more than seen in 2017 (778 deaths), but less than what was seen in 2016 (908 deaths), 2006 (2,323 deaths) and 2003 (2,234 deaths). Clearly these figures show that large numbers of excess deaths are occurring, even with the Heatwave Plan in place (which was introduced in 2004), and this suggests that further adaptation measures might be warranted.

It is more difficult to estimate the number of these fatalities that occurred to people in NHS trust care (the specific NHS outcome), although it is noted that the ASC (2014) reported that 90% of current wards are of a type prone to overheating.

Similarly, there are not numbers on how many people in the social care network die from premature mortality from heat. There has been work on heat-related risks in care homes under the BIOPICCC project (Oven et al 2012). A further study of care homes (JRF, 2016) indicated that these may also be at risk from high temperatures, due to building design and management issues, with the study reported that current monitoring revealed occurrences of overheating in care schemes in 2015.

Future impacts

Climate change will have impacts on heat-related mortality and morbidity in the UK. There is a large literature of studies that take current heat and mortality relationships – as described above – and apply these to look at future climate change. However, these studies have some important limitations. First, in a temperate country like the UK, there is little historic evidence on daily mortality and higher temperatures, and so the application of future temperature to a current heat-mortality function may not adequate capture future mortality rates: this could mean that future impacts are under-estimated. However, different cities have different curves and thresholds (Baccini et al., 2008), reflecting their historic exposure and the adjustment of populations (acclimatisation) to heat. This means that applying relationships from historic observations is likely to over-estimate future impacts, because it does not take account of future acclimatisation. Finally, the majority of these studies do <u>not</u> take account of existing adaptation measures, notably existing heat alert systems, which also thus means they over-estimate future impacts Many of these studies may also not adequately project future localised temperatures, and in particular, they may omit urban heat island effects, or the patterns of extremes (by focusing on average changes, rather than variability and extreme metrics). This means there is uncertainty on whether the current projections are an under- or over-estimate.

There have been several studies that have used these approaches to produce UK and English estimates of future heat-related mortality from climate change (Watkiss and Hunt, 2012; Kovats et al, 2011; Kendrovski et al., 2017): this also includes estimates derived for CCRA1 (Hames and Vardoulakis, 2012) and reported in CCRA2 (Hajat et al, 2014) as well as the ECR (which focused on London) (Frontier et al., 2013).

For this case study, we have used the estimates from Hajat et al, (2014), which were reported in the Adaptation Committee's 2014 and the CCRA2 Evidence report Chapter 5 (Kovats and Osborn, 2016). This study estimated the projected change in mortality with climate change. The effects of increased mean temperatures and population growth/age distribution were projected to increase deaths in summer to approximately 7,000 per year in the 2050s from 2,000 per year now, across the UK, but there was a large range around these central numbers. The time periods (from Hajat) considered were 2020–2029, 2050–2059 and 2080–2089 for the SRES A1B scenario (medium emissions). The use of ten year periods is not the conventional approach (normally 20 or even 30 year periods are considered). A subset of nine regional climate model variants corresponding to climate sensitivity in the range of 2.6–4.9°C was used.

Table 1 Future Projections of Annual Heat-related mortality with Climate Change (UK). A1B scenario. Source CCC 2014, based on Hajat et al. 2014. Note that these projections exclude adaptation in terms of the effects of the heatwave plan, and exclude acclimatisation, but also potential changes in the urban heat island intensity.

	Mean estimates of increased mortality / year			
	2000-2009	**2020s**	**2050s**	**2080s**
heat- present day	1974			
heat projection - climate only		2882	5310	8468
heat projection - climate and population growth		3281	7040	12538

It is noted that the Hajat et al. study has much higher numbers for future heat-related mortality than other literature studies (Watkiss and Hunt, 2012; Kovats et al, 2011; Kendrovski et al., 2017). This was because the frequency of hot days was projected to rise steeply, with over a threefold increase by the 2080s. The Hajat paper included an additional indicator term to represent periods of exceptionally hot weather (heat-waves) and this was simultaneously modelled with the general heat effect to quantify any additional mortality risk due to the more extreme temperatures occurring. The additional heat-wave effect was only found to be significant in the London region, but it did represent a substantial additional burden of 58%, 64%, 70% and 78% on heat-related mortality in London during the 2000s, 2020s, 2050s and 2080s, respectively.

As indicated above, there are a number of important caveats with the above estimates:

- When the growing and aging population is included, the number of projected fatalities is much larger - but note that some of these increases would still happen even in the absence of climate change (although they would still be caused by heat). Around two-thirds of the increase is due to the climate signal, and the other third is attributed to demographic change.
- The Hajat analysis was based on deaths in the period 1993–2006, and therefore the baseline numbers and also the future estimates, mostly do NOT include existing policy, as the current English Heatwave Plan was introduced in 2004 (and was only in place for a small part of the period).
- There will be autonomous (natural) acclimatisation to heat that will reduce future impacts. Studies that include acclimatisation estimate that this could reduce future impacts by one third to one half (Kovats, 2011: Watkiss and Hunt, 2012). This effect and similar reductions are cited by Hajat et al. in the paper, but are not included in the estimates above.

There is also a strong distributional factor with these impacts. The health impacts are disproportionately higher for vulnerable groups (the elderly, those with existing health conditions,), due to a combination of exposure, sensitivity and capacity (including support networks).

For this study, one focus has been to examine the potential effects on the outcome under 2 versus 4°C pathways. The Hajat study only considers one central scenario, but it does look at uncertainty from different global and regional models. The reported uncertainty range is shown below. This provides an indicative guide to the potential variation (as expressed through models with different climate sensitivity) of the difference between 2 and 4°C futures.

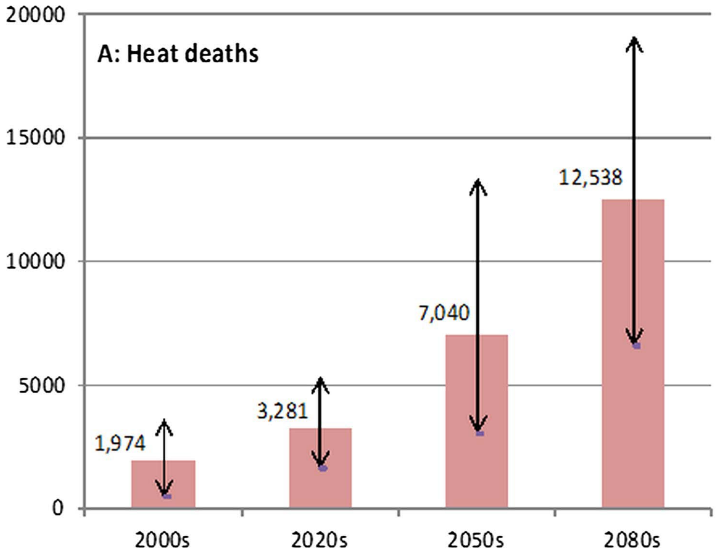


Figure 3 Heat-related deaths in the UK per year for all ages based on ensemble of nine climate models for a medium emission scenario. Mean estimates across the nine models are shown, and upper and lower limits of arrows represent the maximum and minimum. Source Hajat et al., (2014). Note – excludes any effects of the heatwave plan on mortality.

The majority of these deaths are in England, which is the focus of this study. We have therefore used the Hajat et al. study and derived the respective deaths in England attributable to climate change, as well as those attributed to both climate change and population change. They are presented in Figure 4. They show a similar gradual increase over the next 40 years – to just under 6,000 by 2060s, including both climate and population change.

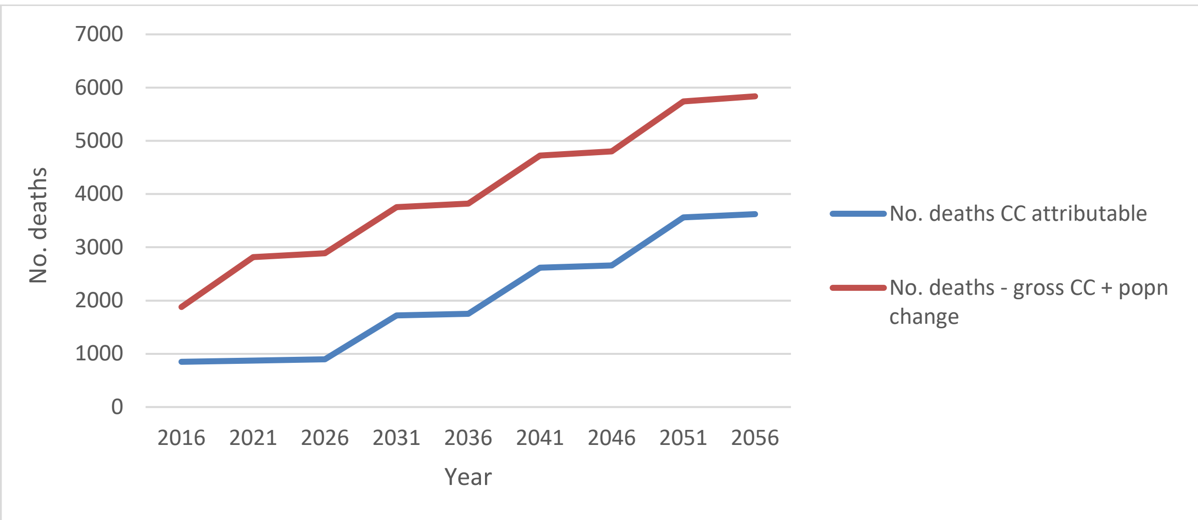


Figure 4. Attributable Deaths in England to Climate Change and Population Change (based on Hajat et al.), without any assumed effects of the heatwave plan on mortality.

Note that in addition to these fatalities, heat (and extreme heat) is linked with a range of other health impacts (morbidity). Previous studies (e.g. CCRA1, HRW, 2012/ Hames and Vardoulakis, 2011) estimated these additional morbidity impacts by correlating incidence with heat-related mortality. This looks at the increase in hospital patient days (hospital admissions as a result of heat-related illnesses), though these should only be considered as indicative. Morbidity incidence was estimated by adopting the mortality: morbidity ratio of 1:102. Note that other studies (Frontier et al, 2013) estimated lower levels of morbidity as compared to mortality. However, as morbidity is a low driver in the economic analysis (See later) we have not undertaken further sensitivity here.

Health care system
As above, there are not good data on the current incidence of heat-related fatalities that take place in hospitals and care homes, which makes it very difficult to estimate the future incidence of fatalities under climate change that are within the health and social care landscape. CCRA1 (Hames et al., 2012) identified healthcare provision may be affected by heatwaves if temperatures in hospital wards, care homes and medicine stores are not effectively controlled, affecting both patient recovery and the performance of staff. The JRF study (2016) undertook climate modelling that indicated limited overheating risks to care homes in the 2050s.

Thresholds
One of the additional methodological issues in this case study is to consider if there are potential thresholds involved with the impact, and whether these might be exceeded under future climate change (and the difference in exceedance between 2 and 4°C pathways). There are important thresholds for heat-related mortality. These relate to:

- The temperature threshold for heat-related mortality, i.e. the 17-20°C range (daily mean temperature) reported in Hajat et al. at which mortality starts to increase, and the threshold of approximately 25ºC (daily maximum temperature) for excess summer deaths reported by PHE (2018a) [note that a daily mean temperature of 20°C is similar to a daily maximum temperature of 25°C]. Some heat-mortality curves also show strong (non-linear) increases in the mortality rate at higher temperatures.
- The HHWS threshold temperatures, and the triggering of HHWS responses (see later), noting these vary with region;
- Threshold indoor temperatures, associated with discomfort, notably for those buildings that have high numbers of the vulnerable (elderly) population, i.e. hospitals, care homes, etc. For example, the Chartered Institute of Building Service Engineers has used fixed metrics such as staying below 1% of occupied hours over 26°C in bedrooms as a threshold for guidance on design standards for homes (but note there are many other building thresholds);
- The potential for a policy threshold, i.e. a major event that is considered an unacceptable policy risk (e.g. a major Paris 2003 type event). For example, the National Risk Register Of Civil Emergencies (Cabinet Office, 2017) identifies heatwaves as having a medium severity and a medium-high likelihood in the next five years.

The UKCP18 Science Overview report (Lowe et al., 2018) provides updated projections of summer temperatures. The 50th percentile result for the summer mean of the daily maximum temperatures is slightly greater than for corresponding daily mean temperatures. The spread of the results is also greater for the maximum temperature than for the daily mean. This means that a higher marginal change in daily maximum temperature that average temperatures. Some initial comparison indicates that UKCP18 shows increased projections of daily maximum temperatures than UKCO09.

It also reports that hot summers are expected to become more common. In the recent past (1981-2000) the probability of seeing a summer as hot as 2018 was low (<10%). UKCP18 reports that the probability has already increased due to climate change and is now estimated to be between 10-20%.

With future warming, hot summers by mid-century could become even more common (with probabilities of the order of 50% depending on the emissions scenario followed). This is similar to previous work that identified that the 2003 summer, which was similar to 2018, would be considered 'normal' by the 2040s under a medium emissions pathway (PHE – as set out in the Heatwave Plan).

What this also means is that there is a strong likelihood of a major unprecedented heatwave event in the next decade, i.e. a heatwave event that exceeds those previously experienced in the UK. Further work is underway on such events (under the UNSEEN initiative from UK Met Office).

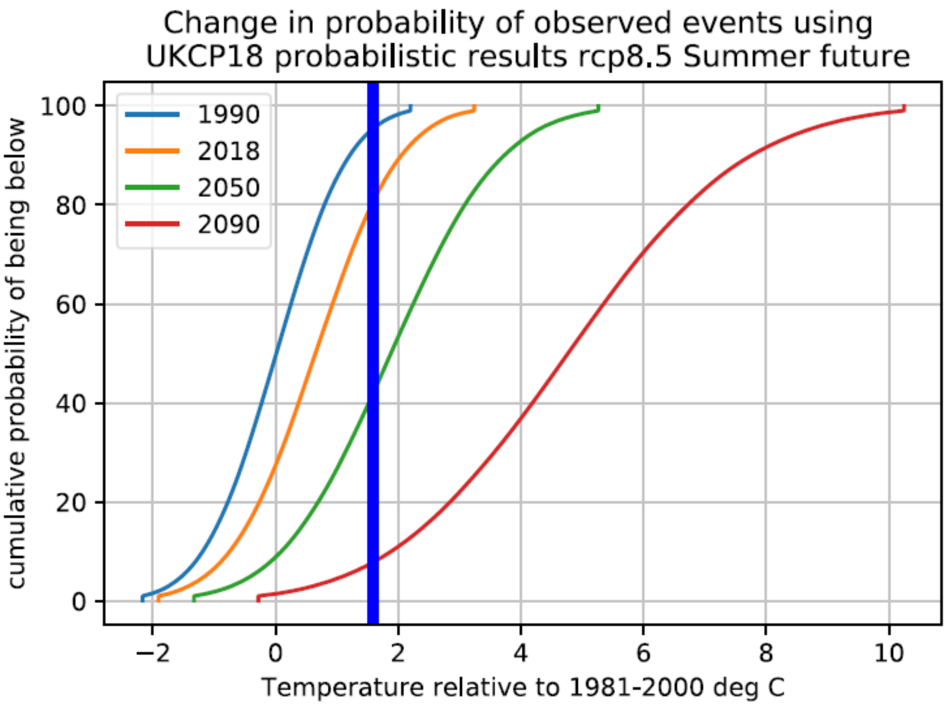


Figure 4 **Simulated change in the summer temperatures relative to the 1981-2000 baseline using the probabilistic projections centred on 1990 (middle of the baseline period), 2018, 2050 and 2090.**

These include model uncertainty and natural variability. The vertical blue line shows an estimate of the warming for summer 1976, which is also similar to that of 2018. Results are for the RCP8.5 scenario. Source Lowe et al., 2018.

Lock-in

There are also potential lock-in issues associated with this outcome. This relates to actions or decisions today that 'lock-in' the potential for future climate risk, and are difficult or costly to reverse or change later. This includes decisions or investments that involve a long life-time, the potential for large future climate risks and a degree of (quasi) irreversibility.

For this analysis, the focus of lock-in is on health-related infrastructure. These include care homes and hospitals (though it is stressed there are important lock-in issue with building design and new houses, with respect to overheating risks).

The first sector to consider is the care sector. Between 2015 and 2035, the absolute numbers of people aged 65 years or older in England will increase by an estimated 49% (Kingston et al, 2018). There is a high projected increase in the numbers of older people (>75 and especially >85 years) who will be dependent (i.e. that are in care). These groups have high vulnerability to heat. The French 2003 heat-wave found excess mortality rates rose dramatically for the 75–94 age group (Pirard et al., 2005) and similarly, the effects of the 2003 heat wave were greatest amongst the elderly in London in terms of the number of deaths per head of population (GLA, 2006). It is noted that old people tend to spend longer periods indoors in their homes, so exposure effects to inside temperatures would also have been more acute.

The care homes sector is worth around £15.9 billion a year in the UK and has around 410,000 residents (CMA, 2017). Kingston et al (2018) looked at the potential increase in care needs and care home places. Based on needs, and assuming that rates of dependency remained the same, the study estimated that there would be an extra 71,000 more care home places by 2025 and 190,000 more places by 2035[1].

There is therefore a degree of lock-in involved in the expansion of the care home sector, especially from new build care homes where there is a degree of irreversibility, related to infrastructure. However, there is also likely to be more people who are cared for in the home. A lack of short-term action could significantly increase the risks for this group (who are probably more at risk). If both cases, if early action is not taken to consider heat risks for this emerging group, there is a risk of locking in future exposure and health risks. This also means that future care policy could have important lock-in risks, e.g. a policy towards greater independent care in the home might actually increase future risks.

	Projected numbers (thousands)			Relative change	
	2015	2025	2035	2015–25	2015–35
65–74 years					
Independent	3655 (3644 to 3669)	4493 (4491 to 4530)	5602 (5602 to 5634)	22·9% (22·8 to 23·9)	53·3% (53·3 to 54·6)
Low dependency	1144 (1144 to 1168)	806 (789 to 808)	967 (949 to 969)	−30·0% (-32·0 to −30·0)	−15·0% (−18·0 to −15·0)
Medium dependency	193 (183 to 193)	130 (124 to 133)	98 (96 to 105)	−33·0% (−33·0 to −27·0)	−49·0% (−49·0 to −43·0)
High dependency	284 (281 to 285)	248 (235 to 250)	241 (229 to 246)	−13·0% (-17·0 to −12·0)	−15·0% (−20·0 to −13·0)
75–84 years					
Independent	1591 (1589 to 1605)	2535 (2506 to 2537)	2778 (2768 to 2803)	59·3% (56·2 to 59·6)	74·6% (72·5 to 76·4)
Low dependency	1084 (1077 to 1100)	1213 (1213 to 1251)	1400 (1380 to 1412)	11·9% (11·9 to 15·2)	29·2% (25·7 to 30·0)
Medium dependency	189 (175 to 189)	200 (189 to 202)	171 (167 to 186)	5·7% (5·7 to 11·8)	−9·4% (−9·4 to 2·8)
High dependency	266 (265 to 272)	317 (309 to 325)	378 (371 to 385)	19·3% (15·8 to 21·0)	42·0% (36·6 to 42·7)
≥85 years					
Independent	295 (290 to 297)	360 (357 to 374)	539 (527 to 555)	21·9% (21·9 to 26·3)	82·6% (79·2 to 88·4)
Low dependency	621 (614 to 630)	916 (901 to 920)	1537 (1513 to 1553)	47·6% (43·1 to 48·8)	148·0% (140·0 to 152·0)
Medium dependency	169 (166 to 173)	179 (171 to 185)	293 (282 to 297)	5·9% (−1·1 to 8·7)	72·9% (65·4 to 75·9)
High dependency	233 (229 to 237)	309 (297 to 309)	446 (434 to 446)	32·9% (27·8 to 32·9)	91·8% (87·3 to 94·1)
All ≥65 years					
Independent	5541 (5535 to 5567)	7388 (7370 to 7419)	8918 (8913 to 8967)	33·3% (32·6 to 34·1)	61·0% (60·6 to 62·0)
Low dependency	2849 (2840 to 2882)	2934 (2929 to 2958)	3904 (3861 to 3909)	3·0% (2·1 to 4·1)	37·1% (34·9 to 37·2)
Medium dependency	552 (523 to 552)	509 (491 to 513)	562 (549 to 581)	−7·8% (−9·0 to −3·5)	1·9% (1·9 to 9·6)
High dependency	783 (778 to 790)	875 (846 to 875)	1065 (1040 to 1065)	11·8% (8·0 to 11·8)	36·0% (32·6 to 36·0)

Data in parentheses are range from ten simulations.

Table 2: **Projected numbers of people aged 65 years or older in England with dependency**

Figure 5 Projected numbers of people aged 65 years or older in England with dependency. Source Kingston et al. The categories include older people with "medium dependency" – for example, needing help preparing a meal – and people with high dependency, needing round-the-clock care.

As highlighted above, 90% of hospital wards are estimated to be of a type prone to overheating (CCC, 2014) and an important lock-in issue relates to the design of new hospitals (to reduce over-heating

[1] As reported in the press, see https://www.ncl.ac.uk/ihs/news/item/profcaroljagger-extra7100carehomeplacesneeded.html

risk. The potential to include design to reduce over-heating, and provide passive cooling, has been the subject of several studies, notably the Design and Delivery of Robust Hospital Environments in a Changing Climate (DeDeRHECC) project (Lomas and Giridharan, 2012). While it found some designs could reduce overheating (Giridharan et al., 2013) some new designs (with well insulated, naturally ventilated hospital wards) could be at risk of overheating even in relatively cool UK summer (Fifield et al., 2018).

Step 3. What are the potential economic costs of not achieving the outcome?

Economic impacts on human health are more difficult to value than many other sectors, because there are no observed market prices. However, it is possible to derive monetary values by considering the total effect of the impact on society's welfare. This requires analysis of three components which each capture different parts of the total effect:

- The resource costs i.e. medical treatment costs;
- The opportunity costs, in terms of lost productivity; and
- Dis-utility i.e. pain or suffering, concern and inconvenience to family and others.

The first two components can be captured relatively easily. Techniques are also available to capture the third component, by assessing the 'willingness to pay' or the 'willingness to accept compensation' for a particular health outcome. These are derived using survey-based 'stated' preference methods and/or 'revealed' preferences methods that are based on observed expenditures such as on consumer safety. For this outcome, the key metric is the valuation of the change in risk of a fatality. Valuation of mortality risk, (or fatality risk), focuses solely on the disutility welfare component; specifically the valuation of changes in the risk of death in a given time period. This is commonly expressed through the metric of a Value of a Prevented Fatality (VPF), also known as the Value of a Statistical Life (VSL). These metrics are already widely used in Government appraisal and cost-benefit analysis, for example in transport appraisal. In order to value these mortality effects in economic terms we adopt the unit value for a value of a prevented fatality, (VPF) that is used in transport appraisal by the Department for Transport (TAG databook, DFT, 2018). The current values are below.

Table 2 Average value of prevention per casualty. 2018 Price year, and 2018 values.

		Lost	Human	Medical &	Total
Casualty type		**output**	**costs**	**ambulance**	
Fatal		670,265	1,278,357	1,151	**1,949,772**
Serious		25,823	177,633	15,644	219,100
Slight		2,729	13,004	1,158	16,890

However, there is some debate on the applicability of these values to the heat and health context, because those affected include a large proportion of people that are old or have existing health conditions, and that had lower life expectancy than assumed in the typical value of a prevented fatality. The period of life lost – notably for heatwaves – may be small. This is often referred to as displaced mortality, i.e. the number of fatalities that occur in those who have existing ill health and would have died anyway within a short period of time (also known as deaths brought forward).

Similar issues to this exist in the air quality context, and previous studies in UK Government appraisal have addressed this by using a different approach, with the value of a life-year (VOLY). This was suggested by the Interdepartmental Group on Costs and Benefits (IGCB, 2007). The value of a life year lost due to the chronic effects of air pollution has been used in recent studies to monetise the all-cause mortality pathway in air pollution damage cost calculations (Defra, 2019). The value used was £42,780

(2017 prices) and is based on life years lost being in normal health. Life years lost due to the acute effects of short-term exposure to air pollution were valued at £22,110 per life year lost (Defra, 2019).

However, the standard method for monetising the loss of quality of life due to health conditions is Quality Adjusted Life Years (QALYs). In accordance with the Green Book, QALYs are valued at £60,000 in 2014 prices - this is different from the value of a life year used in the mortality pathway since the QALY must represent the value of a year lived in perfect health. These values could be transferred to the climate change related context, indeed previous studies have used such as approach (Watkiss and Hunt, 2011: Kovats et al., 2012: Hames et al., 2012). However, this requires information on the average period of life lost from heat-related mortality and the quality of life lost. There is no robust evidence on these. These previous studies used a number of different values, with 6 months, 1 year and 2 years. For this study, we use QALY values, adjusted to 2018 prices, assuming 1 year of (healthy) life lost. The current values are £60000 for a QALY (HMT, 2018) [2014 prices]. It is stressed that there is some debate in the literature as to the relative merits of these the VPF versus the VOLY metrics. Earlier best practice was to use both metrics, at least in sensitivity analysis (see Watkiss and Hunt, 2012). More recent evidence in the economics literature is shifting towards the use of the VPF only. This value is used here, but with a sensitivity range using the QALY also included. The DFT and Defra guidance also sets out that these unit values rise in future years (Defra, 2019). It recommends an uplift of 2% per year, to reflect the assumption that willingness to pay for health outcomes will rise in line with real per capita GDP growth.

The estimates of economic costs are shown below. This shows there is a very large range depending on the valuation assumptions made (i.e. VPF or QALY). The marginal costs i.e. those costs additional to those associated with heat in the present day, are also presented below. As can be seen, with the use of the full VPF, the estimated economic costs from the increase in heat-related mortality is very large, i.e. with £1.8 billion/year (climate only) to £2.5 billion/year (climate and population change) in the 2020s, rising to £6.5 billion/year (climate only) to £9.9 billion/year (climate and population change) in the 2050s. However, with the use of a sensitivity value with the QALY, the values drop significantly, to £58 million to £83 million in the 2020s (climate / climate and population) and £213 million and £323 million in the 2050s. Including the 2% uplift significantly increases the future values.

Table 3 The total economic costs of heat-related mortality from climate change and socio-economic change in the UK. £Million/year. 2018 prices, no GDP growth, from estimates of Hajat et al., 2014.

Value of a Prevented Fatality	**Mean estimates of £Million / year - total**			
	2000-2009	**2020s**	**2050s**	**2080s**
heat- present day	3,849			
heat projection - climate only		5,619	10,353	16,511
heat projection - climate and population growth		6,397	13,726	24,446
Sensitivity QALY (1 year)	**Mean estimates of £Million / year**			
heat- present day	126			
heat projection - climate only		184	339	540
heat projection - climate and population growth		209	449	800

Table 4 The incremental economic costs of heat-related mortality from climate change for the UK. Increase over baseline. £Million/year 2018 prices and values, and with sensitivity including a 2% uplift.

Value of a Prevented Fatality		Mean estimates of £Million / year – additional over baseline		
		2020s	**2050s**	**2080s**
heat projection - climate only		1,770	6,504	12,662
heat projection - climate and population growth		2,548	9,878	20,597
VPF with additional 2% uplift		**Mean estimates of £Million / year**		
heat projection - climate only		2,479	13,534	47,721
heat projection - climate and population growth		3,568	20,552	77,629
Sensitivity QALY (1 year)		**Mean estimates of £Million / year**		
heat projection - climate only		58	213	414
heat projection - climate and population growth		83	323	674
QALY with additional 2% uplift/year		**Mean estimates of £Million / year**		
heat projection - climate only		81	443	1,561
heat projection - climate and population growth		117	672	2,540

The analysis has also estimated the values for England (alone).

The additional cases of heat-related morbidity would add to these costs, although these are low relative to the VPF estimates. The analysis has used the approach adopted in previous studies (e.g. CCRA1, HRW, 2012/ Hames and Vardoulakis, 2011) which estimates the increase in hospital patient days as a ratio of mortality (1:102). The unit values are £8,296 for a respiratory hospital admission and £8,471 for a cardiovascular admission (2017 prices) (Defra, 2019). The resulting estimates are below.

Table 5 The marginal costs of heat-related morbidity in the UK. Increase over base. 2018 prices / values.

Value of a Prevented Fatality		**Mean estimates of £Million / year**		
		2020s	**2050s**	**2080s**
heat projection - climate only		785	2882	5611
heat projection - climate and population growth		1129	4377	9128

What are the Benefits of Adaptation on Current and Future Risks?

The next step in the analysis is to consider the potential impacts of current adaptation (the Heatwave plan) in reducing current and future climate-related heat-related mortality, and thus helping to work back towards achieving the outcome (reducing preventable premature deaths and reducing spring and summer deaths). It is highlighted that previous CCRAs (1 and 2) did not estimate the impact of the current adaptation (including, as relevant for this paper, the Heatwave plan) on future deaths, even though this is an existing policy in place.

It is stressed that most of the evidence on effectiveness comes from heatwave events (rather than the total heat-related mortality burden), and this only captures a proportion of the burden in England. For this case study, the analysis applied the effectiveness of Heatwave responses to the overall heat-related mortality burden.

The Heatwave plan is an example of an adaptation measure that has been introduced in response to experienced/perceived climate extremes, notably the 2003 European-wide heatwave. The Plan sets out what should happen before and during periods of severe heat in England, focusing on what health and social care organisations (and other public agencies and professionals who interact with those most at risk) should do to raise awareness of the risks and what preparations to make to reduce those risks. The main focus is on short-term measures, primarily once hot weather has been forecast, centred on actions following the HHWS. This has been the focus of the analysis below. However, the Heatwave Plan also includes a set of long-term measures, which extend to longer-term planning to reduce heat, extending outside the health and social care responsibility towards the built environment.

The Heatwave plan includes a number of short- and long-term measures (see earlier). A key component of the plan is the HHWS. In the Heat Health Watch System (HHWS), the UK Meteorological Office issues heat-wave weather warnings when there is an expectation of significantly higher than average temperatures in one or more regions of England. The HHWS comprises four levels of response based upon threshold maximum daytime and minimum night-time temperatures. These thresholds vary by region, though an average threshold temperature is 30 °C by day and 15 °C overnight.

The four levels of response are:

- Level 1 - Awareness — the minimum state of vigilance during the summer.
- Level 2 - Alert — triggered as soon as the risk is 60% or above for threshold temperatures being reached on at least two consecutive days to have significant effects on health. This will normally occur 2 to 3 days before the event is expected.
- Level 3 - Heatwave — triggered as soon as the Meteorological Office confirms threshold temperatures will be reached in one or more regions.
- Level 4 - Emergency — reached when a heatwave is so severe and/or prolonged that its effects extend outside the health and social care system.

Table 6 Threshold maximum day and night temperatures defined by the Met Office National Severe Weather Warning Service (NSWWS) region.

NSWWS Region	Day	Night
London	32	18
South East	31	16
South West	30	15
Eastern	30	15
West Midlands	30	15
East Midlands	30	15
North West	30	15
Yorkshire and Humber	29	15
North East	28	15

The triggering of each of these levels is associated with given resource implications, see below, which include resource costs. The three warning systems are formulated principally to require action by health professionals, notably Advanced Nurse Practitioners, (ANPs), who are primarily involved in the care of the local population in their homes, rather than in hospitals. This analysis is based on the previous care provision landscape, and it recognised that this has changed with the addition of social care from local authorities as well, but the resource implications provide indicative estimates of the potential scale. Further work to define updated values is recommended.

Table 7 Roles of Health Professionals and Indicative Resource Implications with HHWS Implementation

Heat-wave Plan Alert Level	Role of Health Professionals	Resource Implications
Level 1 – Awareness	Planning at beginning of heat-wave season to protect vulnerable people: - Be familiar with the principles and core elements of the Heatwave Plan - Be familiar with the client heat-wave advice leaflet and give copies to clients as appropriate. - Consider clients' vulnerability to adverse weather conditions and add to at-risk list	One hour per Health Professional, annually. Other fixed costs components incurred at Level 1 include: - Weather Office contract fee; - Printing, distribution and storage of information leaflets & documentation.
Level 2 – Alert	- Identify list of those from existing caseload who will require daily contact in the event of a heat-wave; - Avoid duplicate contact /visits from multiple agencies; - Determine what non-essential activities could cease.	One and a half hours per Health Professional, each time Level 2 is reached.
Level 3 – Heatwave	- Stop nonessential activities; - Commence daily contact with clients at risk; - Make daily situation reports	Four hours/day per Health Professional, for duration of heat-wave.
Level 4 – Emergency	- Continue to do best for caseload; - Provide situation reports upwards, as requested, and raise any concerns they may have;	Four hours/day per Health Professional, for duration of heat-wave.

Sources: Roles and resources based on Department of Health (2010). Note that the healthcare landscape has evolved since this time, thus the resource estimates should only be treated as indicative.

This case study has undertaken additional analysis to estimate the potential costs and benefits of the HHWS on current and future climate risks, i.e. on heat-related mortality. This involves analysing the potential benefits of the scheme (reduced deaths) but also the increase in costs. The latter is important because rising temperatures, and a greater frequency of heat waves, the level 2,3, and 4 responses (see above) will be triggered more frequently, leading to much higher operating costs. Note that this assumes that the trigger levels stay at the same level – noting in the future these could be adjusted to reflect acclimatisation.

Benefits

Heatwave plans and heat alert systems have been in place for many years in other countries, and are reported to have large benefits in reducing mortality. However, they are not 100% effective in reducing deaths. There is currently no published data that calculates the effectiveness of the Heatwave Plan and HHWS in England, although an evaluation is due to be published soon.

There is some evidence that suggests that the scheme has had some benefits in reducing mortality for temperatures above the HHWS thresholds, but that heat-related mortality below the thresholds has not changed significantly. Green et al. (2016) developed a linear regression model for heat in England and assessed the observed versus estimated fatalities of the sustained heatwave in England in 2013: they found the impact on mortality was considerably less than expected, i.e. the 2013 event had much lower mortality than previous large heat events (2003 and 2006), despite a similarly prolonged period of high temperatures. While the Heatwave plan is a factor in this, the authors report that the reasons for this are unclear and further work needs to be done to understand this.

At the same time, there have been localized studies of the potential benefits and costs of heat alert systems in other countries. Ebi et al (2004) looked at the benefits of a heat alert system in Philadelphia. The study estimated the benefits of the scheme, in terms of the number of lives saved, but it did highlight that the benefits of a HHWS are dependent on the degree to which short-term mortality displacement occurs, i.e. how many of the deaths prevented would have subsequently occurred shortly after. The study also found that the benefits of the scheme far outweighed the costs. A review of the relevant literature by Tooloo et al. (2013) identifies a small number of studies on heat warning effectiveness that have been undertaken globally. Two studies in Europe include Fouillet et al. (2008) that compares deaths before and after heatwave alert implementation in France, and Morabito et al. (2012) that undertake the same comparison in Florence, Italy. Whilst the French study finds effectiveness of 68%, the Florentine finds effectiveness of 9%. This suggests that are a range of context-specific factors that influence the effectiveness of heat warning systems. In North America Tooloo et al. report on findings from Weisskopf et al. (2002) that show a reduction in mortality of 88% in Milwaukee, USA, and Palecki et al. (2001) with a mortality reduction of 84%. Several studies have looked at the potential benefits of heatwave alert systems under climate change (Hunt et al., 2016; Bouwer et al., 2018; Chiabai et al., 2018). These report these schemes have large benefits in reducing future mortality. For example, the estimated benefits on setup of a warning system, real-time surveillance of health data, and emergency plans for vulnerable people with visits and care offer, which are 65% effective and had a high benefit to cost ratios (Chiabai et al., 2018). Hunt et al (2016) used the mid-point of European studies, and thus a 40% reduction.

To explore the potential benefits, we use a sensitivity range with an assumed lower value of 0% and an upper value of 40%. Therefore, the maximum effectiveness is assumed to result in a 40% reduction in fatalities (i.e. it prevents 40% of premature fatalities in Table 3 and 4 above), and it is assumed this level of reduction continues under future climate change. This is used to generate an indicative range. We acknowledge that the Heatwave plan is likely to reduce excess deaths primarily during heatwaves, although it does include year-round actions.

The economic benefits of reducing heat-related mortality by 40% could be very large (i.e. plausibly £1 billion/year by the 2020s, based on the full VPF, based on central estimates reported earlier). In practice, there is an issue of how much of this reduction relates to additional fatalities as a result of the Heatwave plan and during especially during heatwaves, versus how much reflects the total heat-related burden of fatalities (which is larger). We also note that the levels may be much lower (pending the results of the current evaluation). Irrespective of the exact benefits, the Heatwave Plan and HHWs would not be 100% effective in reducing current or future heat-related mortality, and thus there are large residual numbers of fatalities and economic costs.

<u>Costs</u>

The case study has also investigated the potential additional costs of operating the Heatwave plan, specifically the HHWS components. As above, the HHWS comprises four levels of response. The three warning systems principally require action by health professionals, notably Advanced Nurse Practitioners, (ANPs), who are primarily involved in the care of the local population in their homes, rather than in hospitals. We assume that the co-ordinating action of nurse team leaders is included in the time that is allocated to nurses. The current and future costs of the warning systems are calculated according to a series of stages. These are set out below, with an example for London and England (Hunt et al, 2016).

a) The total number, (full-time equivalents), of Health Visitors (HVs) and District Nurses (DNs) currently working, allocated to "acute, elderly and general" populations, are calculated[2]. These totals are 743 and 733, for HVs and DNs, respectively in London, scaled by a factor of approximately seven for England – on the basis that the same staff: population ratio existing for London, applied

[2] Department of Health - NHS staff by occupation code staff groups 1997-2004

country-wide. The sum of these HVs and DNs are the total Health Professionals (HPs) assumed to be employed and engaged in the group most vulnerable to heat-waves.

b) The employment totals are projected over the 50 year time period under the SSP2 population scenario. It is assumed that the population-HP ratio is kept constant at today's levels over this time.
c) The annual cost of employing an HP is calculated from cost information identified. Cost information includes: salary, on-costs, non-capital overheads, capital overheads. These are costs of £147/day (London) (Curtis, 2010).
d) The total HP costs is calculated for the four different warning levels. We adopt the Summer 2003 heatwave as a historical analogue to which costs can be calibrated. The 2003 heatwave is characterized as a 1 in 100 year event, which is projected to become more frequent under all climate change scenarios.

- For Level 1, it is assumed that each HP typically spends one hour of time per year meeting its requirements. This day-fraction, (0.125), is first multiplied by the day resource cost identified above. This HP unit cost is then multiplied by the total numbers of HPs. In addition to these costs, the costs associated with the weather office annual contract fee, plus the costs of printing, distribution and storage of information leaflets and documentation are derived to give a total annual fixed cost of the warning system. This was estimated to be £200,000 for the UK Meteorological Office. This relates to the additional marginal cost for the information provision, and does assume baseline climate service provision is funded in each case. It is highlighted that these costs only include those to the healthcare sector and doesn't include the cost to Public Health England to resource the plans (which are significant) and other activities around the system (the emergency planning).
- For Level 2, the HP unit cost is estimated in the same way as for Level 1. The incidence costs of a level 2 event are estimated on the basis of those incurred in the Summer 2003 event. The probability of an equivalent event occurring is derived from the climate model projections adopted. These probabilities are multiplied by the unit cost; the resulting expected annual HP unit cost is then multiplied by the total numbers of HPs deployed in each year to produce a Level 2 total annual variable cost.
- For Level 3, the total annual variable cost is estimated in the same way as for level 2. The weather event is assumed to last eight days.
- For Level 4, using the Summer 2003 experience in London as an analogue, there are assumed to be no additional HP costs to those associated with Level 3. This is a conservative assumption: a more severe event – of the type experienced by Paris in 2003 – could easily justify an increase in HP costs of 25-50%. This is highlighted as an area for further research. It is highlighted that in reality, given fixed staff numbers, the system will reach maximum capacity during major events.

Level 1 costs are the highest associated with the levels, reflecting the high annual fixed costs associated with having a heat health warning system. Level 3 costs are higher than Level 2 costs, reflecting the fact that in the event of a heat event of this magnitude occurring, the time incurred in providing the care to the population will be substantial. The cost estimates that can be attributed to climate change alone apply to Levels 2 and 3 only, since it is the costs estimated for these two levels that are determined by the changing probabilities of heat-wave events under the climate scenarios. It is noticeable that the costs increase substantially under the 2050s scenarios, as climate change is projected to become more significant. It should also be noted that the costs differ between scenarios, reflecting the different probabilities of the heatwave events under these scenarios.

Table 7. Annualised Costs of Heatwave Plan (in £ 2010-2060 (undiscounted)

	London	England
Baseline	250,000	1,705,000
Cool	264,000	1,793,000
Median	269,000	1,831,000
Hot	281,000	1,908,000

Benefit to cost ratio

Using similar approaches, Hunt et al. (2018), analysing London only, found that the marginal benefit to cost ratio, i.e. the additional benefits versus the increase in additional resource costs, led to a high benefit to cost ratio when the full value (the VPF) was used, ranging from 10:1 to 30:1 for the 2040s depending on the level of climate change (higher BCRs were found with greater warming, even though costs also increased under these scenarios). This assumed the 40% effectiveness level and used the Hajat numbers for all heat-related fatalities. On this basis, there is a high benefit to cost ratio, and this would be maintained even if the effectiveness of the scheme is lower (noting that the benefits assume reductions in all heat-related fatalities, not just during heatwaves).

These benefits would continue, and would be expected to increase in the future, with greater numbers of heat extremes under climate change. While the resource costs will also rise, these would be modest compared to benefits. However, we note that the BCR may be much lower, pending the results of the HHWS evaluation.

Residual adaptation and justification for further adaptation

Even with the Heatwave Plan and HHWs in place, there will be large number of residual fatalities from heat. The absolute number of cases is also estimated to rise over time, and in higher warming scenarios, they would rise very significantly, even accounting for some additional acclimatisation. Indeed, even assuming the upper end of effectiveness (40%), the numbers of annual fatalities would rise to would rise to unprecedented levels. Even under an optimistic scenario, residual economic costs (from fatalities) would be £1.3 billion/year in the 2020s, rising to £4.9 billion/year by the 2050s.

The CCC Progress report (2014) identified further action that could be taken by the Government and others to avoid increasing health risks associated with heat, and identified: heatwave plans, overheating in hospitals (and the need for standards), cost-effective cooling of homes (i.e. shade), and passive cooling. The CCC (2014) identified that evaluations of the Heatwave Plan for England in 2007 showed that awareness of the plan is generally high amongst healthcare managers and inspectors, however, around 30% of care home inspectors and Primary Care Trusts reported that action was only being partially taken, or not taken at all. The report also reported on current over-heating risks in hospitals.

The JRF (2016) case studies on care homes and climate risks found that a lack effective heat management because of design and management issues, including: unwanted heat gains from pipework, lack of investment in long-term strategies to tackle overheating (e.g. external shading), conflicts between cooling strategies and occupants' requirements, and separation of roles in care organisations creating confusion over responsibilities in managing heating controls.

In terms of current policy, the 2nd National Adaptation Programme (HMG, 2018) set out the following actions taken (in addition to the heat wave plan):

Adapting health systems to protect people against the impacts of climate change			
We will work to ensure that all clinical areas in NHS Trusts have appropriate thermal monitoring in place.		By 2023	NHS Sustainable Development Unit, NHS Improvement DHSC
We will work to ensure that all NHS Trusts have in place an adaptation plan, either stand alone or as part of their Sustainable Development Management Plan.		By 2023	As above
All NHS providers will be encouraged to use the Sustainable Development Assessment Tool to assess progress on Adaptation. The tool will support high quality adaptation plans, either stand alone or embedded into Sustainable Development Management Plans.			As above
We will ensure that all NHS trusts are reporting consistently on risk assessment for overheating events.		By 2023	As above
Adaptation measures, particularly thermal monitoring and numbers of risk assessments for overheating events, will be incorporated into the Model Hospital to allow benchmarking of performance.			NHS Sustainable Development Unit, NHS Improvement
The NHS SDU will informally review the coverage of adaptation in mandatory provider trust and commissioners sustainability reports.		Annually	NHS Sustainable Development Unit
System wide performance will be reported annually in the Healthcheck report, alongside other metrics of sustainable development and social value in health and care. The Healthcheck report is published on behalf of the National Cross System Group for Sustainable Health and Care. The metrics will be % NHS providers to have an adaptation plan (stand alone or as part of SDMP) % of clinical areas in NHS trusts covered for thermal monitoring % of NHS providers reporting on adaptation in their annual reports Number of overheating risk assessments undertaken in NHS trust clinical areas (required when temperatures exceed 26C)			NHS Sustainable Development Unit, National Cross System Group for Sustainable Health and Care.
Best practice in adaptation will be sought and recognised annually through the Sustainable Health and Care Awards- Adaptation category			NHS Sustainable Development Unit.
Delivery of health and social care services			
We will take measures to minimise overheating in homes, and other buildings including hospitals, care homes, schools, prisons and offices. We will complete research into overheating in new homes (flats and houses) to determine the extent of the current risk of overheating and whether it will worsen in the future.		End 2018	MHCLG, DHSC, SDU. NHSE, CQC, PHE, MoJ, DfE.
We will develop a single adverse weather and health plan, bringing together and improving existing guidance. This will aim to mainstream action within the health system and local communities, reduce health risks associated with adverse weather and address the health risks identified in the second CCRA.		By 2022	DHSC, PHE, SDU, NHSE, Local
We will continue to undertake research to understand more comprehensively the health consequences of hot weather and the health interventions available to minimise preventable harm.		Ongoing	DHSC, PHE
We will update the evidence base on the health impacts of climate change through the production of an UK focused report ('Health Effects of Climate Change in the UK') based on the latest Climate Change Projections, following publication of UKCP18.		2023	DHSC, PHE

This list is quite comprehensive, especially compared to many of the other risks considered in the NAP. However, a closer examination shows that it is primarily focused on thermal / heat monitoring, as well as process-based outcomes (the production of adaptation plans). This makes it very difficult to know what adaptation to reduce risk directly is planned, and how effective it will be. Therefore, in light of the analysis above, we consider the outcomes (to reduce premature deaths, and reduce heat-related fatalities) are still likely to be missed. There are therefore further opportunities for further additional options. This is considered particularly important, because the likelihood of a major unprecedented heatwave event in the next decade – i.e. a heatwave that exceeds any previously recorded levels and triggers a much greater level of impacts - is considered high. This could have large policy impacts.

Step 4. What are the additional adaptation options to address residual impacts?

The next step is to consider the potential additional adaptation options that could reduce heat and health related risks. This is particularly focused on adaptation options in the health and social care domain (and other public agencies and professionals who interact with those at risk) - to help reduce heat-related deaths. It is noted that there is a wider set of adaptation actions for reducing heat exposure in buildings in general (residential) and the urban environment. The case study has updated a previous literature review of adaptation option for heat and health (Watkiss and Hunt, 2012; ECONADAPT, 2015). This identified a large number of options, included:

- Building capacity;
- Health education;
- Information provision;
- Awareness raising;
- Training of health service staff for heat extremes;
- Improvement of morbidity and mortality records / systems;
- Research on physiological adaptation and socioeconomics;
- Research into physical / mental stressors in old age and climate;
- Heat alert systems;
- Enhanced heat alert system;
- Register of vulnerable and partner / carer systems;
- Structural improvements to institutions e.g. care homes (cool room);
- Air conditioning care homes (all) (retrofit);
- Natural (passive) ventilation care homes (retrofit);
- Structural improvements to hospital (cool room);
- Air conditioning health service (retrofit);
- Natural (passive) ventilation health service (retrofit)
- Air conditioning, residential (retrofit, new build)
- Adjust working hours (outside work) during extremes
- Behavioural change clothing, drink, scheduling daily work
- Health system infrastructure (new)
- Building insulation
- Natural (passive) ventilation new build (design and construction/ building codes)
- Active-cooling systems low energy/low carbon
- Natural (passive) ventilation retrofit
- Green roofs
- Shade using trees
- Green urban areas
- Spatial planning (property, development) - new
- Zoning and transportation (new)
- Spatial planning / zoning (property, development) – retrofit

Much of the literature identified is focused on the built environment. While this will have health related benefits, the focus of this study is more on health and social care options. This is important because if the goal is to reduce heat-related mortality, the most cost-effective approach is likely to be to target those at risk, rather than targeting heat reduction (e.g. through the built environment) in all buildings. In consideration adaptation, two framing concepts have been used.

First, we have used the priorities for early adaptation framework from CCRA3. This has focused on:

- Early low and no regret options that address current risks and build resilience;
- 'Climate-smart' incl. decision making under uncertainty (for early decisions with a long life-time / risk of lock-in);
- Early planning / iterative adaptive management, in cases where there are benefits from early activities / or adaptation that involves long-lead times.

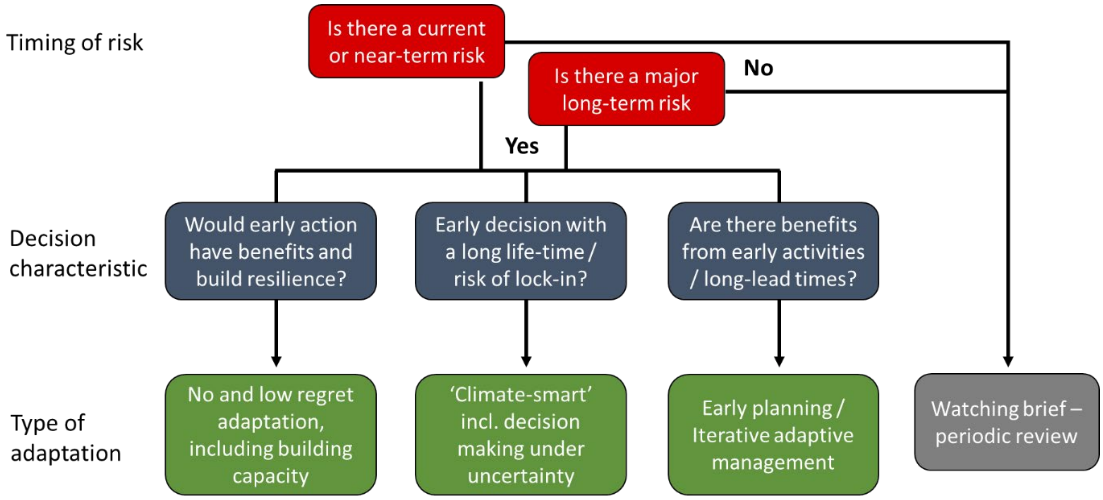
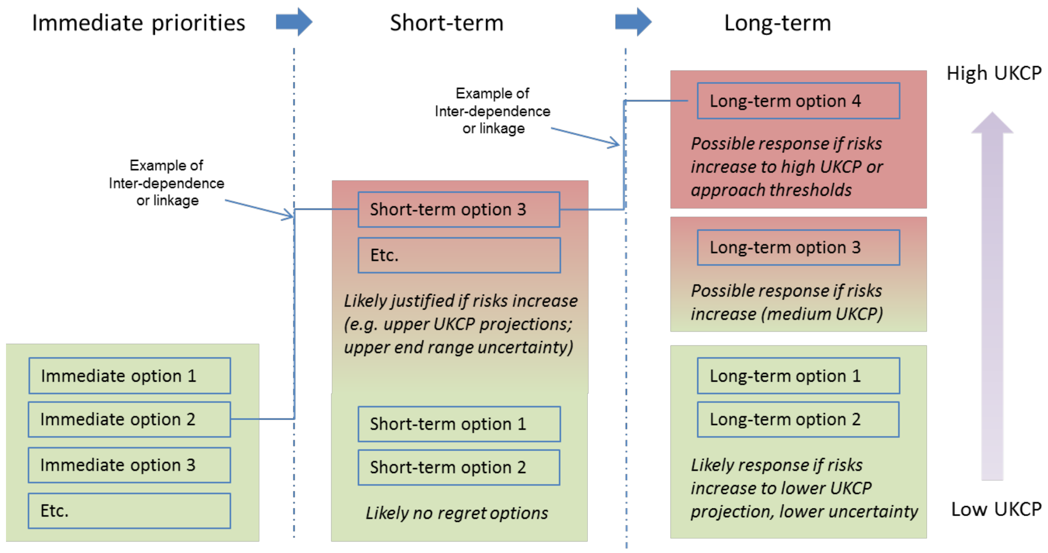


Figure 6 Early priorities for adaptation. Source CCRA3.

Second, we have used the consideration of the long-term adaptation pathways concepts that are being promoted in much of the adaptation literature.



Adaptation pathways. Source Watkiss and Hunt, 2011.

This recognises that over time, adaptation will need to scale-up, and there are inter-dependencies between short and long-term actions.

Heat adaptation pathways have been developed recently in a number of projects. The European Project RAMSES advanced adaptation pathways for heat, looking at case studies in London, Antwerp and Bilbao (RAMSES, 2017). The analysis for Antwerp built on a HHWS. This used thresholds for the

HHWS of Tmax 26°C. The study developed an adaptation canvas for presenting possible options, showing the combination of health and structural responses. It also built adaptation route-maps, but these were primarily focused on additional structural measures. Kingsborough et al (2016) also built an adaptation canvas for London. However, this was more focused on the city scale, and had more focus on buildings than on health responses. These canvases do highlight that to solve the overall problem of heat, a city wide approach is needed that blends health and building responses. For this case study, the focus is on the former, although we acknowledge the overall city scale is important to address risks (as part of an integrated approach).

What is notable about this adaptation pathways literature is that most of the health and social care options are included as short-term options. The longer-term focus is on the built environment and spatial planning. We consider this to be a major gap, i.e. there is a priority to develop iterative adaptation pathways for health and social care options for heat.

Low-and no-regret options

A first set of low regret options are centred on enhancing the effectiveness of the current heat wave warning system and the health care cascade and response. These potentially include:

- Enhanced forecasting (weather and climate services) – for forecast reliability and earlier warning.
- Better information on heat risks and over-heating risks (monitoring).
- Enhanced risk preparedness, i.e. actions to improve resilience, in advance of events.
- Enhanced risk response, i.e. actions during heat wave events.

For the latter two, this includes including behavioural change among the public and for health and social care workers.

Some of these options would correlate to the NAP actions (e.g. monitoring). However, an important point is that this will not just have to respond to more frequent triggering of the scheme, but also to cope with more extreme temperatures.

The Economics of Climate Resilience study (Frontier Economics, 2013) looked at the barriers to effective heatwave planning and response. It also looked at a 'what-if' scenario on how much mortality might be reduced with more effective action, but was not specific on how these might be achieved. However, there are potential lessons from the large number of HHWS introduced in other countries (WHO, 2009: 2018), with potential lessons from European and North America schemes that have been running for longer, and have to cope with more extreme temperatures. What is interesting about these schemes is that some of them achieve much higher effectiveness, as reported in Tooloo et al. (2013), WHO analysis (2018), and many of the US studies. Indeed, some studies report effectiveness levels of 80 to 90%. A key priority for future consideration is therefore to understand the success factors in these studies, and identify additional cost-effective measures for the UK. It is highlighted that these may have important resource costs, so they may be low-regret rather than no-regret, but this does suggest there are many additional options. It is noted that there some of these schemes have highly targeted social care for vulnerable individuals in the community, including greater use of public health, voluntary and community-based approach to make sure they are directly targeted for help and support during heat events, over and above current actions. The Heatwave Plan also highlights links with the Multi-agency Local Resilience Forums and Health and Wellbeing Boards, which could include longer term strategic planning.

A second set of low-regret options would be to address over-heating risks in care home, as a large vulnerable population with disproportionately high risks. As highlighted by CCC (2014), insufficient action was being taken in around 30% of care homes and CCGs, and focusing on these would be a no-regret action, but could extend to a greater focus on preparedness (in advance) as well as response (during a heat wave). The 2014 report highlighted Health and Wellbeing Boards should consider how to enforce and report on actions set out in the Heatwave Plan for health and social care facilities such as care homes. The CCC progress report (2017) highlighted that further action should be taken to assess and reduce the risks of overheating in existing buildings, with the priorities including hospitals, care homes and suggested this could be undertaken for example through the relevant standards agencies such as the Care Quality Commission. This is considered particularly important given the increase in care homes places (or else care in the home) (see earlier), there is a clear priority to target information on preparedness, as well as improving emergency response (during heatwaves), for these groups. Note that as well as capacity (information and awareness), this could include behavioural changes (activities, clothing, etc.), as well as for example, low cost changes to existing buildings. The JRF report (2016) highlights that awareness of the health risks that heatwaves pose to older occupants needs raising. A similar set of issues exist for hospitals. The CCC (2014: 2017) also identified the issue of overheating in hospitals. It recommended that the Care Quality Commission (CQC) should consider setting standards for maximum temperatures in hospitals and investigate how many wards do not have the means to control temperatures. There is a greater focus on monitoring now in NAP2, but there is still further measures that could be taken for immediate short-term responses to manage heat.

It is noted that there is a variety of care settings, catering for different levels of need. People in care homes are more likely to be made aware of the risks, and there is perhaps a greater risk for the emerging pool of people who are cared for at home. It is also worth noting that the private care sector has come under financial pressure in recent years, i.e. which could make the additional resources needed to upscale heat-related care more challenging. As highlighted above, this also means that future care policy could have important lock-in risks, e.g. a policy towards greater independent care in the home might actually increase future risks.

It is also highlighted that the evidence from UKCP18 suggests a greater risk of extreme heat than previously assessed (in UKCP09). The report identifies that the likelihood of a 2018 summer is projected to increase significantly (to a 50% probability by 2050s). Implicitly, this also suggests that an unprecedented extreme heatwave is more likely. This is shown in Figure 4, which shows that the for the current climate (2018), the probability of an event greater than 1976/2018 is already quite high. Indeed, this would suggest the probability of an unprecedented event is likely in the next decade, i.e. what we might characterise as a >40°C temperature extreme. A key question is whether England is prepared for such an event. An early low-regret options would be to undertaken more contingency planning for this type of event, in order to enhance preparedness.

Addressing lock-in for early decisions

There is an obvious set of actions to ensure new care homes and hospitals are designed for the future climate, i.e. they are climate smart. This is particularly important given the lock-in involved, i.e. the higher costs of retrofitting later, while noting this has to be considered in terms of the higher costs (during construction) versus the future benefits (which accrue over time).

It is possible to address future heat risks using air conditioning (AC) (mechanical cooling), which reduces the incidence of heat-related mortality associated with heat waves (Ostro et al., 2010). This can also be adopted retrospectively in existing buildings. However, this comes with some major downsides. First, there are high costs from the energy use. Kovats (2009) reports that structural interventions are expensive and that France spent more than €150 million in 2004 on providing additional staff and cool rooms in residential homes for the elderly (citing Michelon, Magne and Simon-Delaville, 2005). Second, there are major mitigation trade-offs from the associated greenhouse gas, as well as air pollution emissions, thus this can be considered a potential mal-adaptation option, especially in the near-term (in the long-term, the switch to decarbonised electricity will mean the current externalities of AC no longer are an issue).

The alternative is to use passive cooling, which would be a form of climate smart design (orientation, blinds, shading), passive ventilation systems, etc. These are most cost-effective when built into the design. Passive retrofit options are a possibility, but these can involve high retrofit costs depending on the measures used (e.g. external shutters are high cost per household); some passive cooling measures in existing homes such as closing blinds during the day and opening them at night are zero cost.

For care homes, there has also been research on under the project on Built Infrastructure for Older People in Conditions of Climate Change (BIOPICCC) (Curtis et al, 2014). This highlights an evidence gap on nursing homes and heat. As above, the CCC (2017) identifies the need for standards for care homes to reduce heat risks.

The JRF (2016) report highlights that adaptation strategies require input from designers, development teams and care home staff, plus support through enhanced regulations, standards and guidance from care sector bodies and Government departments.

The Heat Wave Plan (2018) sets out possible ways to reduce heat in care homes through changes in the built environment, as below:

- create cooling green spaces in the surrounding environment, with trees, shrubs, trellises, arbours, climbers, green roofs and water features;
- do not extend car parks at the expense of green spaces – this adds to surrounding heat. Introduce an active transport plan or car-sharing schemes to reduce the demand for car park spaces. Plant trees around existing car parks and on top of multi-storey car parks ensure that buildings are well insulated – both loft and cavity insulation helps to reduce heat build-up;
- increase opportunities for night-time ventilation either through vents or windows;
- reflective paint may help on south-facing walls and roofs. This could also be considered for hospital transport – all London buses now have white roofs to reflect heat.

However, for many care home buildings, planned responses during design involve major barriers to implementation, due to higher up-front capital costs and institutional barriers, for example, passive technologies need to be built at the design phase by one actor (the construction firm) to generate benefits for another (the care home operator). This example highlights that autonomous reactive adaptation is unlikely to lead to complementary mitigation-adaptation linkages on its own (i.e. avoiding air conditioning), and that synergistic policy will need to overcome barriers, requiring planned public adaptation to create the enabling environment, relevant legislation or market signals.

This indicates that there will be a need for support from Government needed to create the awareness and enabling environment for the private sector. Further investigation of the options would be highly beneficial.

For hospitals, where the risks are high, the high costs and potential downsides of mechanical cooling might be justified (i.e. for critical infrastructure, and with a very high-risk group). There is also a literature on extreme heat and labour productivity (Lloyd et al, 2016), and heat events in hospital will also have implications for productivity. With respect to adaptation to more frequent heatwaves, a number of possible strategies have been put forward which may imply changes to official guidance for construction of hospital buildings (see Curtis et al, 2014). The result has been the use of mechanical cooling or air conditioning to reduce risks of overheating – though this conflicts with the NHS Carbon Reduction Strategy. There has been pilot work on hospital design (including retrofitting) that emphasis passive approaches in the Design and Delivery of Robust Hospital Environments in a Changing Climate (DeDeRHECC) project Short et al (2012); Giridharan et al., 2013: Fifield et al., 2018) which highlights the potential benefits of such design, but also highlights that other drivers (economics) are not currently leading to the uptake of such design, and that some new buildings are still building in over-heating risks.

Long-term adaptation (long lead times or major future effects)

As highlighted above, there is an emerging literature on adaptation pathways for urban heat. However, this generally include health and social care options as short-term options – with the longer-term pathways approach centred on the built environment and spatial planning. We consider this to be a major gap, i.e. there is a priority to develop longer iterative adaptation pathways for the health and social care sector, and not assume that these future problems will be addressed adequately by the built environment. This will involve enhanced monitoring, research and piloting (i.e. what works). This will need to consider effects that may help reduce risks (acclimatisation) but also those that are likely to increase them (increasing urban heat island effects).

Step 5. What are the benefits and potential costs of additional adaptation?

Finally, the case study has considered the potential costs and benefits of additional adaptation. The current economic studies focus heat-wave warning systems (E.g. Hunt et al, 2016; Bouwer et al, 2018: Chiabai et al., 2018; Pohl et al. 2014) or the built environment (RESIN, 2018) (see also the review findings from ECONADPT, 2015). In the absence of such data, the case study provides a qualitative indication of the possible scale of costs (low, medium, high) and effectiveness (low, medium, high), together with commentary where appropriate. These indicators are designed to indicate options and their associated economic consequences, and to draw attention to the fact that more analysis is needed to develop cost-efficient strategies in the future. A particular focus is to test the hypothesis – advanced from this case study - that that targeted health system responses might be able to achieve higher benefits at lower costs than general measures aimed at the built environment.

Table 9. Possible Additional adaptation options

	Cost rating	**Effectiveness**
Building capacity (in DH-NHS, care homes, etc)		
Awareness raising;	Low: on-going operational across all staff	Medium
Training of health service staff for heat extremes;	Medium: on-going operational across all staff	Medium
Improvement of morbidity and mortality records / systems;	Low: on-going operational	Low
Research on physiological adaptation and socioeconomics	Low: capital and operational	Low-medium
Behavioural change in NHS and social care staff	Medium: on-going operational across all staff	Medium - high
Adaptation Options		
Structural improvements to institutions e.g. care homes (cool room);	High: capital	High
Air conditioning health service (retrofit);	High: capital and operational	High
Natural (passive) ventilation care homes (retrofit);	High: capital	Medium
Adjust working hours (outside work) during extremes	Medium: operational	Low-medium
Behavioural change: clothing, drink	Medium: operational	Medium
Natural (passive) ventilation new build (design and construction/ building codes)	Medium-high: capital	Medium-high
Active-cooling systems low energy/low carbon	Medium-high: capital	High

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