

# THE LANCET

## Planetary Health

### Supplementary appendix 2

This appendix formed part of the original submission and has been peer reviewed.  
We post it as supplied by the authors.

Supplement to: Mitchell D, LoYTE, Ball E, et al. Expert judgement reveals current and emerging UK climate-mortality burden. *Lancet Planet Health* 2024; **8**: e684–94.

## 1 **Supplementary Material**

### 2 **Methods for creating synthesis figures**

3 Here, we describe the statistics and assumptions that were made to create the figures in the main manuscript.

#### 4 ***Burning embers diagram (Figure 1)***

5 The transitions (the mid point between colour changes) are the mean of the individual responses to each question (for the exact  
6 questions, see later in the SI). The range in transitions (vertical bars) is the 10th-90th percentile of all participants answers, and  
7 gives an idea of the uncertainty amongst the experts. The solid dots next to the transitions are a measure of how many experts  
8 answered that question, with one dot representing less than a third of participants, two dots representing between a third and  
9 two thirds, and three dots representing over two thirds.

#### 10 ***Synthesis of mortality diagram (Figure 2)***

11 This figure condenses complex data into a more accessible synthesis. The individual responses to each question are shown in  
12 Figure S1.

13 To pick a reflective value for the number of deaths that is displayed in Figure 2, we choose the mode value of the participants  
14 answers (i.e. from Figure S1). If there are two modes in the answers, we select the mode closest to the mean.

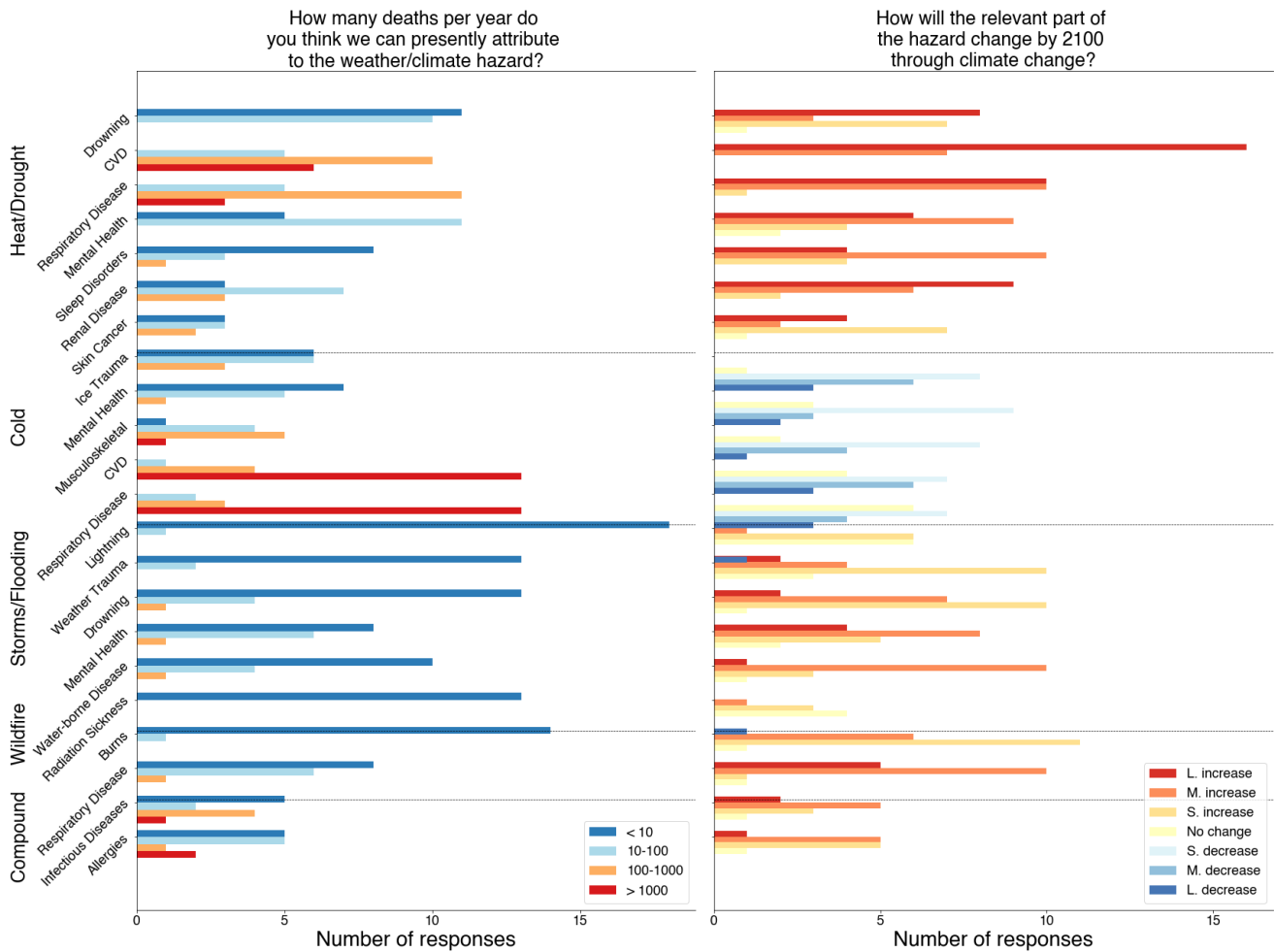
15 For the consensus on the number of deaths (solid versus dashed circles in Figure 2) we use two categories for simplicity.  
16 ‘High’, and ‘lower’, with the latter meaning medium or low consensus. To determine the consensus category, we following  
17 these criteria:

- 18 • CRITERIA 1: if only one mode exists in the answers, and more than a third of the results do not agree with the mode,  
19 then it has lower consensus, otherwise it is listed as high consensus.
- 20 • CRITERIA 2: if there are two modes in the answers, and the answers are not adjacent then it has lower consensus.
- 21 • CRITERIA 3: if there are two modes in the answers, and the answers are adjacent then, we total the number of responses  
22 in both modes, and if that is more than 80% of the total responses for that question it has high consensus If it is less than  
23 80% it has lower consensus.

24 For the y-axis in Figure 2, participants had to assign what level of decrease/increase they expected for the relevant part  
25 of the hazards, by the end of 2100. They also had to answer some calibration questions (see Questions asked in the online  
26 form). To create the y-axis locations of the bubbles, we took the median of those percentages across the answers for each of the  
27 different health outcomes. The y-axis labels, ‘Small increase’, ‘Medium increase, and ‘Large increase’ are placed at the mode  
28 percentage across all participants, which is 20%, 50%, and 100% for each label, respectively.

### 29 **Methods for systematic reviews**

30 One author conducted 26 searches following the relevant PRISMA guidelines for systematic reviews. The searches corresponded  
31 to the 22 individual health outcomes for the various weather/climate hazards, with an additional ‘All Cause’ search for each



**Figure S1. Number of individual responses for each answer in the survey.** The 22 different health outcomes are given on the y-axis, grouped by the 5 hazard categories: Heat/drought, Cold, Storms/Flooding, Wildfire, Compound Hazard. The Compound Hazard category refers to complex combinations of weather types which are not dominated by one in particular hazard, for example, 'allergies' can be strongly impacted by wind, rain, and temperature patterns. The different panels represent a different question asked for the part of the hazard relevant to each of the 22 health outcomes. A summary of this data is displayed in Figure 2.

32 hazard except the 'compound' hazard. No 'all cause' search for the compound hazard was performed due to the broad nature of  
 33 this category. The parameters of each search are given below. The objective for each individual search was to quantify the  
 34 number of existing publications for each hazard and health outcome in the UK (Figure 3).

35 **Eligibility criteria**

- 36 • Original and peer-reviewed research articles - featuring new analysis of climate/weather and health data or models, or  
 37 reporting of health data associated with a weather event;
- 38 • Language - articles with title, abstract and full text in English were included in the systematic reviews;
- 39 • Date of publication and publication status - final publication date restricted to 1st January 2003 and after;

- 40 • Study location - United Kingdom of Great Britain and Northern Ireland, including England, Scotland, Wales, and  
41 Northern Ireland, or any city/region therein (settings of primary studies were reviewed to check for this criterion);
- 42 • Eligible articles that aimed to assess the impact of exposures and outcomes, describe (qualitatively or quantitatively)  
43 associations between exposure and outcome variables from a UK setting. These associations can be calculated based on  
44 a) measured or b) modelled exposure and outcome variables using analytical or numerical models. In the former type of  
45 study, the exposure variable must have been measured within a specified period of time prior to sampling or observing  
46 the outcome variable. For the latter, modelled values of exposure variables must be based on climate models.

47 **Database searched**

48 Scopus, Web of Science

49 **Exclusion criteria**

- 50 • ‘Review article or commentary or correct publication date’: records were excluded if the report was not an original  
51 research article OR was published before January 2003;
- 52 • ‘Incorrect region’: records were excluded if the report did not include data from the UK;
- 53 • ‘Incorrect research topic’: records were excluded if the report did not research the correct weather/climate hazard AND  
54 health outcome. Records studying seasonality were excluded here;
- 55 • ‘Not UK specific’: records were excluded if the report included data from the UK but did not present UK-specific results  
56 (i.e. health outcomes are analysed for a wider region containing the UK);
- 57 • ‘Included in All Cause category’: records were excluded if the report researched the appropriate weather/climate hazard  
58 and EITHER did not research cause-specific mortality/morbidity OR researched multiple health outcomes;
- 59 • ‘Health impacts not linked’: records were excluded if the report researched the appropriate weather/climate hazard  
60 but EITHER health impacts were not considered OR were not explicitly modeled (e.g. risk of vector-borne disease  
61 transmission was calculated, but the expected number of cases was not).

62 **Search terms**

63 The search terms used in the Scopus database are shown in the Supplementary Tables (‘Search Terms’). The equivalent search  
64 was also performed in the Web of Science database, with identical filters and limits.

65 **Data management**

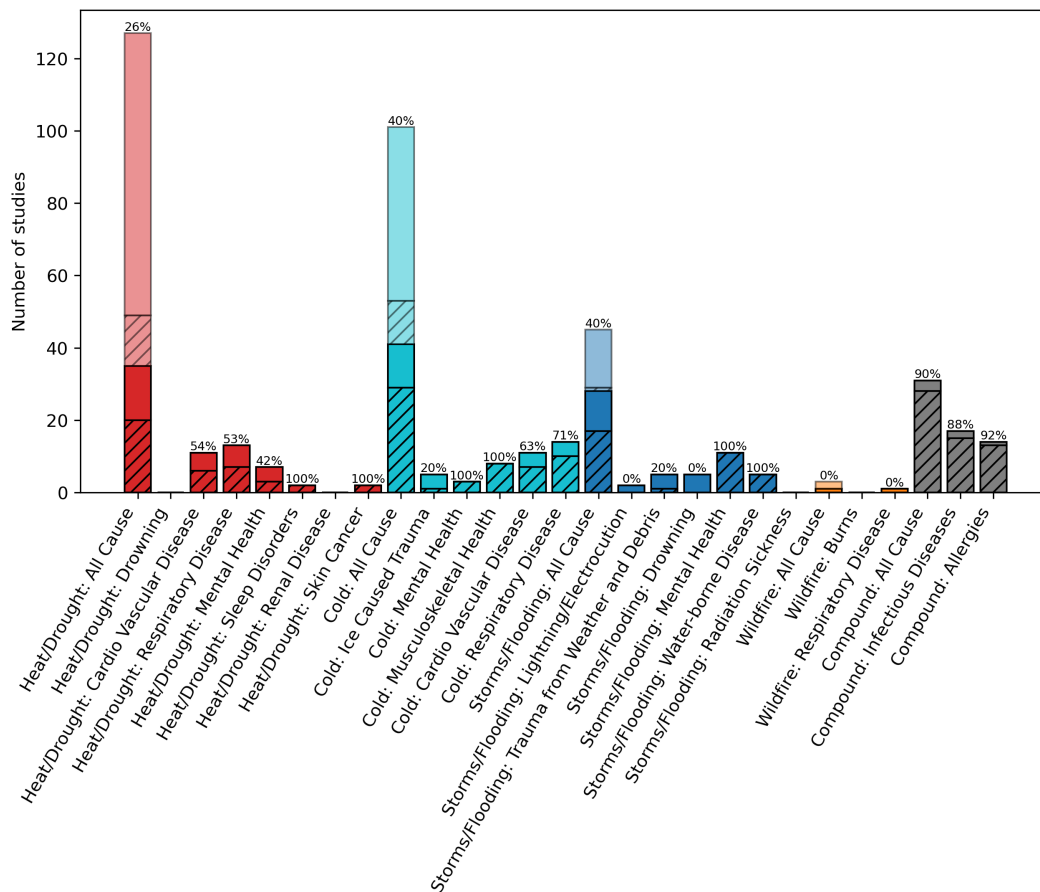
66 Bibliography management was handled through Zotero.

67 **Selection process**

68 One reviewer (EB) performed the searches in each database and assessed identified studies for inclusion. Initially, each record  
 69 was rated as eligible/not eligible/might be eligible according to the inclusion/exclusion criteria based on its Title and Abstract.  
 70 The full text of those studies which could not be clearly excluded was then reviewed to assess eligibility. A second and third  
 71 reviewer (DM/YTEL) then screened any records that were not included/excluded at this point.

72 **Systematic review outcomes**

73 The number of records identified at each stage of the systematic reviews is also given in the Supplementary Tables ('Number of  
 74 Records'). 'HeatDrought Included Articles' describes the included reports for each 'Heat/Drought' review, 'Cold Included  
 75 Articles' for each 'Cold' review, 'StormsFlooding Included Article' for each 'Storms/Flooding' review, 'Wildfires Included  
 76 Articles' for each 'Wildfires' review, and 'Compound Included Articles' for each 'Compound' review.



**Figure S2.** Morbidity versus mortality in the literature. As in Figure 3, except that hatched sections indicate where the literature is referring to morbidity and solid sections indicate where the literature is referring to mortality. The percentage of literature referring to morbidity for each category is given above each bar.

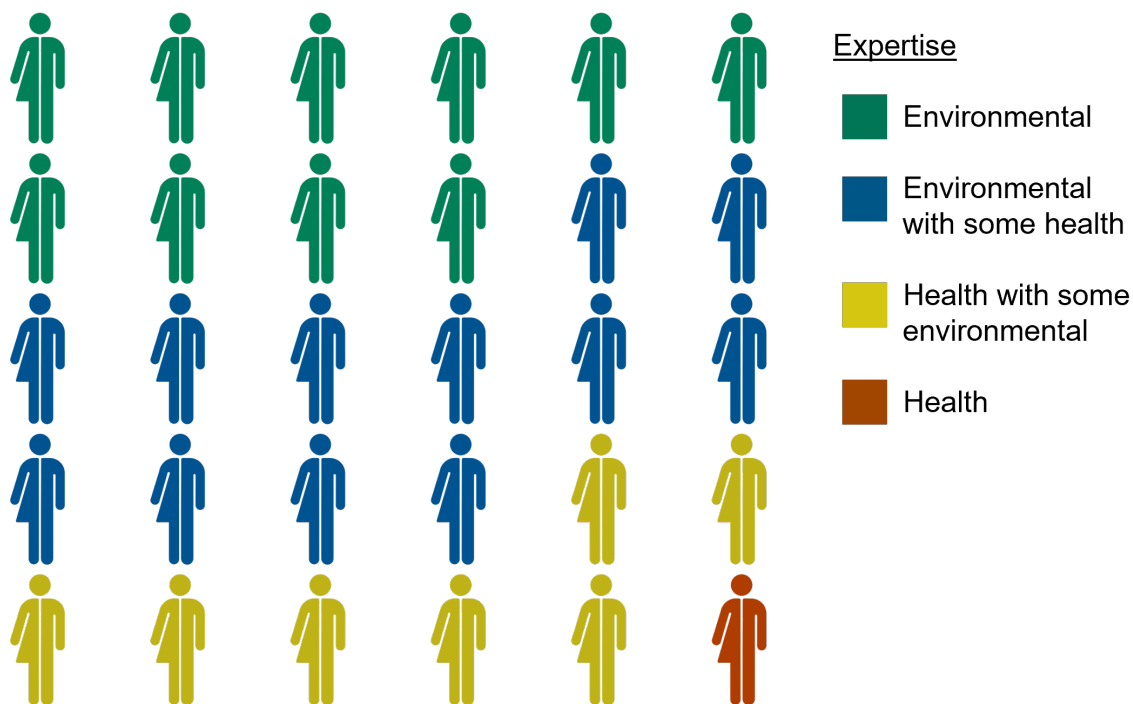
## 77 **Structured expert judgement**

78 The structured expert judgement was set up and shared with relevant experts via an online form. All questions and supporting  
79 information are provided below.

80 Data were assessed throughout the analysis and where there were outliers, or low certainty across the expert responses,  
81 participants were contacted to confirm answers and ask for any further information that might have informed an alternative  
82 view. Any communication with participants was carried out by the project manager (JG) to maintain anonymity.

## 83 **Breakdown of expertise**

84 The SEJ was sent to a number of experts chosen due to their relevant research in either, or both, environmental science and  
85 health. Thirty experts, representing fifteen institutions, participated via an online form with the breakdown of expertise shown  
86 in Figure S3. Institutions represented and the number of experts are provided in Table S1. By default all responses were  
87 anonymised, however all participants were given the option of being listed in the supplementary notes. The names of those  
88 experts are also provided in Table S1.



**Figure S3.** Expertise of structured expert judgement participants (n=30).

<b>Institution</b>	<b>Number of Experts</b>	<b>Experts</b>
University of Bristol	6	Alan Kennedy-Asser, Eunice Lo, Dann Mitchell, Anonymous (x 3)
University of Exeter	3	Mat Collins, Regan Mudhar, Anonymous
University of Graz, Austria	1	Chloe Brimicombe
Institution 1	1	Anonymous
Institution 2	1	Anonymous
Institution 3	1	Anonymous
KNMI, Netherlands	1	Vikki Thompson
University of Leeds	1	Cathryn Birch
LSHTM	2	Shakoor Hajat, Pierre Masselot
Met Office	6	Rosa Barciela, Elizabeth Kendon, Jason Lowe, Christophe Sarran, Anonymous (x 2)
University of Newcastle	1	Stephen Blenkinsop
University of Oxford	2	Nevan Fuckar, Sara Khalid
University of Reading	2	Andrew Charlton-Perez, Claudia Di Napoli
UCL	1	Charles Simpson
UEA	1	Katie Jenkins

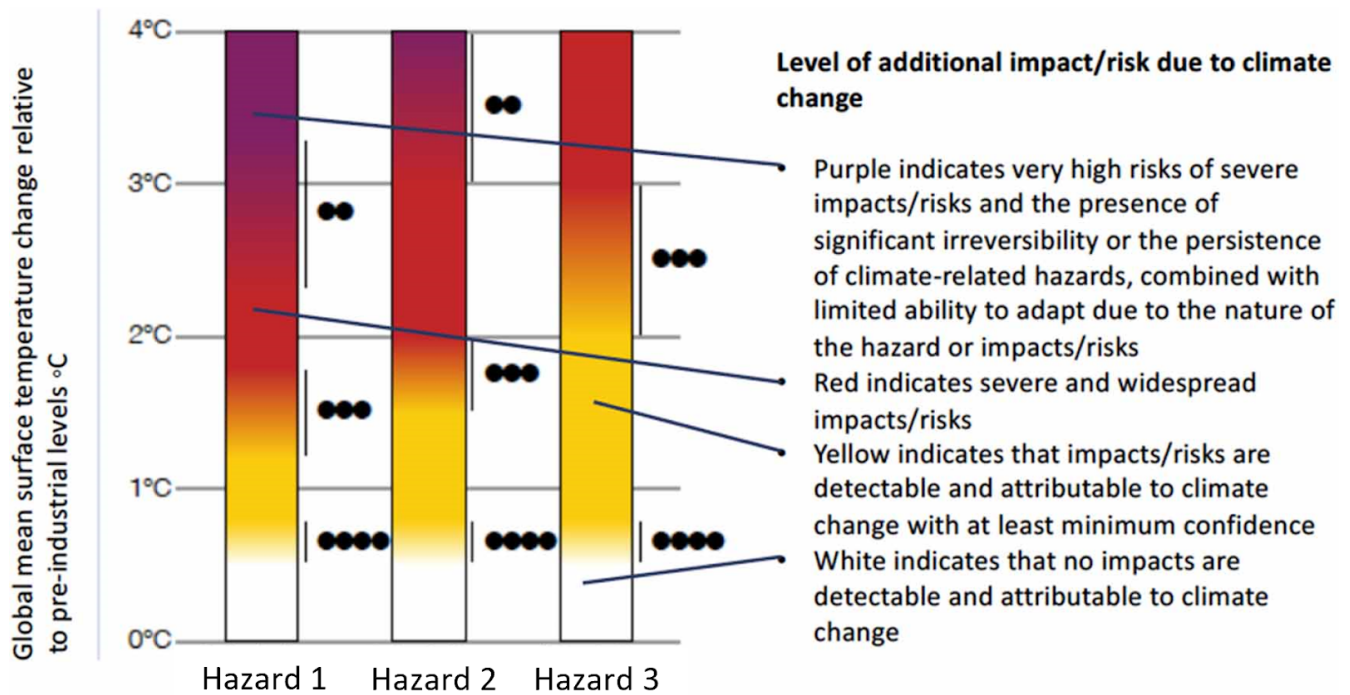
**Table S1.** Institutional affiliation and survey respondents.

89 **Questions asked in the online form**

90 **Section 1: UK Weather and Climate Hazards**

91 An effective way to understand what global warming levels lead to risk transitions of hazards, often used by the IPCC, is  
92 through burning embers (an example figure below). We would like to create such a diagram using your expert opinion for five  
93 weather hazards relevant to UK health; Heat/Drought, Cold, Storms/Flooding, Wildfires, Other (longer term climate suitability  
94 for infectious diseases and allergens). You can base your answers on a single paper, multiple papers, or inference from your  
95 expert knowledge.

96  
97 The example figure below, modified from [Ebi et al 2021 Environ. Res. Lett. 16 044042](#), is the type of burning embers  
98 diagram we would like to create.



99  
100 We are interested in five hazards: **1. Heat/Drought, 2. Cold, 3. Storms/Flooding, 4. Wildfires, 5. Other** (which refers to  
101 longer term climate suitability for infectious diseases and allergens). Note, you can skip any number of answers if you feel  
102 you're not knowledgeable enough.

103  
104 **Question 1) Heat/Drought: What are the global mean temperature increases above pre-industrial levels that cor-**  
105 **respond to risk transitions of heat/drought into low (yellow in the figure above), medium (red) and high (purple) risk,**  
106 **respectively?**

107 Please write three numerical values separated by commas, write NA for any risk transitions you do not feel confident providing  
108 a response for.

109 Example answer: 0.5, 2.5, NA

110 Interpretation of this answer:

111 A 0.5°C increase in global mean temperature has led to a transition of heat/drought from zero to low risk for UK health.

112 A 2.5°C increase in global mean temperature will lead to a transition from low to medium risk.

113 - You are not sure when this transition to high risk may occur.

114

115 **Question 2) Cold: What are the global mean temperature increases above pre-industrial levels that correspond to moderate, high and very high risk decreases in cold hazards, respectively?**

117

118 **Question 3) Storms/Flooding** Please repeat the exercise from Q1 for storms/flooding.

119

120 **Question 4) Wildfires** Please repeat the exercise from Q1 for wildfires.

121

122 **Question 5) Compound hazard** (longer term climate suitability for infectious diseases and allergens) Please repeat the exercise from Q1 for compound hazard.

124

125 **Section 2: UK health outcomes that lead to mortality from hazards in previous section**

126 For each hazard we have identified a range of health outcomes that lead to mortality. For each of these health outcomes we are interested in your expert opinion of 1) the number of current deaths per year, and 2) how climate change will change that hazard by 2100.

129

130 You can base your answers on a single paper, multiple papers, or inference from your expert knowledge. Remember, this is only for the UK.

132

133 Remember, we are only talking about the part of the health outcome modified by weather/climate. For example, for the health outcome 'Skin Cancer', we do not want to know about all Skin Cancer related mortality. Just the change in mortality caused by more people going outside in hot weather, or caused by changes in cloud cover. These numbers may not exist which is why we are keen on your expert opinion.

137

138 For health outcomes which depend on persistent changes in climate, such as many warmer days given in the Skin Cancer example above, we define mortality as where someones life was reduced by at least a year.

140

141 If you do not want to give an answer either leave the column blank, or tick NA.

142

143 Example 1: Description of hazard to health outcome: Heat/Drought: Cardio Vascular Disease

144 1) Deaths per year estimate: 100 - 1,000

145 2) Climate change signal: Large increase

146

147 Example 2: Description of hazard to health outcome: Wildfire: Burning

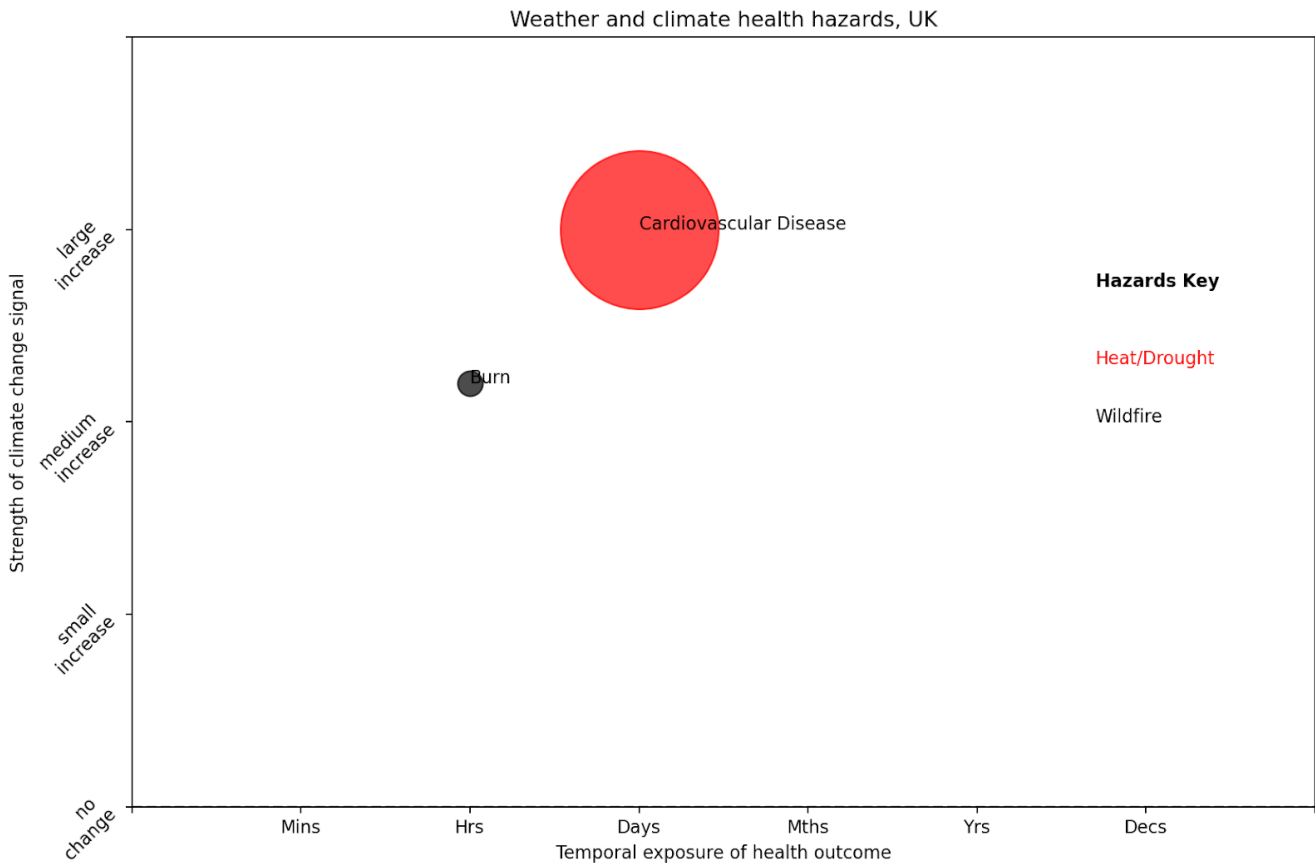
148 1) Deaths per year estimate: 0 - 10

149 2) Climate change signal: Medium increase

150

151 The figure below gives an example of how this might be displayed. The size of the bubble is a measure of current UK  
152 deaths per year, the x-axis gives the temporal exposure and the y-axis gives the climate change signal.

153



154

155 **Question 1) For each health outcome, how many deaths per year do you think we can presently attribute to the**  
156 **weather/climate hazard?** A specific definition of what we mean by each health outcome is given in the survey notes which  
157 you should have been sent as a pdf.

	< 10	10 - 100	100 - 1,000	> 1,000	NA
Heat/Drought: Drowning	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heat/Drought: Cardio Vascular Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heat/Drought: Respiratory Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heat/Drought: Mental Health	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heat/Drought: Sleep Disorders	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heat/Drought: Renal Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heat Drought: Skin Cancer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold: Ice Caused Trauma	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold: Mental Health	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold: Musculoskeletal Health	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold: Cardio Vascular Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold: Respiratory Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Storms/Flooding: Lightning/Electrocution	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Storms/Flooding: Trauma from Weather and Debris	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Storms/Flooding: Drowning	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Storms/Flooding: Mental Health	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Storms/Flooding: Water-borne Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Storms/Flooding: Radiation Sickness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wildfire: Burns	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wildfire: Respiratory Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other: Infectious Diseases	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other: Allergies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

158

159 If you wish, add relevant references that you have based part of your opinion on.

160

161 **Question 2) How will the relevant part of the hazard change by 2100 through climate change?** Here, for instance,  
 162 the relevant part of the hazard for Ice Caused Trauma, is the frequency of icy days. But the relevant part of the hazard for cold  
 163 induced Cardio Vascular Disease is the frequency of any cold days.

	Large increase	Medium increase	Small increase	No change	Small decrease	Medium decrease	Large decrease	NA
Heat/Drought: Drowning	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heat/Drought: Cardio Vascular Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heat/Drought: Respiratory Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heat/Drought: Mental Health	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heat/Drought: Sleep Disorders	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heat/Drought: Renal Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heat/Drought: Skin Cancer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold: Ice Caused Trauma	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold: Mental Health	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold: Musculoskeletal Health	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold: Cardio Vascular Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold: Respiratory Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Storms/Flooding: Lightning/Electrocution	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Storms/Flooding: Trauma from Weather and Debris	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Storms/Flooding: Drowning	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Storms/Flooding: Mental Health	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Storms/Flooding: Water-borne Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Storms/Flooding: Radiation Sickness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wildfire: Burns	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wildfire: Respiratory Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other: Infectious Diseases	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other: Allergies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

164

165 **Section 3: Calibration**

166 We would like to calibrate how the participants interpret 'small', 'medium' or 'large' increase/decrease i.e. the position on the y  
 167 axis.

168 Example: Please give the value of X in the following sentence: By "medium increase" I mean an X% increase in occurrence of

169 a hazard by 2100 from present day conditions.

170 Answer:  $X = 100\%$

171 Interpretation: This participant thinks that a doubling of the hazard (100% increase from present) represents a 'medium' increase.

172

173 Conceptually, we have found that it is easiest to think of X as "the change in the number of days of the relevant hazard". So if you consider days above 30°C as the heat hazard, the above example would be interpreted as twice as many days  
174 ard". So if you consider days above 30°C as the heat hazard, the above example would be interpreted as twice as many days  
175 per year above 30°C in 2100 compared to present day. We realise that in practise, many of you may see the hazard data as  
176 continuous, rather than threshold based, but it is easiest to think of in this way, and should not dramatically change your answers.

177

178 **Please give the value of X in the following sentences:**

179 **1) By "small increase" I mean an X% increase in occurrence of a hazard by 2100 from present day conditions**

180 **2) By "medium increase" I mean an X% increase in occurrence of a hazard by 2100 from present day conditions**

181 **3) By "large increase" I mean an X% increase in occurrence of a hazard by 2100 from present day conditions**