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Clinical vulnerability and heat preparedness among UK adults reporting heat-related symptoms: a cross-sectional survey

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Abstract

Background

Older adults and people with chronic conditions may be more susceptible to heat. We compared risk recognition, advice usefulness, anticipatory preparation and protective action by study-defined clinical-risk status among UK adults reporting heat-related symptoms.

Methods

We conducted an online cross-sectional survey (11 September–7 October 2026) about the most recent hot-weather period since 1 June 2026. Preparation questions were shown only to respondents reporting symptoms. Clinical risk comprised selected heart, lung, neurological or mobility-limiting conditions, diabetes, pregnancy, or age 65 or over. Modified Poisson models estimated prevalence ratios for five domains, adjusting for age, sex, education and financial strain, with Holm correction. All respondents aged 65 or over met the risk definition, limiting interpretation of age-adjusted comparisons.

Results

Among 1,074 participants, 278 (25.9%) met the clinical-risk definition. Risk recognition was more common in this group (85.3% vs 75.7%; adjusted prevalence ratio [aPR] 1.13, 95% CI 1.06–1.20; Holm-adjusted p = 0.0014). There was no clear evidence of differences in advice usefulness (33.1% vs 33.9%), preparation (46.8% vs 41.9%) or core protective actions (64.7% vs 65.2%). Absence of selected symptoms and frequent sleep disturbance was less common (24.5% vs 27.6%; aPR 0.77, 95% CI 0.60–0.99), but this comparison did not meet the multiplicity-adjusted threshold (p = 0.151). Preparation was associated with strong perceived personal risk (aPR 1.31, 95% CI 1.13–1.53), strong confidence (1.21, 1.04–1.41) and advice usefulness (1.24, 1.08–1.44), but not clearly with clinical risk (1.05, 0.89–1.24). Exploratory analyses showed differing patterns for older age and qualifying conditions among younger adults. Few at-risk respondents reported receiving (4.7%) or seeking (5.0%) professional advice.

Conclusions

In this symptom-selected volunteer sample, clinical-risk status was associated with greater risk recognition but not clearly greater preparedness. Non-significant comparisons do not establish equivalence. Findings support evaluating personally relevant advice and feasible preparation plans, but cannot establish causal effects or population-wide unmet need.

Background

Heat protection is an increasingly important task for public health and clinical services. In England, an estimated 2,985 excess deaths were associated with five heat episodes during summer 2022 [1]. International attribution research has also demonstrated that human-induced warming has already contributed substantially to heat-related mortality [2]. These findings support preparedness as a current health-system responsibility. Identifying people who may be especially susceptible is one component of that responsibility; understanding whether those people recognise their risk, receive useful advice and prepare before hot weather is another. A clinical-risk designation is therefore a starting point for examining protection, rather than evidence that the support required has been received or acted upon.

Vulnerability to heat reflects the interaction of health, behaviour and environment. UK Health Security Agency guidance identifies older adults, people with specified chronic conditions, pregnant women, people taking certain medicines and those with difficulties adapting their behaviour among groups requiring particular consideration [3]. The relevance of functional and social circumstances was demonstrated in the Chicago heatwave case-control study, in which being confined to bed and living alone were associated with increased mortality, while access to working air conditioning and transport were associated with lower risk [4]. Such evidence supports an approach that considers what people can do and what assistance they can access, alongside their diagnoses or age.

Medicines create an additional reason for advice to be individually relevant. Clinical guidance from the US Centers for Disease Control and Prevention describes interactions between heat and some medicines through altered thermoregulation, fluid balance, blood pressure and drug clearance. It recommends individual review and planning, rather than abrupt cessation of treatment [5]. For research on preparedness, the issue is consequently broader than whether respondents have encountered a general warning. It includes whether they understand which advice applies to their circumstances and whether professional advice is available when needed. Reported medicine use can identify a group of interest, but cannot establish the heat-related risk of a particular regimen without information about the medicines involved.

In England, the Adverse Weather and Health Plan brings together preparedness and response arrangements and builds on the earlier Heatwave Plan for England [6]. The Heat-Health Alert service, operated by the UK Health Security Agency in partnership with the Met Office, communicates expected health impacts to support action [7]. This policy context makes the timing of preparation particularly relevant. Having a plan in place before hot weather differs from responding after discomfort or symptoms have begun. Public-facing advice and professional preparedness are complementary components of this response, but the existence of national guidance does not establish its reach, perceived usefulness or application within individual households.

Self-care provides a useful perspective on this relationship between public guidance and individual action. The World Health Organization situates self-care within an enabling environment and emphasises access to professional support when people want or need it [8]. For adults managing long-term conditions, a relevant research question is therefore whether public communication is accompanied by

the understanding, confidence and support needed to act. The capability, opportunity and motivation model of behaviour (COM-B) describes how these three components interact [9]. In the present context, this distinction helps separate recognising a threat from believing that protective actions are useful, feeling able to undertake them and having the practical means to prepare.

The mismatch between externally defined vulnerability and perceived personal risk has a longstanding empirical basis in the UK. In interviews with 73 adults aged 72–94 years in London and Norwich, Abrahamson and colleagues found that few considered themselves old or personally at risk from heat, despite relevant chronic illness in many participants [10]. This finding matters for how risk groups are described and approached. Membership of an age or diagnostic category should not be assumed to correspond to a person's interpretation of their own circumstances. Equally, disagreement with a vulnerability label need not imply an absence of protective behaviour: people may adapt their routines without describing themselves as vulnerable.

Research following the 2013 UK heatwave also documented variation in the protective actions reported by different demographic groups [11]. In related work, Lefevre and colleagues found that people who recalled recommendations reported more protective behaviour and greater perceived effectiveness of those behaviours, while positive feelings about hot weather complicated responses to the hazard [12]. These associations suggest that the receipt of advice, its interpretation and its application should be examined separately. They do not establish that communication caused subsequent behaviour change, but provide a basis for investigating whether advice is considered actionable and personally relevant. This distinction is especially pertinent when messages must address both general exposure and condition-specific concerns.

A subsequent evaluation of the Heatwave Plan for England examined attitudes and behaviours among adults categorised by age and health status. Erens and colleagues found that many vulnerable or potentially vulnerable respondents did not consider hot weather a personal health risk, and only around one-quarter reported changing their behaviour because of advice during the 2017 alert period. Their qualitative findings also identified confusion between protection from ultraviolet radiation and protection from high temperatures [13]. This work demonstrates that recognising a weather event, recognising its health implications and responding appropriately are separable issues. The findings raise a further question about whether awareness and advice are accompanied by preparation before hot weather begins, particularly among people with greater clinical vulnerability.

Recent studies reinforce the need for a more specific account of preparedness. Howarth and colleagues identified differences between perceptions of national preparedness and personal vulnerability in a survey of 1,750 UK residents conducted in 2023 [14]. Khosravi and colleagues subsequently examined heat-health alert responses among 1,097 adults in England surveyed in 2025, reporting gaps in alert exposure and protective action, alongside associations with perceived severity, benefits, barriers and self-efficacy [15]. These studies establish an active evidence base on communication and behaviour. A

useful extension is to examine how clinical-risk status relates to preparation undertaken before hot weather, alongside advice usefulness and the practical actions reported during a specific period.

Anticipatory preparation deserves particular attention because an action already in place represents a different state of readiness from one initiated after temperatures rise. Getting the home ready, planning adjustments to responsibilities and arranging contact with another person also involve different decisions from maintaining fluid intake during the event. Examining these activities separately can distinguish established routines from reactive responses and identify which forms of preparation merit further investigation. Likewise, professional advice-seeking should be interpreted alongside perceived need: not seeking advice does not necessarily indicate an unmet need, and difficulty obtaining advice should be distinguished from choosing not to seek it. These distinctions support a more precise description of preparedness without attributing every gap to individual motivation or service failure.

Risk recognition, advice usefulness, preparation and protective action can be organised as related domains of heat protection. These domains should not be treated as a fixed sequence. People may act through habit or prior experience without recalling a warning, and those who prepare may still experience symptoms. In a cross-sectional survey, beliefs recorded after a hot period may also reflect the experiences reported. The value of examining these domains together is therefore descriptive and comparative: it allows assessment of whether greater clinical vulnerability is accompanied by greater reported preparedness, while keeping causal explanations and evaluation of service effectiveness outside the study's scope.

Using the UK arm of the HEATWAVE study, the primary aim was to compare recognition of personal heat risk, perceived usefulness of advice, anticipatory preparation and uptake of core protective actions between adults meeting the study definition of clinical risk and other respondents within the symptom-selected analytic sample. Secondary aims were to distinguish preparation undertaken before the hot period from reactive preparation; examine factors associated with preparing ahead, including perceived risk, confidence and advice usefulness; describe advice sources, professional advice-seeking and post-information knowledge about medicines; and compare selected self-reported health outcomes as contextual indicators of burden. These analyses concern participants' most recent hot-weather period since 1 June 2026. Our companion analysis of the same survey examines practical cooling constraints and their associations with reported health effects (companion manuscript, "Cooling constraints and self-reported health effects during hot weather in the United Kingdom: a cross-sectional survey", unpublished). Together, the companion papers distinguish clinical susceptibility and preparedness from practical opportunities to keep cool. Their analytic samples use different eligibility criteria within the same underlying survey and should not be interpreted as independent replication.

Methods

Study design and setting

We conducted a cross-sectional online survey of adults living in the UK. The survey was open between 11 September and 7 October 2026 and asked about the most recent period of hot weather that participants had experienced since 1 June 2026. This paper is one of two companion papers from the UK arm of the HEATWAVE study; the companion paper examines cooling constraints and heat-related harm. Reporting follows the STROBE guideline for cross-sectional studies [16] and the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) [17] (Additional files 3 and 4).

Participants and recruitment

Adults aged 18 years or over who usually lived in the UK were eligible. Participants were recruited using an anonymous survey link shared through Prolific, social media, the mailing lists of partner organisations and the research team's personal and professional networks. Participants recruited through Prolific received the standard payment set by the platform; no other incentives were offered. This was an open, voluntary survey; because the number of people who saw the invitation is unknown, we report consent among recorded survey openers and completion among consenting participants; an invitation-based response rate could not be estimated. No sample size was calculated in advance; all eligible responses received during the survey period were included. Participants read a participant information sheet, which stated that participation was voluntary and anonymous and that the survey would take about 12 minutes, and gave informed consent online before starting the survey. Participants could optionally leave contact details at the end of the survey for a follow-up interview; these were stored separately on a secure, access-restricted university OneDrive available only to the research team and were removed from the analysed dataset. The median completion time among those who finished was about 9 minutes.

Survey instrument

The questionnaire was developed by the study team, informed by UK heat-health guidance and previous UK heat surveys [3, 11, 13], and piloted with 50 adults, after which the wording of some items was revised. Pilot data were not included in the analytic sample. It covered exposure to the most recent hot period; protective self-care actions; thermal comfort, sleep, daily activities and heat-related symptoms; timing of preparation, sources and usefulness of advice, and heat-related beliefs; housing and practical constraints; practical heat knowledge; and sociodemographic and health characteristics. The survey was hosted on Qualtrics (Qualtrics, Provo, UT, USA) and used display logic, so that questions about the hot period were shown only to participants who reported experiencing one, and the preparation and advice questions only to those who reported at least one heat-related symptom. A short heat-safety message was shown after the symptom questions and before the questions on preparation, advice, beliefs and knowledge. Responses were required for all items except the optional contact details, there was no Back button, the questionnaire spanned 13 pages, and the Qualtrics 'prevent multiple submissions' browser cookie was used to limit duplicate responses. The survey was available in English, Spanish, French, Polish, Romanian, Urdu, Arabic, Persian and Bengali; all but one participant completed it in English. The full questionnaire is provided in Additional file 2.

Analytic sample

The analytic sample included participants who consented, reported experiencing a period of hot weather in the UK since 1 June 2026, and answered the questions on the timing of preparation. Because of the survey routing, these questions were shown only to participants who reported at least one heat-related symptom (confirmed in the Qualtrics survey flow, which bypassed the preparation block when ‘None of these’ or ‘Do not remember’ was selected), so the analytic sample comprises adults who reported hot weather and at least one heat-related symptom.

Measures

Clinical risk

Participants were classed as at clinical risk if they reported a heart or circulation condition, a lung or breathing condition, diabetes, a neurological, memory or cognitive condition, a condition affecting mobility or self-care, or pregnancy, or were aged 65 or over. This study-defined composite adapts selected risk categories identified in UK public health guidance [3]; it is not a validated clinical prediction score. Age 65 or over was used because UKHSA guidance identifies adults over 65 as at increased risk from heat, and the conditions were those listed in the guidance that the survey captured as distinct response options [3]. Some groups named in the guidance, such as people with kidney disease or serious mental illness, could not be identified separately; mental health conditions were captured only as a single broad category and were therefore included in the broader definition. The composite and age threshold were defined for this analysis rather than prespecified in the study protocol. Participants who answered the health questions but selected none of the qualifying conditions, including those who selected only ‘Not sure’ or ‘Prefer not to say’, were classed as not meeting the clinical-risk definition unless aged 65 or over. A ‘None of the above’ option was offered in the survey but was not included in the data export. Because responses to this question were required, participants who selected no listed option must have selected ‘None of the above’, because the other non-condition options (‘Not sure’ and ‘Prefer not to say’) were exported and 687 of the 690 participants with no listed option went on to complete the survey. Consistent with this, 97.1% of them reported no limiting long-term condition. Participants who did not answer the health questions were not classified. A broader definition, adding mental health conditions, other long-term conditions and regular use of prescribed medicines, was used in sensitivity analyses.

Timing of preparation

Preparing ahead meant having the home ready to keep cool or activity changes planned before the hot period. For four preparation actions (making sure drinks were available, getting the home ready to keep cool, planning changes to activities or responsibilities, and arranging for someone to check on them or

on someone else), participants reported whether the action was already in place before the hot period began, first done after it began, not done, wanted but not possible, not relevant, or not remembered.

Advice and beliefs

Participants reported where they had seen or heard hot-weather advice since 1 June 2026, how much the advice they remembered most clearly helped them understand what to do and decide what applied to them, and their agreement with three statements on personal risk, the effectiveness of their own actions and confidence in protecting their health. They also reported whether they had sought advice from a doctor, nurse or pharmacist about heat and a health condition or medicine and answered a true or false statement on stopping prescribed medicines during hot weather. This statement came after a short heat-safety message shown earlier in the survey that advised not stopping prescribed medicines without professional advice, so it reflects knowledge after this message rather than prior knowledge.

Heat-protection domains

Five operational domains were defined: recognising personal risk, finding advice useful, preparing ahead, taking core protective actions and reporting no selected warning-sign symptoms or frequent sleep disturbance (Additional file 1: Table S1). These domains describe a cross-sectional profile, not an observed sequence or a validated clinical pathway. People can undertake an action without meeting every preceding criterion. The final domain, labelled “avoiding selected heat-related harm” in the tables and figure, was operationalised as reporting neither selected warning-sign symptoms nor sleep disturbance often or almost every night; it does not denote absence of all adverse effects or demonstrate that protective actions prevented harm. Recognising personal risk meant agreeing or strongly agreeing that very hot weather could seriously affect one’s health. Taking core protective actions meant reporting at least four of six core actions (avoiding direct sun, cooling the skin, shading windows, opening windows when cooler outside, moving to a cooler place and using a fan) often or always; ‘wanted to but could not’, ‘not relevant’ and ‘do not remember’ were counted as not done. Finding advice useful required that the advice helped ‘a lot’ or ‘a great deal’, and a response of ‘I do not remember’ was counted as not meeting this criterion.

Covariates

Age, sex, highest qualification, financial strain (ease of making ends meet), housing tenure and living alone.

Statistical analysis

Participant characteristics and survey responses were described using frequencies and percentages for categorical variables and mean (standard deviation), median (interquartile range) and range for age, overall and by clinical-risk status. Percentages were calculated from the number of participants who answered each item, including those who chose "Prefer not to say"; missing values are reported as

counts. For select-all-that-apply items, percentages use participants who answered that item and do not sum to 100%.

Modified Poisson regression (Poisson regression with robust standard errors) was used to estimate prevalence ratios (PRs) with 95% confidence intervals (CIs), as all outcomes were common. For each domain, people at clinical risk were compared with others using crude PRs and adjusted PRs (aPRs), adjusting for age, sex, highest qualification and financial strain, and Holm's method was used to adjust the five adjusted comparisons for multiple testing. Age was entered as a continuous linear term (per 10 years). Complete-case models included 1,031–1,034 participants for the domain comparisons and 1,026 for the preparing-ahead model. Multiplicity correction was confined to the five domain comparisons; confidence intervals for all other analyses are nominal, and secondary and sensitivity analyses are regarded as exploratory. Because all participants aged 65 or over meet the clinical-risk definition, there is no observed non-risk comparator in that age range. The age-adjusted contrast is therefore model-dependent and should be interpreted alongside the crude estimates. The crude comparison describes differences between the composite groups as observed; the adjusted comparison is a model-based summary that should not be read as a uniform effect of clinical vulnerability. Because the composite combines older age with condition-defined risk, the component-specific comparisons (adults under 65 with a qualifying condition, and adults aged 65 or over, each compared with adults under 65 without a qualifying condition) are reported alongside the main results in Table 3. As a secondary descriptive analysis, each domain was also compared among participants meeting the immediately preceding criterion; these conditional prevalences do not estimate longitudinal transitions. Preparing ahead was modelled against clinical risk, strong agreement that hot weather could seriously affect one's health, strong confidence in protecting one's health, finding advice useful, financial strain, housing tenure, living alone, age, sex and highest qualification, all entered together, and model-standardised predicted proportions were estimated by clinical-risk status. Advice from health professionals, seeking professional advice and knowledge about medicines were described only, as numbers were small.

Sensitivity analyses used the broader clinical-risk definition, compared regular medicine users with others, used an alternative definition of preparing ahead that also included arranging for someone to check on them or on someone else, and excluded participants who selected only ‘Not sure’ or ‘Prefer not to say’ to the health conditions question. To separate the two components of the composite, we repeated the domain comparisons among participants aged under 65, in whom clinical risk was defined by conditions alone, and compared three mutually exclusive groups (aged under 65 with a qualifying condition and aged 65 or over, each compared with those aged under 65 without a qualifying condition), adjusting for sex, highest qualification and financial strain. These additional analyses were not prespecified. All analyses used complete cases and were unweighted. Analyses were conducted in Stata 18 (StataCorp, College Station, TX, USA).

Ethics

The study was approved through the Imperial College Research Ethics Committee (ICREC) process by the Research Governance and Integrity Team (RGIT) on 9 September 2026 (ICREC reference 8705479).

All participants gave informed consent online, and the study was conducted in accordance with the Declaration of Helsinki.

Results

Survey participation and characteristics of participants by clinical-risk status

Of 1,327 people who opened the survey, 5 (0.4%) declined consent and 1,322 (99.6%) consented, of whom 1,278 (96.7%) completed the survey. Of the 1,322 consenting participants, 1,301 reported experiencing hot weather in the UK since 1 June 2026. Of these, 27 left the survey before the preparation questions and 200 selected no symptoms or could not recall symptoms (‘None of these’, n = 196; ‘Do not remember’, n = 4) and were therefore not shown them, leaving 1,074 in the analytic sample (Fig. 1). All 1,278 completed surveys are accounted for: 1,068 in the analytic sample, 199 routed past the preparation questions and 11 from participants who did not report hot weather. Of the analytic sample, 278 (25.9%) were at clinical risk, 793 (73.8%) formed the comparison group, and 3 could not be classified because they did not answer the health questions. In the comparison group, 522 selected no listed condition (treated as ‘None of the above’) and 36 selected only ‘Not sure’ or ‘Prefer not to say’.

Participants at clinical risk were older than others (mean age 51.9 vs 40.0 years), and 29.1% were aged 65 or over (Table 1). They were more often female (64.7% vs 54.4%) and White (88.8% vs 77.2%), and less often held a degree (57.6% vs 66.1%). Slightly more of those at clinical risk made ends meet with some or great difficulty (41.7% vs 36.4%). Half of those at clinical risk had a long-term condition that limited daily activities (50.0% vs 16.5%), almost half regularly took prescribed medicines (48.9% vs 16.8%), and fewer rated their health as good or very good (40.3% vs 69.6%). The most common conditions in the at-risk group were lung or breathing conditions (27.0%), heart or circulation conditions (21.2%), conditions affecting mobility or self-care (20.5%) and diabetes (19.1%).

Table 1
Characteristics of participants by clinical-risk status (n = 1,074)

Characteristic	Total[a] (n = 1,074)	At clinical risk (n = 278)	Comparison group (n = 793)
Age, years			
Mean (SD)	43.0 (13.7)	51.9 (15.2)	40.0 (11.7)
Median (IQR)	41.0 (21.0)	53.0 (26.0)	38.0 (18.0)
Range	18 to 100	18 to 100	18 to 64
UK nation or English region			
North East	46 (4.3)	14 (5.0)	31 (3.9)
North West	130 (12.1)	31 (11.2)	98 (12.4)
Yorkshire and the Humber	108 (10.1)	35 (12.6)	73 (9.2)
East Midlands	85 (7.9)	26 (9.4)	59 (7.4)
West Midlands	105 (9.8)	20 (7.2)	85 (10.7)
East of England	86 (8.0)	26 (9.4)	60 (7.6)
London	148 (13.8)	30 (10.8)	117 (14.8)
South East	128 (11.9)	29 (10.4)	99 (12.5)
South West	96 (8.9)	30 (10.8)	66 (8.3)
Scotland	74 (6.9)	18 (6.5)	56 (7.1)
Wales	53 (4.9)	15 (5.4)	38 (4.8)
Northern Ireland	15 (1.4)	4 (1.4)	11 (1.4)
Sex registered at birth			
Male	448 (41.8)	95 (34.2)	353 (44.5)
Female	611 (57.0)	180 (64.7)	431 (54.4)
Another sex	1 (0.1)	1 (0.4)	0 (0.0)
Prefer not to say	11 (1.0)	2 (0.7)	9 (1.1)
Missing	3	0	0
Ethnic group			
White	859 (80.2)	247 (88.8)	612 (77.2)
Mixed or multiple ethnic groups	25 (2.3)	5 (1.8)	20 (2.5)

Characteristic	Total[a] (n = 1,074)	At clinical risk (n = 278)	Comparison group (n = 793)
Age, years			
Asian or Asian British	97 (9.1)	19 (6.8)	78 (9.8)
Black, African, Caribbean or Black British	65 (6.1)	4 (1.4)	61 (7.7)
Other ethnic group	15 (1.4)	2 (0.7)	13 (1.6)
Prefer not to say	10 (0.9)	1 (0.4)	9 (1.1)
Missing	3	0	0
Highest qualification			
No formal qualifications	15 (1.4)	7 (2.5)	8 (1.0)
GCSEs or equivalent	93 (8.7)	34 (12.2)	59 (7.4)
A-levels or equivalent	153 (14.3)	32 (11.5)	121 (15.3)
Vocational, technical or apprenticeship	119 (11.1)	44 (15.8)	75 (9.5)
Undergraduate degree	441 (41.2)	106 (38.1)	335 (42.2)
Postgraduate degree	243 (22.7)	54 (19.4)	189 (23.8)
Prefer not to say	7 (0.7)	1 (0.4)	6 (0.8)
Missing	3	0	0
Current work or other activity			
Employed or self-employed	801 (74.8)	169 (60.8)	632 (79.7)
Student	42 (3.9)	3 (1.1)	39 (4.9)
Unemployed or looking for work	55 (5.1)	7 (2.5)	48 (6.1)
Not working due to long-term illness or disability	31 (2.9)	20 (7.2)	11 (1.4)
Retired	75 (7.0)	59 (21.2)	16 (2.0)
Unpaid carer	7 (0.7)	1 (0.4)	6 (0.8)
Looking after home or family	40 (3.7)	13 (4.7)	27 (3.4)
Another situation	7 (0.7)	3 (1.1)	4 (0.5)
Prefer not to say	13 (1.2)	3 (1.1)	10 (1.3)
Missing	3	0	0

Characteristic	Total[a] (n = 1,074)	At clinical risk (n = 278)	Comparison group (n = 793)
Age, years			
Making ends meet on household income			
With great difficulty	60 (5.6)	20 (7.2)	40 (5.0)
With some difficulty	345 (32.2)	96 (34.5)	249 (31.4)
Fairly easily	355 (33.1)	83 (29.9)	272 (34.3)
Easily	185 (17.3)	47 (16.9)	138 (17.4)
Very easily	96 (9.0)	26 (9.4)	70 (8.8)
Not sure	3 (0.3)	1 (0.4)	2 (0.3)
Prefer not to say	27 (2.5)	5 (1.8)	22 (2.8)
Missing	3	0	0
Household members[b]			
Lives alone	147 (13.7)	42 (15.1)	105 (13.2)
Child aged under 5	137 (12.8)	24 (8.6)	113 (14.2)
Child aged 5 to 17	298 (27.8)	59 (21.2)	239 (30.1)
Adult aged 18 to 64	739 (69.0)	167 (60.1)	572 (72.1)
Adult aged 65 or over	132 (12.3)	66 (23.7)	66 (8.3)
No fixed household	1 (0.1)	0 (0.0)	1 (0.1)
Prefer not to say	20 (1.9)	3 (1.1)	17 (2.1)
Missing	3	0	0
Health conditions and medicines[b c]			
Heart or circulation condition	59 (5.5)	59 (21.2)	0 (0.0)
Lung or breathing condition	75 (7.0)	75 (27.0)	0 (0.0)
Diabetes	53 (4.9)	53 (19.1)	0 (0.0)
Neurological, memory or cognitive condition	35 (3.3)	35 (12.6)	0 (0.0)
Mental health condition	174 (16.2)	66 (23.7)	108 (13.6)
Condition affecting mobility or self-care	57 (5.3)	57 (20.5)	0 (0.0)

Characteristic	Total[a] (n = 1,074)	At clinical risk (n = 278)	Comparison group (n = 793)
Age, years			
Pregnant	8 (0.7)	8 (2.9)	0 (0.0)
Regularly takes prescribed medicines	269 (25.1)	136 (48.9)	133 (16.8)
Another long-term condition	129 (12.0)	55 (19.8)	74 (9.3)
Not sure	7 (0.7)	0 (0.0)	7 (0.9)
Prefer not to say	30 (2.8)	1 (0.4)	29 (3.7)
Missing	3	0	0
Long-term condition limiting daily activities			
Yes, a lot	69 (6.4)	46 (16.5)	23 (2.9)
Yes, a little	201 (18.8)	93 (33.5)	108 (13.6)
No	759 (70.9)	131 (47.1)	628 (79.2)
Not sure	14 (1.3)	2 (0.7)	12 (1.5)
Prefer not to say	28 (2.6)	6 (2.2)	22 (2.8)
Missing	3	0	0
Self-rated general health			
Very good	134 (12.5)	13 (4.7)	121 (15.3)
Good	530 (49.5)	99 (35.6)	431 (54.4)
Fair	330 (30.8)	120 (43.2)	210 (26.5)
Bad	57 (5.3)	37 (13.3)	20 (2.5)
Very bad	12 (1.1)	9 (3.2)	3 (0.4)
Prefer not to say	8 (0.7)	0 (0.0)	8 (1.0)
Missing	3	0	0
Receives care from a carer (paid or unpaid)			
Yes	28 (2.6)	20 (7.2)	8 (1.0)
No	1,035 (96.6)	258 (92.8)	777 (98.0)
Prefer not to say	8 (0.7)	0 (0.0)	8 (1.0)
Missing	3	0	0

Characteristic	Total[a] (n = 1,074)	At clinical risk (n = 278)	Comparison group (n = 793)
Age, years			

Data are n (%) unless stated otherwise. Percentages use the number of participants who answered each item, including those who chose "Prefer not to say"; missing values are shown as counts only. Clinical risk: heart or circulation condition, lung or breathing condition, diabetes, neurological, memory or cognitive condition, condition affecting mobility or self-care, pregnancy, or age 65 or over. Comparison group: participants who did not meet the clinical-risk definition. SD, standard deviation; IQR, interquartile range.

[a] Includes 3 participants whose clinical-risk status could not be determined because they did not answer the health questions.

[b] Select-all-that-apply item; percentages use participants who answered the demographic questions and do not sum to 100%.

[c] The "None of the above" option was not included in the data export; because responses were required, participants who selected no listed option were treated as having selected it.

Timing of preparation, usefulness of advice and heat-related beliefs by clinical-risk status

Most participants in both groups had drinks available before the hot period began (72.3% at clinical risk vs 72.9% in the comparison group; Table 2). Getting the home ready to keep cool was more often done in advance by those at clinical risk (42.8% vs 36.8%), whereas planning changes to activities was mostly reactive in both groups, with only around one in five doing it beforehand (20.9% vs 21.2%). Arranging for someone to check on them, or on someone else, before the period began was uncommon (14.4% vs 8.4%), and around four in ten did not do this (38.8% vs 43.0%).

Around a third of each group said the advice they remembered helped a lot or a great deal to understand what action to take (33.1% vs 33.9%). People at clinical risk were more likely to agree that very hot weather could seriously affect their health (85.3% vs 75.7%), but less likely to feel confident they could protect their health (75.9% vs 83.9%). Agreement that their own actions could reduce the effects of heat was high in both groups (89.9% vs 91.7%).

Table 2
Timing of preparation, usefulness of advice and heat-related beliefs by clinical-risk status (n = 1,074)

Characteristic	Total[a] (n = 1,074)	At clinical risk (n = 278)	Comparison group (n = 793)
Timing: Made sure drinks were available			
Already in place before the period began	780 (72.6)	201 (72.3)	578 (72.9)
First done after the period began	254 (23.6)	65 (23.4)	188 (23.7)
Did not do this	29 (2.7)	9 (3.2)	19 (2.4)
Wanted to but could not	8 (0.7)	2 (0.7)	6 (0.8)
Not relevant	2 (0.2)	0 (0.0)	2 (0.3)
Do not remember	1 (0.1)	1 (0.4)	0 (0.0)
Timing: Got the home ready to keep cool			
Already in place before the period began	412 (38.4)	119 (42.8)	292 (36.8)
First done after the period began	504 (46.9)	111 (39.9)	392 (49.4)
Did not do this	107 (10.0)	36 (12.9)	70 (8.8)
Wanted to but could not	36 (3.4)	8 (2.9)	28 (3.5)
Not relevant	10 (0.9)	2 (0.7)	8 (1.0)
Do not remember	5 (0.5)	2 (0.7)	3 (0.4)
Timing: Planned changes to activities or responsibilities			
Already in place before the period began	227 (21.1)	58 (20.9)	168 (21.2)
First done after the period began	609 (56.7)	166 (59.7)	443 (55.9)
Did not do this	162 (15.1)	30 (10.8)	130 (16.4)
Wanted to but could not	51 (4.7)	15 (5.4)	36 (4.5)
Not relevant	17 (1.6)	6 (2.2)	11 (1.4)
Do not remember	8 (0.7)	3 (1.1)	5 (0.6)
Timing: Arranged for someone to check on me, or to check on someone else			
Already in place before the period began	108 (10.1)	40 (14.4)	67 (8.4)
First done after the period began	166 (15.5)	43 (15.5)	123 (15.5)

Characteristic	Total[a] (n = 1,074)	At clinical risk (n = 278)	Comparison group (n = 793)
Timing: Made sure drinks were available			
Did not do this	451 (42.0)	108 (38.8)	341 (43.0)
Wanted to but could not	17 (1.6)	4 (1.4)	13 (1.6)
Not relevant	319 (29.7)	81 (29.1)	238 (30.0)
Do not remember	13 (1.2)	2 (0.7)	11 (1.4)
Advice helped to understand what action to take[b]			
Not at all	89 (8.3)	28 (10.1)	59 (7.4)
A little	258 (24.0)	72 (25.9)	186 (23.5)
Moderately	336 (31.3)	75 (27.0)	261 (32.9)
A lot	206 (19.2)	57 (20.5)	148 (18.7)
A great deal	156 (14.5)	35 (12.6)	121 (15.3)
Do not remember	29 (2.7)	11 (4.0)	18 (2.3)
Advice helped to decide what was relevant to own circumstances[b]			
Not at all	92 (8.6)	21 (7.6)	69 (8.7)
A little	217 (20.2)	62 (22.3)	155 (19.5)
Moderately	319 (29.7)	78 (28.1)	241 (30.4)
A lot	244 (22.7)	64 (23.0)	179 (22.6)
A great deal	169 (15.7)	41 (14.7)	128 (16.1)
Do not remember	33 (3.1)	12 (4.3)	21 (2.6)
Very hot weather could seriously affect my own health			
Strongly disagree	12 (1.1)	3 (1.1)	7 (0.9)
Disagree	86 (8.0)	5 (1.8)	81 (10.2)
Neither agree nor disagree	139 (12.9)	33 (11.9)	105 (13.2)
Agree	619 (57.6)	160 (57.6)	459 (57.9)
Strongly agree	218 (20.3)	77 (27.7)	141 (17.8)
Actions I can take could reduce the effects of heat on my health			

Characteristic	Total[a] (n = 1,074)	At clinical risk (n = 278)	Comparison group (n = 793)
Timing: Made sure drinks were available			
Strongly disagree	7 (0.7)	2 (0.7)	3 (0.4)
Disagree	18 (1.7)	6 (2.2)	12 (1.5)
Neither agree nor disagree	72 (6.7)	20 (7.2)	51 (6.4)
Agree	679 (63.2)	177 (63.7)	502 (63.3)
Strongly agree	298 (27.7)	73 (26.3)	225 (28.4)
I am confident that I can protect my health during very hot weather			
Strongly disagree	8 (0.7)	3 (1.1)	3 (0.4)
Disagree	53 (4.9)	15 (5.4)	38 (4.8)
Neither agree nor disagree	137 (12.8)	49 (17.6)	87 (11.0)
Agree	618 (57.5)	155 (55.8)	463 (58.4)
Strongly agree	258 (24.0)	56 (20.1)	202 (25.5)

Data are n (%) unless stated otherwise. Percentages use the number of participants who answered each item, including those who chose "Prefer not to say"; missing values are shown as counts only. Clinical risk: heart or circulation condition, lung or breathing condition, diabetes, neurological, memory or cognitive condition, condition affecting mobility or self-care, pregnancy, or age 65 or over. Comparison group: participants who did not meet the clinical-risk definition.

[a] Includes 3 participants whose clinical-risk status could not be determined because they did not answer the health questions.

[b] Refers to the hot-weather advice or warning the participant remembered most clearly.

Sources of advice and contact with health professionals

The Met Office was the main source of hot-weather advice in both groups (70.1% at clinical risk vs 71.2% in the comparison group), followed by TV, radio or news websites (57.6% vs 60.3%; Additional file 1: Table S2). The NHS was a more common source for people at clinical risk (44.2% vs 36.6%). Few participants heard advice from a doctor, nurse, pharmacist or other health professional (4.7% vs 2.0%). Among people at clinical risk, 178 (64.0%) did not seek advice from a health professional about heat and a health condition or medicine and 85 (30.6%) reported that they did not need it; 14 (5.0%) sought advice, of whom 4 could not obtain it. These small numbers distinguish not seeking, reporting no need and unsuccessful attempts, but cannot quantify population-level unmet need.

Knowledge about medicines and planned changes for future hot weather

After the in-survey safety message, most participants at clinical risk correctly answered that prescribed medicines should not be stopped during hot weather without professional advice (87.8% vs 71.8% of others), rising to 93.4% among those at clinical risk who regularly took prescribed medicines (Additional file 1: Table S3). Around half of each group had made or planned changes for future hot weather after the hot period (49.6% vs 52.3%), while about one in five had not thought about it (22.7% vs 21.1%).

Heat-protection domains by clinical-risk status

In both groups, the prevalence of recognising personal risk was substantially higher than that of meeting the advice-usefulness threshold (Table 3, Fig. 2). Among people at clinical risk, 85.3% recognised their personal risk, 33.1% reported that advice helped a lot or a great deal, 46.8% prepared ahead, 64.7% took core protective actions and 24.5% met the criterion for absence of selected heat-related harm. These separate prevalences do not represent attrition through successive stages.

Compared with others, people at clinical risk were more likely to recognise their personal risk (85.3% vs 75.7%; aPR 1.13, 95% CI 1.06–1.20; Holm-adjusted p = 0.0014). There was no clear evidence of differences in finding advice useful (aPR 1.01, 95% CI 0.82–1.25), preparing ahead (aPR 1.07, 95% CI 0.90–1.26) or taking core protective actions (aPR 1.02, 95% CI 0.92–1.14). The adjusted estimate suggested a lower prevalence of meeting the criterion for absence of selected heat-related harm (24.5% vs 27.6%; aPR 0.77, 95% CI 0.60–0.99), but this comparison did not meet the conventional significance threshold after Holm adjustment (p = 0.151). Component-specific comparisons are shown in Table 3: higher risk recognition and a lower prevalence of avoiding selected harm were concentrated among adults under 65 with qualifying conditions, whereas adults aged 65 or over resembled the reference group in risk recognition and more often avoided selected harm. Conditional comparisons among participants meeting the immediately preceding criterion also provided no clear evidence of group differences, with all CIs including 1; these are not estimates of progression over time.

Table 3
Proportion of participants meeting each heat-protection domain, by clinical-risk status

Domain	At clinical risk n/N (%)	Comparison group n/N (%)	Crude PR (95% CI)	Adjusted PR[a] (95% CI)	Holm-adjusted p
All participants					
1. Recognised personal risk	237/278 (85.3)	600/793 (75.7)	1.13 (1.06–1.20)	1.13 (1.06–1.20)	0.001
2. Found advice useful	92/278 (33.1)	269/793 (33.9)	0.98 (0.80–1.18)	1.01 (0.82–1.25)	1.000
3. Prepared ahead	130/278 (46.8)	332/793 (41.9)	1.12 (0.96–1.30)	1.07 (0.90–1.26)	1.000
4. Took core protective actions	180/278 (64.7)	517/793 (65.2)	0.99 (0.90–1.10)	1.02 (0.92–1.14)	1.000
5. Avoided selected heat-related harm	68/278 (24.5)	218/790 (27.6)	0.89 (0.70–1.12)	0.77 (0.60–0.99)	0.151
Among those meeting the preceding domain					
2. Found advice useful (given domain 1)	87/237 (36.7)	210/600 (35.0)	–	1.04 (0.84–1.29)	–
3. Prepared ahead (given domain 2)	45/92 (48.9)	137/269 (50.9)	–	0.88 (0.67–1.15)	–
4. Took core protective actions (given domain 3)	97/130 (74.6)	237/332 (71.4)	–	1.02 (0.90–1.16)	–
5. Avoided selected heat-related harm (given domain 4)	29/180 (16.1)	105/516 (20.3)	–	0.81 (0.56–1.17)	–
Components of clinical risk (exploratory)					
1. Recognised personal risk: under 65 with a qualifying condition	177/197 (89.8)	600/793 (75.7)	–	1.17 (1.10–1.25)	–
1. Recognised personal risk: aged 65 or over	60/81 (74.1)	600/793 (75.7)	–	1.03 (0.90–1.17)	–
2. Found advice useful: under 65 with a qualifying condition	66/197 (33.5)	269/793 (33.9)	–	0.99 (0.79–1.23)	–

Domain	At clinical risk n/N (%)	Comparison group n/N (%)	Crude PR (95% CI)	Adjusted PR[a] (95% CI)	Holm-adjusted p
All participants					
2. Found advice useful: aged 65 or over	26/81 (32.1)	269/793 (33.9)	–	0.96 (0.68–1.34)	–
3. Prepared ahead: under 65 with a qualifying condition	95/197 (48.2)	332/793 (41.9)	–	1.15 (0.97–1.37)	–
3. Prepared ahead: aged 65 or over	35/81 (43.2)	332/793 (41.9)	–	0.97 (0.73–1.28)	–
4. Took core protective actions: under 65 with a qualifying condition	135/197 (68.5)	517/793 (65.2)	–	1.05 (0.94–1.17)	–
4. Took core protective actions: aged 65 or over	45/81 (55.6)	517/793 (65.2)	–	0.85 (0.70–1.03)	–
5. Avoided selected heat-related harm: under 65 with a qualifying condition	32/197 (16.2)	218/790 (27.6)	–	0.62 (0.44–0.88)	–
5. Avoided selected heat-related harm: aged 65 or over	36/81 (44.4)	218/790 (27.6)	–	1.54 (1.16–2.05)	–

PR, prevalence ratio from modified Poisson regression comparing people at clinical risk with others; CI, confidence interval.

[a] Adjusted for age, sex, highest qualification and financial strain (n = 1,031 to 1,034 for all participants). Holm-adjusted p-values account for the five comparisons among all participants. Domain definitions are given in **Additional file 1: Table S1**.

[d] Exploratory, not prespecified. Each subgroup is compared with participants aged under 65 without a qualifying condition (the comparison group; all are under 65); adjusted for sex, highest qualification and financial strain but not age, which defines the groups (n = 1,031 to 1,034). Confidence intervals are nominal.

Factors associated with preparing ahead of the hot period

Overall, 42.9% of participants in the complete-case sample (n = 1,026) prepared ahead (Table 4). Preparing ahead was associated with strongly agreeing that hot weather could seriously affect one's health (aPR 1.31, 95% CI 1.13–1.53), strong confidence in protecting one's health (aPR 1.21, 95% CI 1.04–1.41) and finding advice useful (aPR 1.24, 95% CI 1.08–1.44). There was no clear evidence of an association between clinical risk and preparing ahead (aPR 1.05, 95% CI 0.89–1.24), with model-standardised proportions of 44.4% among people at clinical risk and 42.3% among others. There was

also no clear evidence of associations between preparing ahead and financial strain, housing tenure, living alone or demographic characteristics.

Table 4
Factors associated with preparing ahead of the most recent hot period

Factor	Prepared ahead n/N (%)	aPR (95% CI)
Clinical risk		
Comparison group	315/757 (41.6)	1.00 (ref)
At clinical risk	125/269 (46.5)	1.05 (0.89–1.24)
Strongly agreed hot weather could seriously affect own health		
No	323/813 (39.7)	1.00 (ref)
Yes	117/213 (54.9)	1.31 (1.13–1.53)
Strongly agreed confident to protect own health		
No	308/772 (39.9)	1.00 (ref)
Yes	132/254 (52.0)	1.21 (1.04–1.41)
Found advice useful		
No	263/676 (38.9)	1.00 (ref)
Yes	177/350 (50.6)	1.24 (1.08–1.44)
Financial strain (making ends meet)		
Easily or very easily	128/281 (45.6)	1.00 (ref)
Fairly easily	141/348 (40.5)	0.91 (0.77–1.09)
With some or great difficulty	171/397 (43.1)	0.95 (0.79–1.13)
Housing tenure		
Owner	277/613 (45.2)	1.00 (ref)
Social renter	45/105 (42.9)	0.89 (0.70–1.14)
Private renter	90/221 (40.7)	0.90 (0.74–1.08)
Other arrangement	28/87 (32.2)	0.73 (0.53–1.02)
Lives alone		
No	376/882 (42.6)	1.00 (ref)

Complete-case sample (n = 1,026). Prepared ahead: had the home ready to keep cool, or had planned changes to activities, before the hot period began. aPR, adjusted prevalence ratio from modified Poisson regression, with all factors in the table entered together; CI, confidence interval; ref, reference category.

Factor	Prepared ahead n/N (%)	aPR (95% CI)
Clinical risk		
Yes	64/144 (44.4)	1.05 (0.86–1.28)
Age		
Per 10 years	–	1.01 (0.95–1.07)
Sex		
Male	182/434 (41.9)	1.00 (ref)
Female	258/592 (43.6)	1.05 (0.91–1.21)
Holds a degree		
No	166/368 (45.1)	1.00 (ref)
Yes	274/658 (41.6)	0.93 (0.80–1.08)

Complete-case sample (n = 1,026). Prepared ahead: had the home ready to keep cool, or had planned changes to activities, before the hot period began. aPR, adjusted prevalence ratio from modified Poisson regression, with all factors in the table entered together; CI, confidence interval; ref, reference category.

Sensitivity analyses

Sensitivity analyses showed some variation by risk definition (Additional file 1: Table S4). Using nominal 95% CIs, with the broader clinical-risk definition, people at risk were again more likely to recognise their personal risk (aPR 1.18, 95% CI 1.10–1.26) and less likely to avoid harm (aPR 0.78, 95% CI 0.63–0.96), and were also more likely to take core protective actions (aPR 1.11, 95% CI 1.02–1.22). Regular medicine users were more likely than others to recognise their personal risk (aPR 1.15, 95% CI 1.08–1.22), with no clear evidence of differences in the other domains. There remained no clear evidence of an association between clinical risk and preparing ahead when arranging check-ins was included (aPR 1.08, 95% CI 0.93–1.26), and the same three factors remained associated with preparing ahead. Excluding participants with uncertain or undisclosed health responses (n = 36) left the primary estimates materially unchanged (for example, avoiding selected harm: aPR 0.76, 95% CI 0.59–0.97). Among participants aged under 65, those with a qualifying condition (n = 197) more often recognised their personal risk than those without (89.8% vs 75.7%; aPR 1.17, 95% CI 1.09–1.24) and less often avoided selected heat-related harm (16.2% vs 27.6%; aPR 0.61, 95% CI 0.43–0.86), with no clear differences in the other domains or in preparing ahead (aPR 1.10, 95% CI 0.93–1.31). In the three-group comparison, adults aged 65 or over (n = 81) resembled those under 65 without a qualifying condition in risk recognition (74.1% vs 75.7%; aPR 1.03, 95% CI 0.90–1.17) but more often avoided selected harm (44.4% vs 27.6%; aPR 1.54, 95% CI 1.16–2.05).

Discussion

Principal findings

Among symptom-reporting participants in this UK survey, adults meeting the study definition of clinical risk were more likely to recognise that hot weather could seriously affect their health, but this recognition was not accompanied by clear differences in anticipatory preparation, perceived usefulness of advice or uptake of core protective actions. Risk recognition was reported by 85.3% of the clinical-risk group and 75.7% of other respondents; the adjusted association remained evident after correction for the five domain comparisons. In contrast, the confidence intervals for advice usefulness, preparation and protective actions included both lower and higher prevalences. Greater risk recognition was not accompanied by clearly greater reported preparedness; this does not establish equivalence between groups. Exploratory analyses separating the components of the composite suggested that higher risk recognition and a lower prevalence of avoiding selected harm were concentrated among adults under 65 with qualifying conditions, whereas adults aged 65 or over resembled other respondents in risk recognition and more often avoided the selected harms; the overall estimate for harm may therefore combine opposing patterns.

The pattern within the clinical-risk group is informative. Although 85.3% recognised personal risk, 33.1% reported that advice helped a lot or a great deal, 46.8% met the preparation criterion and 64.7% reported at least four core protective actions. These are separate cross-sectional prevalences, not successive losses along an observed pathway. The advice threshold also excludes moderate usefulness and should not be interpreted as showing that two-thirds found advice unhelpful. Preparation of drinks was common, whereas planning changes to activities and arranging check-ins before hot weather were less frequent. In the mutually adjusted preparation model, strong risk recognition, strong confidence and perceived advice usefulness were associated with preparing ahead; clinical-risk status itself was not clearly associated. Beliefs may facilitate preparation, but prior preparation or experience of heat may also shape those beliefs.

The findings complement our companion paper by distinguishing recognition and planning from practical opportunities to keep cool. That paper examines cooling constraints and reported health effects; the present analysis asks whether a study-defined clinical-risk designation corresponds to greater preparedness. The absence of clear associations between financial strain and preparation here does not negate the financial barriers described in the companion paper: undertaking at least one preparatory action and having adequate cooling opportunities are different constructs. Both papers draw on the same underlying survey, with different analytic eligibility criteria, and therefore provide complementary perspectives rather than independent replication. Together, they suggest that clinical susceptibility, perceived capability and material circumstances should be considered jointly when designing heat protection.

Comparison to existing literature

The high prevalence of risk recognition in this sample contrasts with earlier UK studies in which older or otherwise vulnerable adults often rejected personal vulnerability to heat [10, 13]. This contrast cannot establish an improvement over time: recruitment, risk definitions, question wording and weather experiences differ. More recent UK research similarly separates public preparedness, perceived personal risk and responses to alerts [14, 15]. International evidence supports that distinction. Sheridan's survey across four North American cities found widespread awareness of warnings but substantially less reported behavioural change [18]. Research in New York City likewise identified obstacles to protection involving perceived susceptibility and the costs or availability of cooling [19]. The present study extends this literature by distinguishing actions already in place before the recalled hot period from those initiated after it began.

The associations between preparation, confidence and perceived advice usefulness are consistent with behavioural accounts in which recognising a threat is only one determinant of action. In Adelaide, perceived benefits and cues to action were associated with adaptive behaviours during heatwaves [20]. COM-B provides a complementary interpretation: motivation cannot produce protection without the capability and opportunity to undertake an appropriate response [9]. These frameworks help generate explanations but were not formally tested as causal models here. Social support is also more complex than whether a person lives alone or arranges contact. Qualitative work in two UK cities showed that close social networks could reinforce perceptions of low vulnerability, illustrating why contact does not invariably deliver effective protection [21]. The content, timing and practical consequences of support warrant attention alongside its availability.

Clinical susceptibility remains important even where reported behaviour is similar. Experimental research has demonstrated impaired heat dissipation in physically active men with type 2 diabetes during exercise in the heat [22], although this specific finding should not be generalised to every condition included in our composite. Medication-related vulnerability is similarly heterogeneous. A systematic review found effects on thermoregulation for some drug classes but highlighted a small evidence base dominated by young, healthy participants [23]. An observational study of older Medicare beneficiaries with chronic conditions linked several medication classes to heat-related hospitalisation, without demonstrating consistent synergistic effects between medication exposure and heatwaves [24]. Regular medicine use in this survey cannot identify the relevant mechanisms or distinguish treatment effects from underlying illness. Moreover, correct responses to the medicines question followed an in-survey safety message and cannot establish pre-existing knowledge, adherence or the effectiveness of routine professional counselling.

Intervention evidence suggests that actionable, targeted support can change some protective behaviours, but effects are neither uniform nor assured. A randomised trial among older South Australians found improvements in selected cooling behaviours and lower self-reported heat stress following preventive information [25]. A Quebec trial of automated telephone warnings improved some adaptive behaviours but did not demonstrate overall reductions in symptoms or health-service use [26]. In a Japanese community trial, warnings combined with labelled bottled-water delivery improved several

behaviours relative to the control group, although geographical allocation and the bundled intervention limit attribution to individual components [27]. These studies justify testing support that connects advice with practical action; they do not establish that any particular delivery model would be effective in this UK population.

Implications for policy and practice

Clinical-risk identification should prompt a discussion about readiness before hot weather, rather than be treated as evidence that protection is in place. Primary care, community pharmacy and services supporting people with long-term conditions could incorporate a brief, individualised heat-preparedness review into suitable existing contacts. Consistent with UKHSA guidance and clinical reviews, this could establish whether someone can keep their home or another accessible location cool, adapt activities, obtain help and recognise when symptoms require assessment [3, 28]. The proposed review should address what the person can realistically do, identify an agreed source of advice and record unresolved practical needs. Implementation would require evaluation of reach, workload and benefit; this survey does not demonstrate the effectiveness of such a service.

Medication and hydration advice should be tailored to the clinical situation. Generic messages should not encourage abrupt treatment withdrawal or disregard prescribed fluid restrictions. A clinician or pharmacist can clarify whether a specific regimen, condition or care plan requires an agreed response during hot weather, including how to obtain advice if circumstances change [5]. The small number reporting professional advice-seeking in this survey suggests an opportunity to examine access and perceived relevance, but does not establish widespread unmet clinical need: most respondents either did not seek advice or explicitly considered it unnecessary. Those who tried and could not obtain advice represent a more direct access concern, although their numbers are too small to quantify population-level service inadequacy reliably.

Public communication should connect a recognisable situation with a feasible action and an available source of support. Messages about preparing a room, adjusting responsibilities or arranging contact may be more actionable when accompanied by assistance with housing, cooling costs, transport or care. This is the practical connection to the companion paper: advice and clinical targeting operate within the opportunities available to households. Materials and delivery channels should accommodate different literacy, language, sensory and digital-access needs, with co-design involving people who manage chronic illness and those facing financial or functional constraints. A diagnosis-based approach should supplement broad access to heat protection, because people outside the study's clinical-risk category can still face substantial environmental or social vulnerability.

Evaluation should distinguish message reach, comprehension, feasible preparation, actual cooling and health outcomes. Reviews of warning systems have reported heterogeneous evidence and difficulty separating alerts from accompanying public-health measures [29]. A study of 20 US cities found no overall mortality reduction associated with heat alerts, despite variation between cities [30], whereas a quasi-experimental evaluation in Montreal supported benefits from a broader heat action plan, including

among disadvantaged groups [31]. These findings favour evaluating coordinated programmes in context rather than assuming that issuing an alert is sufficient. Prospective UK studies could link repeated measures of preparedness with temperature exposure, service contacts and health outcomes, while measuring unequal access to effective protection.

Strengths and limitations

The strengths of this study include the explicit distinction between anticipatory and reactive preparation, the examination of several related domains within one survey, and the presentation of both crude and adjusted comparisons. Reporting professional advice-seeking separately from perceived need avoids treating all non-use as a service failure. Holm correction limits overinterpretation of the five domain comparisons, while alternative risk definitions, an expanded preparation definition and exclusion of uncertain health responses provide some assessment of dependence on analytic choices. The companion design also permits a coherent account of clinical and practical dimensions of heat protection without requiring them to be collapsed into one vulnerability score.

Nevertheless, the online sample cannot be assumed to represent UK adults, particularly people with limited digital access, severe illness or cognitive impairment. Approximately two-thirds of classified respondents held a degree. Because the preparation questions were shown only to participants who reported at least one heat-related symptom, the findings describe respondents reporting symptoms and should not be generalised to all heat-exposed adults. Restricting analysis to symptom reporters may induce selection bias if clinical risk and preparation both influence symptom reporting; the direction of any such bias cannot be determined here. Compared with the analytic sample, the 200 participants routed past these questions were older (mean age 48.8 vs 43.0 years) and less often at clinical risk (20.6% vs 26.0%), financially strained (23.8% vs 38.9%) or living with a limiting long-term condition (14.4% vs 26.2%), so the restriction changed the composition of the analytic sample. A further 27 participants left before these questions, and complete-case regression introduced additional selection. If participation or completion depended jointly on health and preparedness, associations could be biased as well as prevalences. The relatively small clinical-risk group also limits assessment of specific conditions, pregnancy and interactions between health, socioeconomic circumstances and ethnicity. UK-wide recruitment does not establish that findings apply equally across nations, whose service arrangements differ.

Clinical risk was a study-defined composite, not a validated prediction score. It combines age with heterogeneous conditions without information on severity, multimorbidity or specific medicines; the main definition also excludes some potentially relevant conditions captured only in sensitivity analyses. Consequently, the comparison group should not be interpreted as free of heat vulnerability. Because the export omitted the ‘None of the above’ option, this response was inferred from the forced-response design rather than read directly from the data. A further limitation arises because everyone aged 65 or over was classified as at risk, yet age was also included in adjusted models. There is no observed non-risk comparator in that age range. This lack of overlap means that an age-adjusted group contrast cannot be interpreted simply as a comparison between otherwise similar adults across the full age

distribution; it depends on modelling assumptions [32]. Exploratory analyses that separated older age from condition-defined risk among adults under 65 clarified this estimand and suggested that the two components behaved differently, particularly for avoiding selected harm; these analyses were not prespecified, used nominal confidence intervals and involved small groups, including only 81 participants aged 65 or over.

All principal measures were self-reported after the hot period, and a short heat-safety message preceded the questions on preparation, advice, beliefs and knowledge, which may have influenced these responses. Recall error, shared reporting tendencies and reverse causation could influence associations between beliefs, advice, behaviour and symptoms. Without linkage to local or indoor temperatures, differences in exposure cannot be separated adequately from differences in susceptibility or response. The five domains are not a validated clinical pathway, and analyses conditional on the preceding domain do not estimate progression or mediation. Preparation thresholds combine distinct activities; the protective-action count does not establish that actions were appropriate or sufficient for a particular exposure. Similarly, 'avoiding heat-related harm' denotes the absence of selected warning-sign symptoms and frequent sleep disturbance, not absence of every adverse effect or a clinically verified outcome.

Finally, statistical uncertainty warrants restraint. The primary adjusted estimate for avoiding the selected harm outcome had a nominal confidence interval excluding 1, but its Holm-adjusted p-value was 0.151. It therefore did not provide clear evidence under the applied multiplicity correction. Secondary and sensitivity estimates should be regarded as exploratory, especially where broader risk definitions change the apparent pattern. Conversely, non-significant comparisons do not demonstrate equivalence or exclude meaningful differences in preparation. The present findings identify questions about how recognition, advice and practical support relate to preparedness; they do not establish the effectiveness of individual behaviours, clinical counselling or national heat-health policy.

Conclusions

Among respondents reporting heat-related symptoms, adults meeting the study definition of clinical risk more often recognised their susceptibility to heat, but did not report clearly greater preparation, advice usefulness or uptake of core protective actions. These findings support examining preparedness explicitly rather than inferring it from either a clinical-risk label or stated awareness. Read alongside the companion paper, they point towards heat protection that combines personally relevant advice with feasible plans, clinical support where needed and practical opportunities to keep cool. Prospective evaluation is required to determine whether this coordinated approach improves protection and reduces inequalities in heat-related harm.

Abbreviations

aPR

adjusted prevalence ratio
CDC
Centers for Disease Control and Prevention
CHERRIES
Checklist for Reporting Results of Internet E-Surveys
CI
confidence interval
COM-B
capability, opportunity, motivation–behaviour
ICREC
Imperial College Research Ethics Committee
NHS
National Health Service
NIHR
National Institute for Health and Care Research
PR
prevalence ratio
RGIT
Research Governance and Integrity Team
STROBE
Strengthening the Reporting of Observational Studies in Epidemiology
UK
United Kingdom
UKHSA
UK Health Security Agency.

Declarations

Ethics approval and consent to participate

The study was approved through the Imperial College Research Ethics Committee (ICREC) process by the Research Governance and Integrity Team (RGIT) on 9 September 2026 (ICREC reference 8705479). All participants provided informed consent online before taking part. The study was conducted in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Clinical trial number

Not applicable.

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Author Contribution

AEO and MR conceived and designed the study. SA, MR and AEO contributed to data collection. SA performed the formal analysis with support from MR and AEO. SA, MR, AEO, SP, WJ and AM contributed to the interpretation of the findings. SA and AEO wrote the first draft of the manuscript. All authors critically reviewed and edited the manuscript and read and approved the final version. AEO is the guarantor.

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Data Availability

The anonymised dataset analysed during the current study is available from the corresponding author on reasonable request. The analysis code (Stata and R) is available from the corresponding author on request.

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Figures

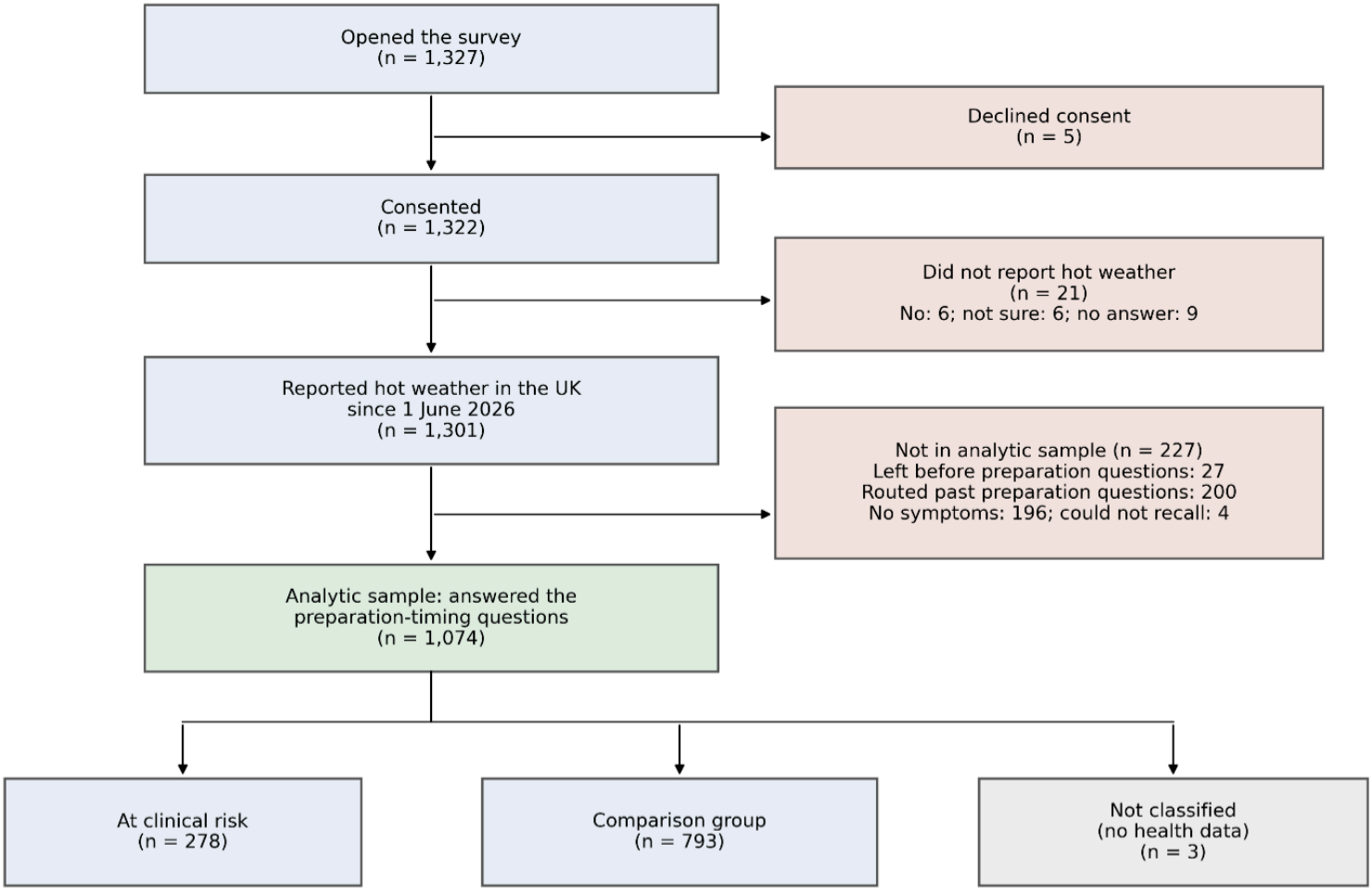

Figure 1

Flow of participants into the analytic sample and by clinical-risk status

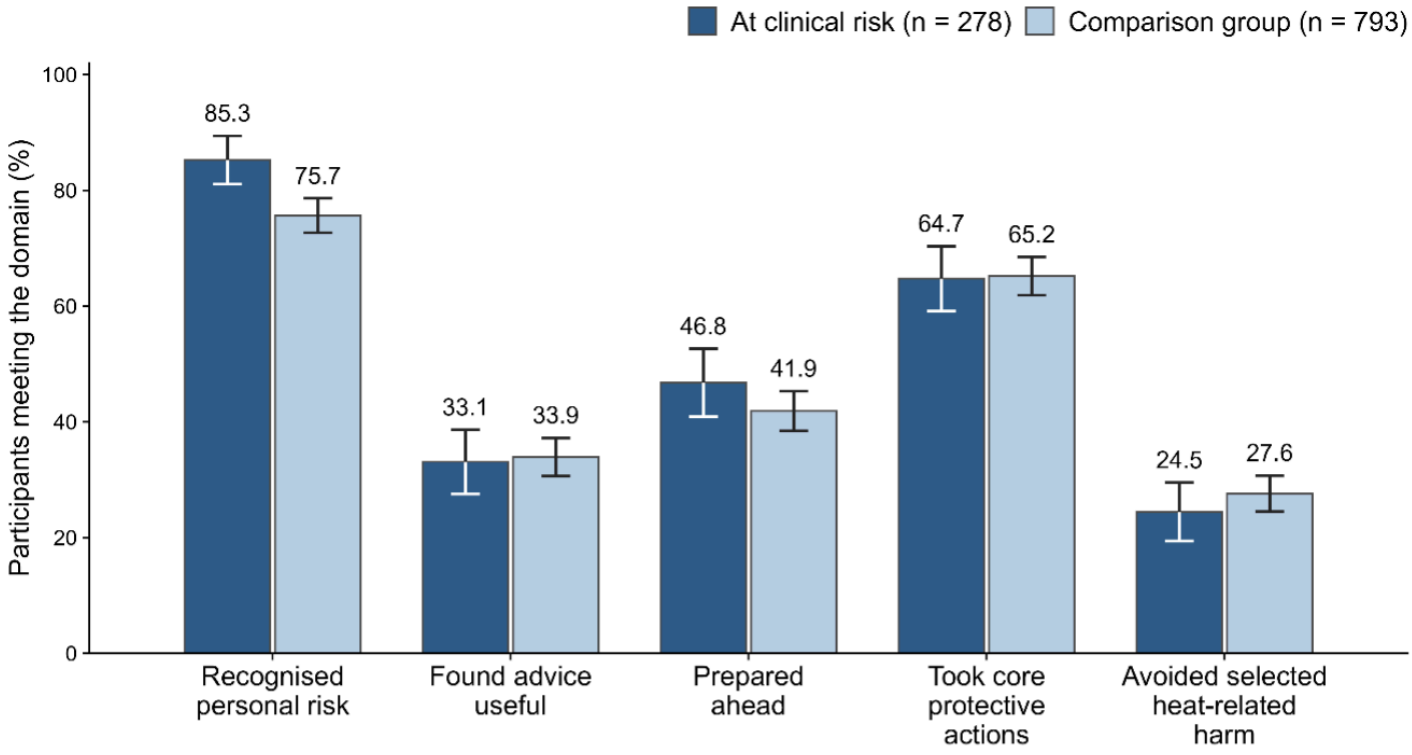

Figure 2

Heat-protection domains by clinical-risk status. Bars show the percentage of each group meeting each domain, among participants with data on that domain (at clinical risk n=278; comparison group n=790 to 793). Error bars show 95% confidence intervals. Domain definitions are given in Additional file 1: Table S1.

Supplementary Files

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