**Article:**
Hudson, Paul, DUNLOP, LYNDA and Turkenburg - van Diepen, MARIA GERTRUDIS WILHELMINA (2026) Extreme heat risk perceptions and readiness in schools. International Journal of Disaster Risk Reduction. 106109. ISSN: 2212-4209

https://doi.org/10.1016/j.ijdrr.2026.106109

International Journal of Disaster Risk Reduction 138 (2026) 106109

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr

# Extreme heat risk perceptions and readiness in schools

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ARTICLE INFO

*Keywords:*
Extreme heat
Heatwave
Disaster risk
School
Adaptation

ABSTRACT

The increasing frequency and intensity of heatwaves poses significant challenges to schools, particularly in terms of ensuring the safety and well-being of pupils and staff. This paper investigates the perceptions of extreme heat risks and the readiness of schools to adapt to such conditions in the United Kingdom (UK), focusing on the experiences and viewpoints of schoolteachers and wider school staff. A survey was disseminated through multiple avenues to gather a diverse sample of teachers and school staff to assess the perceived impacts of heatwaves, their perceptions of the associated risks, and the measures currently in place to mitigate these effects. Findings reveal a degree of awareness regarding heat-related risks among school staff (e.g., heat risks, increased disruptive behaviour, worsening educational environment). Key adaptation measures include relaxation of uniform policies, increased hydration breaks, and the provision of shaded areas. However, these actions are mainly behavioural measures and very few building-level adaptation measures were implemented or planned. The sample overall reports a belief that the adaptation measures at their disposal can limit the risks associated with high temperatures, and that they could implement other measures, but that they are deemed to be too difficult/expensive to employ. The study underscores the urgent need for systemic support for adaptation education amongst school leaders and investment in sustainable adaptation strategies to enhance resilience against extreme heat in UK schools. Recommendations for policymakers and schools are provided to improve readiness and ensure a safer learning environment in the face of rising temperatures.

## 1. Introduction

Hazards, such as heatwaves, floods, and windstorms, are becoming more frequent and intense due to climate change, socio-economic development, and human behaviour [1,2], bringing a range of cascading impacts on society [3]. In 2021 a German flood caused €33bn of damage with 189 deaths [4]. The 2003 European heatwave resulted in over 70,000 excess mortality across Europe, and over 61,000 mortalities specifically attributable to heat during the 2022 European heatwave [5]. The impacts of heatwaves, or extreme heat, is problematic as heatwaves in Europe that were expected to occur twice a hundred years in the early 2000s are now expected to occur twice a decade [6]. Moreover, heatwaves have a wide geographical range over which they can occur. For instance, heatwaves in 2003, 2010, 2018, 2019, and 2022 impacted a large proportion of Europe. Smid et al. [7] show that all the metropolitan areas of the European Union will become more exposed to extreme heat due to climate change, with the geographical spread of locations threatened also increased. Indeed, up to 50% of Europe's population could be at very high risk of heat stress by 2050 [8] and it

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https://doi.org/10.1016/j.ijdrr.2026.106109
Received 26 October 2025; Received in revised form 18 March 2026; Accepted 19 March 2026
Available online 26 March 2026

is uncertain to what extent adaptive behaviour can combat heat-related mortality or stress [9]. Extreme heat events are becoming more likely and widespread meaning that there is likely to be an increased occurrence of heat-related health conditions, mortality, disruption to agriculture, transport and other infrastructure, and increased energy demand for cooling during the summer. Within the United Kingdom (UK), those living in Greater London, the South East and Eastern regions of England are most exposed to extreme heat [10]. The potential impacts of these hazards must be limited to prevent a deterioration of human wellbeing.

Human wellbeing is multifaceted and heat based hazards can have a range of impacts. For instance, extreme heat has a range of negative health consequences [11,12] as well as changes in worker productivity [13–15] and as such potentially economic output (Carcia-Leon et al., 2021, [16]). In terms of economic output and productivity human capital is a key element of economic output and is often tied to educational outcomes (see, e.g., Ref. [17]). Extreme heat events have detrimental impacts on education outcomes [18] with loss of learning associated with fatigue and loss of concentration, e.g., 26°C is the upper comfortable temperature in schools [19]. School closures associated with infrastructure vulnerability are associated with lower test scores [20,21]. Recent modelling suggests [19] that the most at-risk schools in England could experience up to 15 school days per year of internal temperatures above 35 °C if the climate warms to 2 °C above pre-industrial temperatures, with newer schools more likely to overheat than older schools (see for example, [19]) even as they attempt to be climate resilient [22].

Given the importance of limiting the growing impacts of climate change and the resulting impacts of extreme heat on educational outcomes, there is a need to employ adaptation or risk management strategies. These can range from changing the built environment to individual behavioural changes. For example, changes in the built environment can vary from increased use of air conditioning (which can become maladaptive if powered by fossil-fuel rather than renewable electricity), landscape changes (increasing blue and green spaces to mitigate urban heat island effects), to wider building changes (e.g., changing materials and natural ventilation). There is also a wide range of individual behaviours that can be employed such as changing working hours or anticipated activities, changing the clothes that are worn, and increased focus on hydration [23].

There has been a wider behavioural turn in how we approach the management of different natural hazards as part of integrated disaster risk management [24,25]. Integrated disaster risk management implies that all of those threatened by a hazard should play some role in limiting the hazard's impact in line with their abilities and capacities. Therefore, it is important to understand how differing socio-behavioural drivers determine a person's or organisation's knowledge of what to do before, during, and after an extreme event. This is important because different members of society will have different levels of capacity and autonomy to act against the threat posed by heatwaves. For instance, children feel overheated quicker not only because of physiological differences to adults [26] in extreme heat conditions (Faulk and Dotan, 2008) but also because they have access to fewer personal adaptive behaviours, and because they are not in control of adaptations at the classroom level [27]. Moreover, depending on the age of the child children not only overheat quicker, but they may not realise they are overheating and as such may employ fewer heat risk mitigation strategies, as noted in, for example, Ravanelli et al. [28]. Children therefore have the potential to be disproportionately impacted by the effects of extreme heat because power differentials present means that children do not necessarily have the autonomy or authority to change their behaviour during an extreme heat event. Children can suffer from negative health impacts [29,30] as well as worsening educational performance [21,31,32], and both of these can negatively impact the development of a child's human capital [33] leading to substantial long-term consequences [34,35].

In recognising the threat posed by extreme heat and the significant role that educational staff has on the behaviour of their charges, in 2023, the UK Health Security Agency (a public health body) released guidance for teachers and other educational professionals on looking after children and those in early years settings before and during an extreme heat event [36]. This supplements guidance from unions, drawing on guidance from the Department for Education, Acas and UKHSA [37]. There is no maximum legal temperature for schools, and the Department for Education advises against closing schools during an extreme heat event [38], so it is important to understand how better knowledge of heat threat posed can be promoted, and how behaviour can be altered. It is essential that schools are prepared for extreme heat events and are aware of actions that can be taken to enable pupils and staff to cope with high temperatures. However, Brimicombe et al. [39] have described heatwaves as an 'invisible risk' in the UK with action largely lacking. Whilst studies have been conducted on individual adaptive behaviours of children in the UK [27], we do not currently have a baseline understanding of how prepared schools are to adapt to extreme heat conditions, nor the extent to which schools develop and use evidence-informed heat action plans.

The development of a heat action plan is the first step in recognising the potential implications of changing patterns of extreme heat in the UK. For instance, Dillenardt et al. [40] study German risk communication materials for fluvial flooding. Dillenardt et al. [40] find that while hazards and adaptation options were mentioned at a high level, the way in which flood adaptation was communicated did not match understanding of behavioural theory for effective adaptation. However, in other contexts, successful shifts in risk communication have been managed. For example, Parida et al. [41] find that Canadian municipalities managed a shift from communicating natural hazard risk as 'objective' to one that recognises natural hazard risk as a social construct determined by community-level vulnerabilities; implicitly recognising the need for locally tailored responses. While it is unclear how far we can apply behavioural theories to that of organisations, Dillenardt et al. [40] and Parida et al. [41] indicate that information provided in early warnings, and wider risk communication, needs to be aligned with knowledge about how to spark proactive action and with local needs and considerations. Kreibich et al. [42] and Mehta et al. [43] also note that for warning messages to successfully reduce impacts, recipients must have knowledge of warning triggers and plans that they feel confident to deploy. Messages often have different meanings for different audiences which leads to a wide scope of interpretations and potential actions ([44]; Lefevre et al., 2015; Taylor et al., 2019), so it is important to develop local heat action plans which have a basis in contextual knowledge about how to respond to extreme heat. Therefore, the warning itself does not need to be informative, as long as school staff know what to do and are empowered to act during a heatwave.

In this study we conducted a survey of schools across the UK to provide a stocktake of currently employed extreme heat risk knowledge and management strategies across schools, to understand where school staff find information about effective strategies, and their experiences of implementing a range of strategies. As van Valkengoed and Steg [45] note, extreme heat adaptation is poorly understood compared to other hazards such as flooding. Therefore, the key research objectives for this paper are

1. To what extent do UK school staff perceive extreme heat risk as a priority, and how do they perceive it as a potential within a school context?
2. What is the relative perceived prevalence of behavioural versus building-level adaptation measures implemented in UK schools, and what are the perceived barriers to implementing heat action plans and wider risk management strategies?

In answering these two questions, we can establish a suitable baseline of information and future research directions to advance how the UK will manage the problem of extreme temperatures within schools. In principle this work serves a similar purpose to Otto and Thieken's study of child care facilities in Germany in identifying relevant gaps that identify pertinent policy gaps in action.

## 2. Study context, methods, and data

### 2.1. UK school system

Education in the UK is commonly classified according to five stages: early years, primary (usually age 5-11, or 4-11 in Northern Ireland), secondary (from age 11), further (post-16, post-compulsory) and higher (university level, offering qualifications higher than level 3 on the Framework for Higher Education Qualifications). Education is a devolved matter in the UK, meaning that each of the constituent jurisdictions (England, Northern Ireland, Scotland and Wales) have separate systems with varying policies. This has led to a divergence of policy over the past two decades of devolution in terms of spend per pupil, curriculum and assessment [46]. This also applies to responses to extreme weather. Education spend in the UK is broadly similar to the average of OECD countries in secondary education, but is among the lowest for early years education [47]. Children in the UK spend almost 30% of their life in school, with about 70% of that time spent in classrooms [48]. There is significant concern about the state of the school estate in the UK, particularly in England, where the National Audit Office [49] has reported declining conditions, with around 700,000 pupils reportedly learning in a school that needs major rebuilding or refurbishment and safety concerns escalated to the government risk register.

While we acknowledge differences across the constituent countries of the UK, we shall use the term as shorthand for our sample. The limitations of this are discussed in section 4.2.

### 2.2. Data and sampling approach

#### 2.2.1. Sampling approach

A school, much like a community, is not a single entity. There are various groups within schools that experience different levels of vulnerability and capacity to act against heatwaves. For instance, pupils can be perceived as having less autonomy to independently act given the authority of teaching and leadership staff. Teachers could be seen to have more capacity to act and change behaviour, but they must juggle varying objectives while following policies and procedures developed by the school's leadership team. This project focuses on staff and not the pupil population because staff have the greatest agency to act and awareness of school policies and procedures.

We disseminated the survey through multiple channels to try and maximise the potential number of responses. We kept the survey open for a period of approximately one month between 25th June and 26th July 2024, meaning the survey was being conducted during the time where heatwaves are most likely to occur, helping to increase the presence of the threat in people's minds and their inclination to respond. There is a downside in that the survey was conducted about one week before the end of the teaching year in Northern Ireland and Scotland, and relatively close to the end of the school year in England and Wales, which may have influenced the response rate. Response rate was also likely affected by the perception that extreme heat is not the most important effect of climate change on the UK [50], a message we heard during the recruitment process.

We sent a link with the survey via email to the 20 largest multi-academy trusts, to members of the research schools and eco schools' networks, via the STEM Learning Community newsletter and the Association for Science Education (ASE) newsletter, and through a range of professional networks (e.g., unions, school business managers). We advertised the survey via social media from various institutional accounts. Finally, we systematically sought out school contact addresses via education authorities, as well as publicly available Freedom of Information datasets on school contacts. In all cases we directly asked the participants to "snowball" the sample to other schools or relevant stakeholders. Therefore, this study is based on a 'convenience' sample as derived from a purposive sampling strategy. Our purposive sampling approach aimed at engaging pertinent and relevant stakeholders from as broad a cross-section as possible both across and within schools. Purposive sampling was suitable for our research questions, because with an exploratory focus, the priority is to uncover the range of existing practices and barriers rather than generalisability through an approach similar to a case study. Consequently, by prioritizing the generation of key themes, these findings serve as a step towards later more representative studies.

#### 2.2.2. Theoretical and conceptual background

A range of socio-psychological models have been used to structure the analysis of people's behaviour regarding natural hazards. For example, the protection motivation theory (PMT; Maddux and Rogers [51], the protective action decision model (PADM; [52]), the theory of planned behaviour (TPB; Ajzen [53], have been widely used [25]. These theories exist on a spectrum between rationalist (i.e., that there are consistent principles governing behavioural processes across contexts) and constructivist (i.e., behaviour is a contextual phenomenon driven by socio-cultural factors) emphasising different aspects of the behavioural process [54]. Previous research has highlighted the role of various cognitive, affective, and socio-economic factors in shaping behaviour [45,55–57].

This study integrates elements from the PMT and PADM behavioural models. Lindell and Perry [52] present PADM as a model that integrates various social, environmental, and psychological cues to act. They define three pre-decision processes for PADM that underpin the need to act as: attention (i.e., a cue to kickstart the thinking process), exposure (i.e., a source of information), and comprehension (i.e., the person's ability to understand and act upon the information). This leads to the formation of three core perceptions – threat perceptions, protective action perceptions, and stakeholder perceptions – that generate the potential for a protective action once situational facilitators and impediments to action are considered. It must be noted that these core perceptions have substantial overlap with the constructs of PMT. Therefore, the two can be operationalised as PMT nested within the PADM framework, see e.g., Dillenardt et al. [58], and Strahan and Watson [59]. Both of these behavioural frameworks have been applied to heatwave adaptation studies, with PADM used in, e.g., Beckmann et al. [60] or Ng et al. [61], while PMT has been used in, e.g., Mehiriz and Cherqaoui [62] or Murtagh et al. [63], although not to date to understand school adaptation to extreme heat.

In this study's joint operationalising of the PMT and PADM, we draw upon the concepts of threat appraisal (i.e., the perceived probability and consequences of a heatwave), coping appraisal across the concepts of self-efficacy (i.e., the perceived ability to implement risk management strategies), response-efficacy (i.e., the perceived effectiveness of risk management strategies), and response-costs (i.e., the perceived cost, in time effort and money, of the risk management strategies). While these core concepts (threat appraisal and coping appraisal) cover the key elements of PMT, we extend them by a consideration of the information gathering and reception pathways of PADM by asking questions about their perceptions and experiences of heatwave early warning systems and

**Table 1**
Sample summary.

| | | |
|---|---|---|
| Location (n = 233) | England | East Midlands (27), West Midlands (15), East of England (12), London (41), Northeast (9), Northwest (22), Southeast (36), Southwest (12), Yorkshire (40) |
| | Scotland | Lothian (3), Aberdeenshire (1), Argyll and Bute (1), Falkirk (1), South Ayrshire (1) |
| | Wales | Bridgend (1), Flintshire (4), Merthyr Tydfil (1), Pembrokeshire (1), Wrexham (3) |
| | Northern Ireland | Antrim (1), Armagh (1) |
| Role in school (n = 250) | Teacher/head of subject/teaching assistant | 166 (66%) |
| | Leadership (headteacher/assistant/deputy head) | 20 (8%) |
| | Technician | 17 (7%) |
| | Administrator/welfare officer/special needs coordinator | 26 (10%) |
| | Estates/facilities staff | 16 (6%) |
| | Cover supervisor/supply teacher | 5 (2%) |
| Length of time in current school (n = 249) | Less than 1 year | 5% |
| | 1-2 years | 13% |
| | 3-5 years | 17% |
| | More than 5 years | 64% |
| Length of time in education in general (n = 249) | Less than 1 year | 1% |
| | 1-2 years | 4% |
| | 3-5 years | 8% |
| | More than 5 years | 88% |
| What level of schooling (n = 250) | Early years | 2% |
| | Primary | 28% |
| | Secondary (including middle) | 60% |
| | Further Education | 6% |
| | Other | 4% |
| Type of school (n = 250) | Grammar | 7% |
| | Independent | 2% |
| | Special | 1% |
| | State Maintained (Academy) | 42% |
| | State Maintained (local education authority) | 42% |
| | Other | 6% |
| School size/number of pupils (n = 231) | 0-100 | 4% |
| | 101-200 | 5% |
| | 201-300 | 9% |
| | 301-400 | 5% |
| | 401-500 | 8% |
| | 501-1000 | 16% |
| | 1001-1500 | 33% |
| | 1500+ | 20% |
| | Don't know | 1% |

school level policy.

### 2.3. Analysis

The analysis of the survey data is primarily based on descriptive statistics due to the relatively small sample and the overall research objective of conducting a stocktake of current risk perceptions. This allows us to compare the mean responses to questions on risk perceptions, and take stock of current actions and future intentions across schools. We employ a range of inferential statistics (t-tests, Mann-Whitney *U* test, and Kruskal–Wallis) to explore if different stakeholders within a school display different tendencies (e.g., a classroom teacher may have a different perception of their coping capacity compared to that of a school's senior leadership team), although this inferential analysis is limited by the relatively small sample for specific school roles. This analytical approach has been used in similar work by Otto and Thieken [64] and is valid because it strategically aligns its methods with the study's objectives and sample constraints, allowing us to conduct a "stocktake" of current risk perceptions and actions, providing a clear summary of the status quo following a purposive sampling strategy. The limited sample size, particularly for specific school roles, makes prioritizing descriptives a statistically sound choice, avoiding over-generalisation from insufficient data.

The open text responses also provide wealth of further information on the perceptions and perspectives behind the quantitative answers provided. To provide an analytical structure to understand the open text, the responses for a particular question were extracted from the survey database and then a blended coding approach was used (see, e.g., Linneberg and Korsgaard [65]). This involved an initial stage of inductively generating themes from the data to produce a long list of themes. The second stage revised these initial codes by aggregating them into larger groupings until only distinct thematic groups emerged.

The exception to this approach was the analysis of respondents' knowledge of heat stress/stroke symptoms and the actions to undertake. This text response was converted into a score between 0 and 3 based on the following criteria: A score of **0** means the information provided was completely inaccurate or unrelated; **1** if the answer was somewhat relevant but vague or incomplete, or largely inaccurate; **2** if the answer was moderately accurate but missing key symptoms or details; **3** if the answer was accurate and comprehensive, listing key symptoms clearly. The scoring was performed by a single reviewer (PH), following the rubric that was developed described above in collaboration across the author team. Where the application was unclear a discussion between authors (PH and LD) was undertaken to determine understanding of how to apply the rubric. Finally, the lead author reviewed the answers and scores one month after the original coding to confirm satisfaction with the scores.

## 3. Results

### 3.1. Sample description

Table 1 presents the summary statistics of our final sample. Despite efforts to disseminate the survey across all four nations in the UK, the majority of responses came from various regions of England. This was not unexpected as England has more educational institutions to approach, a larger population, and at the time the survey was disseminated further away from the end of the academic year compared to Scotland, Wales, and Northern Ireland. It is also the region that experiences the highest temperatures. The majority of respondents were teaching staff as compared to management or administrative or other supporting roles. Again, this is not surprising as teaching staff are over-represented in the teaching workforce. Established teachers (e.g., more than 5 years of experience) who have spent a significant amount of time in their current school (e.g., more than 5 years) who work in state-maintained schools are over-represented, but this is a suitable sample for our study because it represents staff overall who are familiar with their pupils and are familiar with the capacity of their school and the overall system. It should be noted that there are differences in the number of observations due to 'missing observations' where respondents did not answer a question either as a proactive choice or user error. In the absence of further information we assume this is 'missing at random'.

### 3.2. Survey results

#### 3.2.1. Heatwave risk perceptions & perceived impacts

Out of the sample, 86% could remember the last heatwave they experienced and when asked when that event occurred 24% referred to a heatwave in 2024, 38% an event in 2023, 37% in 2022, <1% an event before 2022. Overall, 90% responded that they had experienced the referred to heatwave while working in their school. While staff referred to the dates differently, it appears that they identified the heatwave occurring between June and September. There may be an element of availability bias, where we tend to see perceptions biased towards the most recent experiences of an individual. See, e.g., Di Baldassarre et al. [66] as an example. However, the technical threshold for a heatwave had been exceeded in most of the UK in late June, despite being a cooler summer overall [67], hence the 24% who referred to a heatwave in 2024. In 2023 the maximum observed temperature was 33.5 °C, and in 2022 the highest recorded UK temperature was 40.3 °C.

In terms of the perceived impact, see Fig. 1, we note that there is a statistically significant difference in the mean values associated

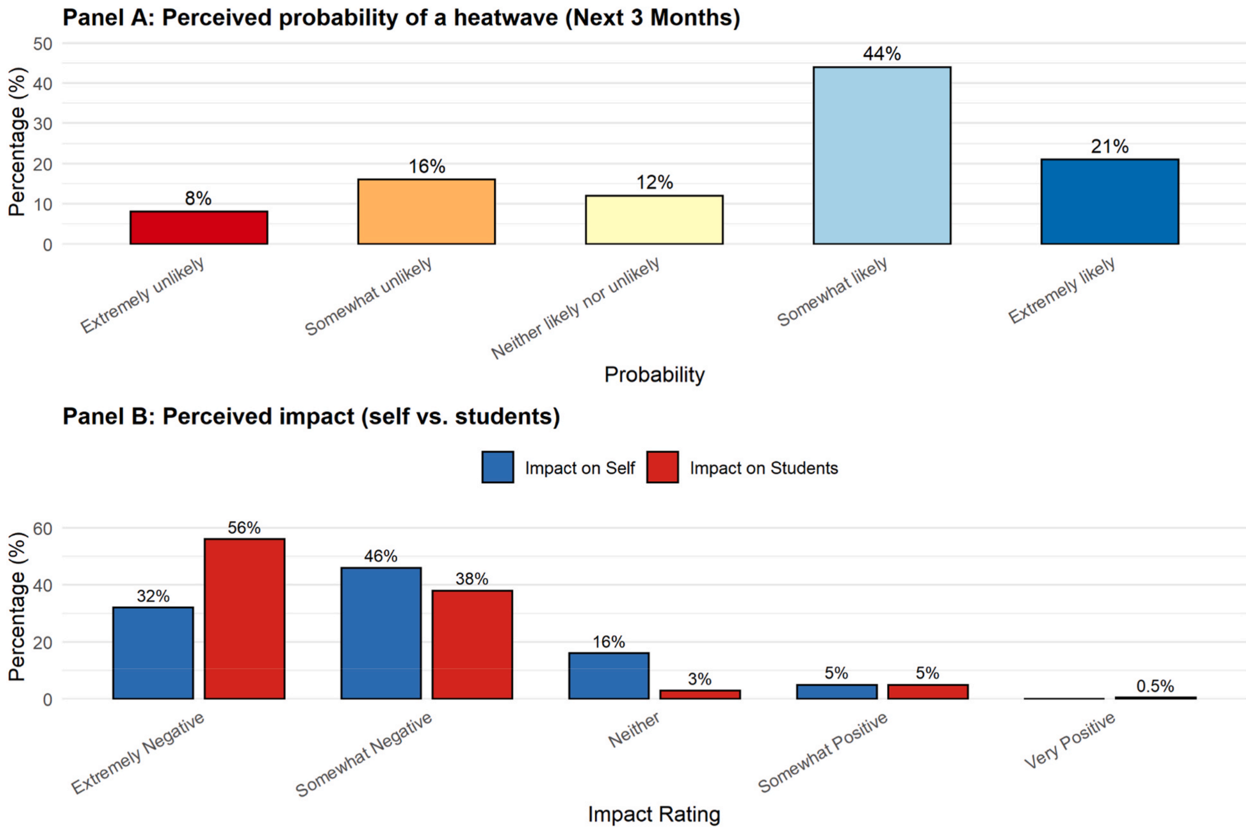


**Fig. 1.** Summary of Threat Appraisal (perceived probability and perceived impacts) as histograms.

with their perceived impact on themselves compared to the perceived impact on pupils. This difference is statistically significant at the 1% level for both a *t*-test or a Kruskal-Wallis test.[1] Therefore, it appears that teaching staff view themselves as less impacted than their pupils, as can also be seen by comparing the absolute value difference between the scores provided for the two questions that 40% of the sample rated the impact on their pupils at least one point higher than the score for the impact on themselves, with 95% of the responses indicating the impact was just as bad if not greater than on themselves.

When asked to identify how the staff expected the impacts of heatwaves to manifest, they presented the following impact groupings:

- The most common group highlights concern on the significant impact on **concentration, behaviour, and focus** due to excessive heat. The responses indicated that both pupils and teachers alike are perceived to find it difficult to concentrate and this was attributed to both physical discomfort and cognitive difficulties.
- The second most identified category of impacts can be **physical discomfort and health and safety concerns,** specific concerns included worries of heat exhaustion/heat stroke, sunstroke, dehydration, discomfort from the uniform code and possible limitations on managing personal comfort, inability to fully alter teaching activities to accommodate higher temperatures.
- The third most common theme of impacts identified was **decreased energy levels and fatigue** where the comments provided a general sense of lethargy and tiredness, which affects pupils' and teachers' ability to engage in learning activities and the quality of education.

While the above questions are concerned with the impact today, we also asked how their perception of the threat posed by heatwaves could change by 2030. Out of the responses collected 90% agreed with the statement that it is only to get worse, while only 10% stated that it would stay the same or improve by 2030. Reasons were classified into the following thematic groups:

[1] Assuming that the two questions can be considered independent for the *t*-test results in a mean value of 4.06 for personal impact (somewhat negative) and 4.47 for perceived impact on pupils. There is a t-stat of 0.41 with a p-value smaller than 1%. Similarly, for the Kruskal-Wallis test comparing the distributions there is a test statistic of 24.8 and a p-value less than 1%.

- **Acknowledgment of climate change/global warming** where the comments recognised climate change as a real and present phenomenon driving the threat, often claiming the support of scientific evidence.
- **Increasing frequency and severity of extreme weather** where the comments focused on these events due to climate change, but placed a stronger emphasis on the overall pattern of extreme weather events.
- **Inadequate infrastructure and adaptation/mitigation** where the comments identified a lack of infrastructure and adaptation to cope with the effects of climate change or that there is a strong need for immediate action to combat climate change and its effects. Therefore, this set of answers focused on their inability to cope and adapt.
- **Uncertainty** where the comments expressed uncertainty about future impacts and weather due to the complexity of the climate system and 2030 being too close.

### *3.2.2. Understanding and identification of heat exhaustion and heat stroke*

*3.2.2.1. Symptoms.* When looking at the commonly described symptoms of heat exhaustion the respondents successfully identify a range of physical (e.g., sweating, dizziness, rapid breathing, dehydration), and behavioural (e.g., fatigue, increased irritability) symptoms. The common themes among the symptoms of heat exhaustion reported by respondents include a combination of physical, behavioural, and observable changes. The primary physical symptoms recognised are heavy sweating, pale or flushed skin, high temperature, nausea, and headaches. Behavioural symptoms recognised include fatigue, confusion, and irritability. Observable changes were described as reduced engagement, quietness, and possible cessation of sweating in severe cases. Recognising these symptoms early can help in addressing heat exhaustion effectively before it escalates to more serious conditions like heat stroke. The common themes among the symptoms of heat stroke as reported by respondents include a combination of severe physical, behavioural, and observable changes. Heat stroke symptoms are more intense and severe than those of heat exhaustion, with a high risk of loss of consciousness and potential seizures. However, there was little difference between the two in survey responses despite a suggestion that heat stroke should be a worsening of the symptoms.

In analysing the symptoms of heat exhaustion (see section 2.3 for a presentation of the scoring system), the data reveals an average score of 1.7 and a median score of 2. For recommended actions in response to heat exhaustion, the average score is 1.9 with a median of 2. Regarding the symptoms of heat stroke, the average score is 1.3 with a median score of 1. For recommended actions, the average score is also 1.3, with a median of 2. This means that by our metric most responses were vague, inaccurate and/or imprecise.This may be because the question was open-ended and only partial answers were given, These questions had a relatively low response rate of between 41% and 53%.

We also saw a correlation coefficient of 0.29 (statistically significant at the 1% level) between the questions on heat exhaustion symptoms and actions, and a correlation coefficient of 0.23 between the questions on heat stroke symptoms and actions (statistically significant at the 5% level). Thereby indicating that a person who provided a more detailed assessment of the symptoms of heat stroke/exhaustion were more able to articulate the correct actions to take in response.

This lower scoring can be attributed to the repetition of symptoms initially described for heat exhaustion, without adequately emphasising the increased severity characteristic of heat stroke. This is concerning, as heat stroke is a life-threatening condition requiring prompt and specific interventions. The responses exhibited a somewhat greater focus on fluid intake, which can have varied implications depending on the individual's condition. However, it is noteworthy a subset of respondents correctly identified heat stroke as a critical medical emergency, necessitating immediate contact with emergency services. Several respondents highlighted that directly calling emergency services might contravene school policies, which mandate contacting the school nurse or welfare officer to make that decision. While heat exhaustion can often be managed without escalation—unless symptoms persist beyond 30 min—many respondents indicated a risk averse approach by immediately involving the school's nurse or welfare officer. This cautious approach may indicate that often respondents struggled to disentangle the two conditions, and therefore took more conservative action.

*3.2.2.2. Responses.* In terms of the responses to heat exhaustion, we see that the common actions of teachers make sense because they suggest a focus on increased hydration along with trying to cool the individual down by moving to a cooler location, as well as the use of cold compresses and loosening/removing clothing as appropriate. They also reported monitoring pupils that they had observed as suffering from heat exhaustion. This is a sensible precaution because one of the indications that heat exhaustion has progressed to heat stroke (or was heat stroke from the start) is no improvement after 30 min of effort to cool down and rehydrate. While heat exhaustion itself may not be a pleasant experience as it is not immediately life threatening, school staff reported that they would contact first aiders, medical staff or call 111 (non-emergency medical services) for further assistance and direction. When asked about heat stroke there was in general a strengthening of the language used to describe what they would do (possibly influenced by the understanding that the word “stroke” signifies a worse condition than “exhaustion”). While many of the same measures were mentioned there was also a stronger focus on immediate and more rapid attempts to cool, as well as a much stronger focus on calling emergency services.

### *3.2.3. Precautionary behaviours & capacity perceptions*

The subject of precautionary behaviours was approached in two ways. The first was an open question asking the participants to state what they have done during a heatwave to investigate what they can recall in an unstructured manner. We then followed this up with two sets of questions asking participants if they have employed or intended to employ a predetermined set of behavioural and structural adaptation measures based upon recommendations from UKHSA to provide a more direct and quantitative comparison of actions and/or intentions.

When the respondents were asked the open question, we can organise their responses into thematic groups:

- **Uniform and dress code adjustments,** where respondents stated that they enabled a relaxation of the uniform rules so that pupils were able to wear lighter more breathable clothing. Several respondents also acknowledged that they relaxed their dress code, but they then felt less "professional looking" indicating a possible hesitation due to a desire that pupils are "presentable".
- **Hydration and cooling measures** where they more strongly encourage regular water breaks, refill their water bottles, and increased hydration during lessons as well as employing additional fans (sometimes at their own expense), trays of water to cool feet, as well as ice packs.
- **Classroom environment adjustments** such as open windows and doors, use fans to circulate air, with the aim of improving ventilation and air circulation. This was combined with closing blinds to reduce direct sunlight and cool classrooms. Several respondents noted that they had air conditioning, but their responses indicated that it was a relative rarity. Moreover, some respondents said that they encouraged use of sunscreen, hats, etc., with one stating that all pupils and staff must wear hats when outside as a school rule.
- **Timetable and activity modifications,** which involves limiting or modifying outdoor activities to limit exposure to the hottest temperatures, as well as adjusting lesson plans to reduce workload or physical activity or structured breaks to allow for pupils to drink water or create additional airflow and reduce the opportunity for pressure.

Figs. 2 and 3 show the results of the structured comparison of possible precautionary measures that the respondents could undertake. Fig. 2 focuses on building level adaptation measures, which we categorise further into groups of high, medium, and low cost measures (e.g., see Rözer et al. [68] or Bubeck et al. [69] for property level flood resilience measures as an example).

We categorise automated night ventilation, installing air conditioning systems, green roofs/walls, wall/roof insulation and having a cooling centre (a central air conditioned space that provides refuge from extreme heat) as high-cost measures. This is because these measures typically involve significant construction, installation, equipment investments or ongoing specialist maintenance costs. For medium-cost measures, we consider thermal insulation glazing or window protection films, greening school grounds, and unsealing sealed surfaces as they are less complex than the measures presented in the high-cost group but are still based upon specialist installation or work. The remaining measures (use of fans, making sure windows have blinds/curtains to block sunlight, making sure there are shady areas) are low-cost.

Excluding the "don't know" options, the high-cost measures have an implementation rate of between 2% and 43% where the respondents believed it possible to implement, with known plans to implement them ranging at 0-4%. The most implemented measure of wall and roof insulation stands at about 43% of all respondents where it was deemed possible, followed by having air conditioning and a cooling centre. However, in all cases the respondents are either unaware of such measures or know that their school does not have them. Across all measures (once "don't know" and "would not be possible" are excluded) the rate of implementation on average across measures is about 19% of respondents, with an average planned to implement rate of 3% and about 78% for non-implementation

Excluding the "don't know" options, the medium-cost measures have an implementation rate of between 0% and 40% where the respondents believed it possible to implement, with known plans to implement them ranging at 1-11%. The most implemented measure is greening the school grounds at 41%, followed by thermal glazing switch (25% of all respondents deemed it possible), followed by having air conditioning and a cooling centre. However, in all cases the respondents are either unaware of such measures or know that their school does not have them. Across all measures (once "don't know" and "would not be possible" are excluded) the rate of implementation on average across measures is about 22% of respondents, with an average planned to implement rate of 6% and about 72% for non-implementation.

Excluding the "don't know" options, the low-cost measures have an implementation rate of between 50% and 71% where the respondents believed it possible to implement, with known plans to implement them ranging at 5-10%. The most implemented measure is the use of simply closing blinds/curtains at 71%, providing shady areas at 61% and fans at 50% of all respondents where it was deemed possible. However, in all cases the respondents are either unaware of such measures or know that their school does not have them. Across all measures (once "don't know" and "would not be possible" are excluded) the rate of implementation on average across measures is about 61% of respondents, with an average planned to implement rate of 7% and 32% for non-implementation.

Fig. 3 shows the precautionary measures that can be considered as behavioural in nature. The implementation rate was higher than for building level measures. The rate at which these measures were deemed as not possible to implement ranges up to 41% with an average across all measures considered of 9%. This overall is, unsurprisingly, far lower than implementing structural measures in their schools. The measures within the timetable adjustment category are the two measures that go against this trend as they report values of 21% and 41% for not being possible to implement, which is in line with the values presented for building-related precautions. This is likely because of the disruption that this would create, if we refer to the common impacts that teachers identified as a concern.

If we consider the rate of implementation, behavioural activities are in a narrow range ranging from 49 to 57% (with timetable adjustments being the outlier at 18%) once we exclude the responses for whom it is not considered as possible to implement (though the gap is larger if included). In terms of responses who have not knowingly implemented a measure but consider that they would implement it, we again see a narrow band of 30%. Timetable adjustments see 25% of respondents report that they would do it and deem it possible to do so. Those who have not done one of these measures, nor will not, range between 10% and 56% on average across categories.

The high rates of both implementation and willingness to continue or adopt measures such as closing curtains/blinds, drinking plenty of fluids, and maintaining access to water indicate a recognition of their perceived effectiveness and practicality among school staff. These measures, it can be argued, are relatively easy to implement and provide immediate relief from heat.

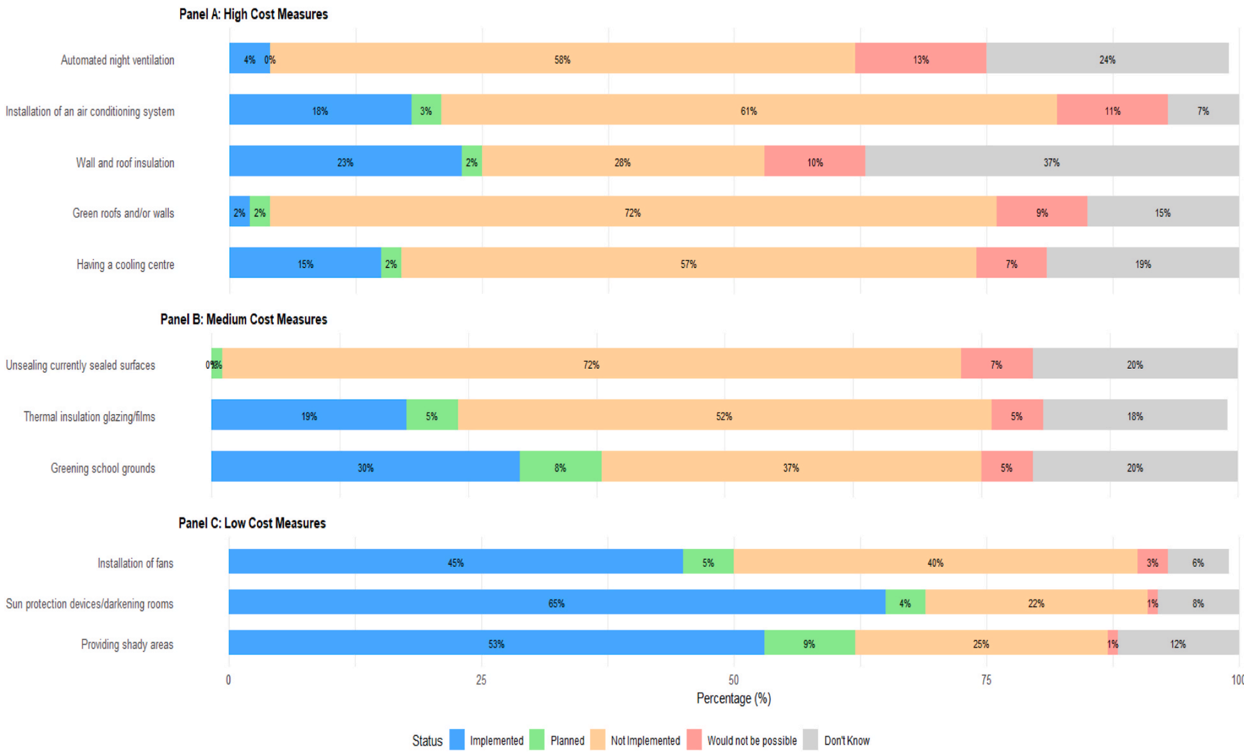


**Fig. 2.** Summary of building level precautionary measures.

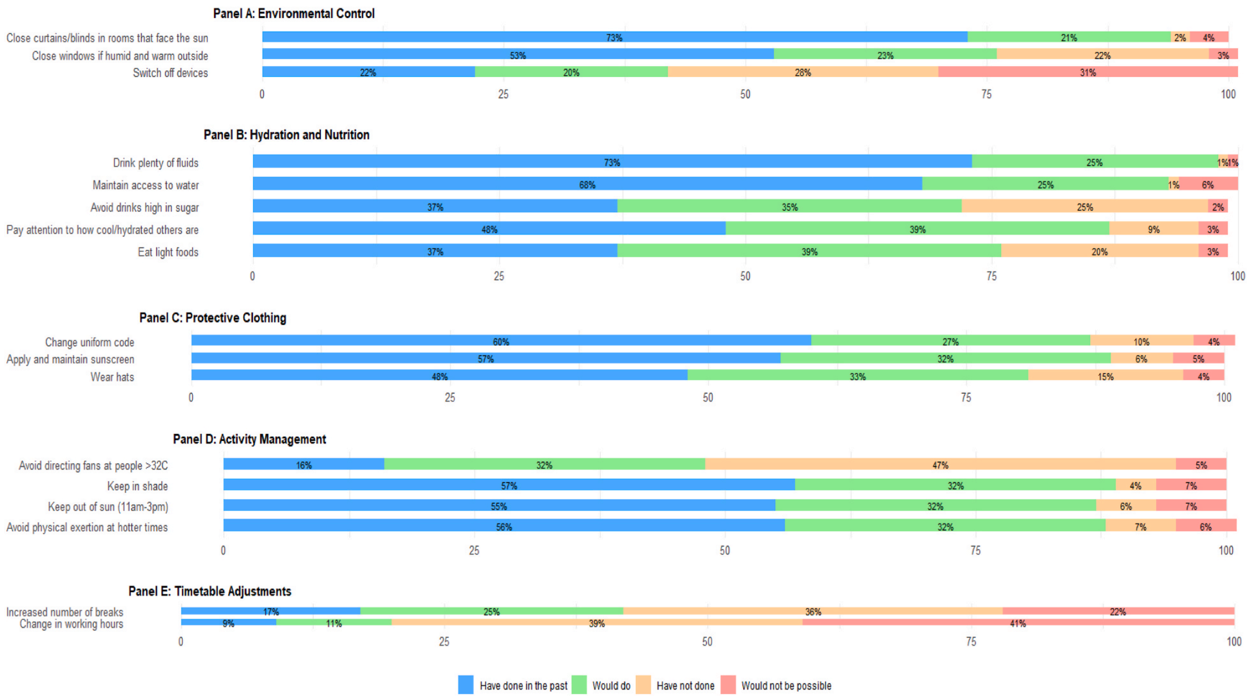


**Fig. 3.** Summary of behavioural precautionary measures.

Measures such as changing uniform rules, wearing hats, and applying sunscreen show moderate levels of implementation and future willingness to implement. This suggests an understanding of their importance but possibly some barriers related to school policies, or the necessity of creating new habits among pupils and staff. These measures, although slightly more complex than those with higher rates, are still considered feasible and beneficial.

The low implementation and perceived feasibility of measures like switching off devices, changing working hours, and increasing breaks highlight significant challenges. These measures likely face institutional and logistical barriers, such as rigid school schedules, inflexible lesson planning, technological dependencies, and the need for uninterrupted instructional time. The fact that a substantial proportion of respondents deem these measures not possible points to structural constraints that need addressing for successful implementation or even their suitability in the context of schools. This can also be seen when comparing the results of "How well prepared to deal with the consequences of a heatwave in your school do you feel?" and "How well prepared to deal with the consequences of a heatwave outside of your school do you feel?" There is a clear shift away from "not well at all" prepared towards a higher level of preparedness confidence (though only with a marginal change in the "extremely well" prepared category). Therefore, it seems that the staff overall seem to feel much more able to deal with the consequences of a heatwave outside of school rather than inside of school.

When asked if the respondents felt that there is nothing that they could do against heat stress and the damage it causes, see Fig. 4, only 20% of the sample agreed with the statement (N = 177). When asked "I try not to focus on how heatwaves might negatively affect me" 44% agreed with this statement (N = 195). When asked "It will not get as unbearably hot as it was in the summer of 2022" only 6% (N = 195) agreed with the statement. When asked "Heat is just one problem among many and simply not a priority for me or my school" only 31% of the sample agreed, 38% stated that they neither agree nor disagree. (N = 194).

The results shown in Fig. 5 would indicate that there is a degree of belief that measures that a school can employ *do* work (67% agree somewhat or strongly), there is a slight tendency towards an overall belief that the staff can implement the measures (50% of the sample agree somewhat or strongly), but also that it is too difficult in terms of costs (48% agree with the statement somewhat or strongly). However, 32% strongly or somewhat disagree with the statement as well. It appears that the staff believe that they can act but lack the resources to do so.

### 3.2.4. *Action plans & alert systems*

When asked if the respondent was aware that their school had an action plan or procedure to deal with the consequences of a heatwave (n = 186), only 12% of respondents said "yes", while 37% said "no", but 51% stated that they "Don't know". Effectively not knowing is the same as "no", as if you do not know if there is a plan then there is effectively no plan. This can indicate many schools do not have a plan, meaning that any response will be more ad-hoc and dependent on more general advice rather than suggestions tailored to the specific needs and contexts of the school.

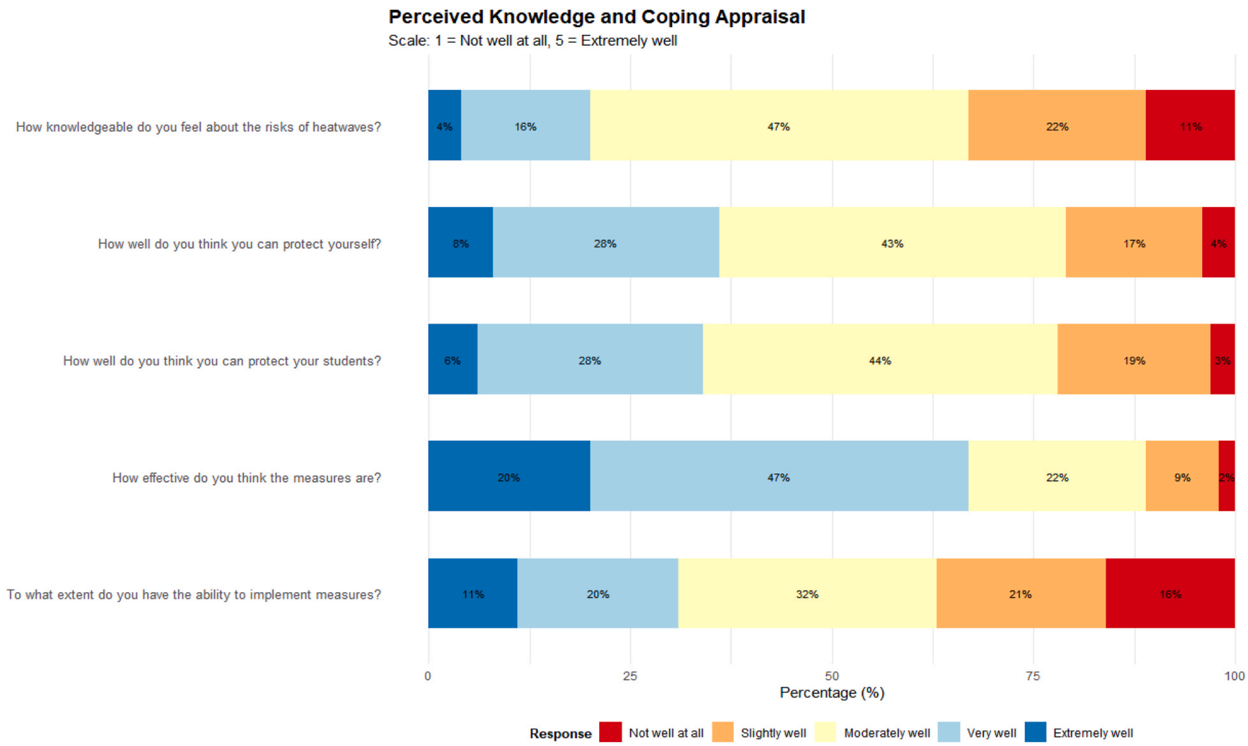


**Fig. 4.** Summary of knowledge and preparedness appraisals.

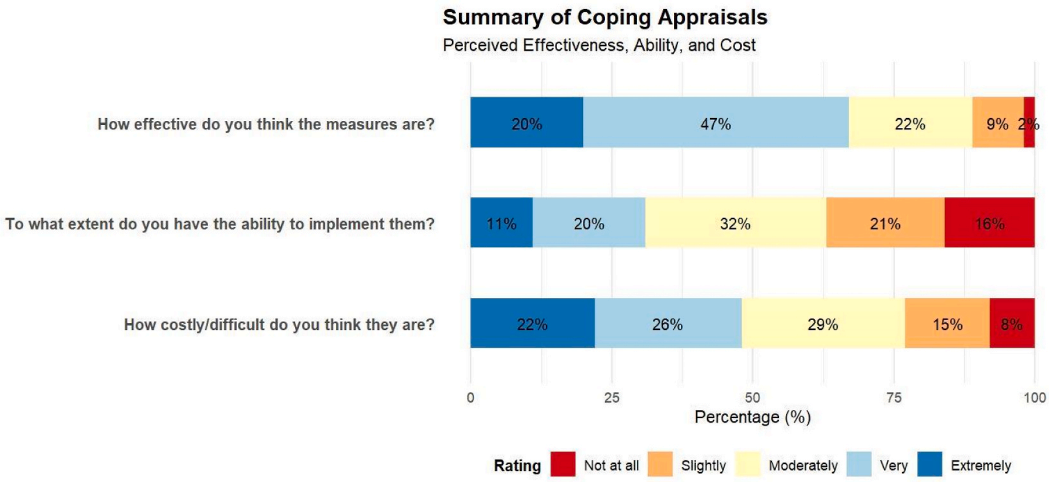


**Fig. 5.** Summary of coping appraisals.

The ~20 respondents that were aware of their school's heat plan were roughly equally split between those who do not know if the plan is reviewed and updated regularly (mainly teaching staff) and those who state that such a review happens annually (mainly those in leadership positions). Furthermore, 43% of these respondents did not know if it was based on any guidelines or scientific evidence. About 25% reported that it was designed based on feedback from other schools, and 25% from government guidelines. The remainder stated it was not based on guidance. The plan was designed mostly by the school leadership team (57%), or in consultation with the governors (24%), or as part of an all-staff consultation (19%).

For the majority who did not know if their school had an action plan, but if a plan were to be created, about 70% would like it to be reviewed annually. This makes sense given the variability in the school population. About 90% would like the plan to be based upon clear government guidelines rather than the experience of other schools or medical professionals. There was a consensus that the plan's development should be comprehensive across all levels of staff and pupils.

Only 26% of respondents are aware of a warning being issued in the last year ($n = 179$). The most common sources of warning were the BBC, the Met office and Local governments. Only 11% recalled receiving a warning in the last year, of which 60% did not find it particularly informative. From $n = 175$, the respondents felt that the messages should include information on possible recommended actions (27%), expected duration (30%), and signs/symptoms to watch out for (10%).

### *3.3. Differences in perceptions between school staff and school leadership*

In this section we present the results of the inferential statistics exploring if and how perceptions differ across the different roles within a school. We limit our analysis to the questions that were most frequently answered and compare responses between job roles that can be considered as school leadership roles and wider school staff. This comparison was selected from the narrative in the open comments left by school staff of discontent between teaching staff and their perceptions of their senior leadership teams. Therefore, we explored the differences between the results presented in table A3-A5 to see if the results differed significantly between school leadership and the remainder of the staff through a series of t-tests and Mann-Whitney tests. While the school's leadership teams might represent about 10% of the sample, collectively it is still a small sample from which to judge statistically significant differences. Therefore, the statistical tests are likely only to be able to detect relatively large differences.

It is relatively unsurprising that for most of the topics covered there are no statistically significant differences between the groups, assuming teaching staff are the baseline group. However, there are statistically significant differences (using the 10% level of significance to account for the small sample size) regarding "Perceived impact personally [$n = 196$], $t = -0.78$, $p = 0.06$"[2] and "How well prepared to deal with the consequences of a heatwave in your school do you feel? [$n = 196$], $t = 0.74$, $p = 0.001$".[3] Therefore, it appears that school management feel significantly better prepared and confident with what to do during a heatwave as compared to the teaching staff, as when tested by a Mann-Whitney test it reports a z score of 2.91 and a p value of 0.004.

This highlights the potential institutional complexity of climate change adaptation in disaster risk management in schools as different levels in the school hierarchy perceive both the threat and their capacity to act differently, and the need to communicate risk management plans with all staff in the institution.

[2] The mean value for non-leadership respondents is 3.84, while for leadership respondents the mean was 3.05.

[3] The mean value of the question for non-leadership respondents is 1.6, while for school leadership it is 2.33.

## 4. Discussion

### 4.1. Research implications for schools

In terms of the relative perceived prevalence of behavioural versus building-level adaptation measures implemented in UK schools, we see a larger relative focus on behavioural measures as compared to structural measures. This may reflect that the behavioural measures are mostly cheaper and easier to implement and relatively more within the remit of their authority as teaching staff. However, there is still a recognition of the features of their built environment that aid in the management of high temperatures.

The more substantive implications arise in respect to our first research question on the extent to which UK school staff perceive extreme heat risk as a priority, and as a threat within a school context. While the overall level of preparedness and adaptation in schools can be considered low, we do see a recognition of a range of adaptive behaviours and, less often, structural measures which school staff on the whole believe can be successful (i.e., a strong response efficacy, on top of the high risk perception) but we see a substantial number of respondents embracing maladaptive thinking processes (e.g., avoidance in “I try not to think of heatwaves”) because they see themselves (or their schools) with limited capacity to act (i.e., a low coping appraisal). Maladaptive thinking occurs because of this observed mismatch between a high threat appraisal and low coping appraisal [70]. Maladaptive thinking is a psychological coping mechanism that rationalises the lack of adaptive actions undertaken by the actor. In a manner of speaking, the observation that a significant proportion of respondents engaged in maladaptive thinking processes could be explained by the mismatch in authority and capacity to act between the school staff and school management (i.e., teachers do not feel empowered to undertake behavioural adaptation measures and are unable to input into decisions on structural adaptation measures). School management on the other hand, face a multitude of competing budgetary pressures within a recent period of high cost inflation and governmental budget cuts, for example with a fall in spending per pupil in England over the years 2009/10 to 2019/20 [71]. Moreover, while the NAO [49] has reported declining conditions as a significant number of schools that need major rebuilding or refurbishment, this offers an opportunity to climate proof these buildings for the future weather of the UK by integrating these design concerns into the rebuilding/refurbishment process.

Responding to these combined pressures might make it difficult for schools to successfully implement heat adaptation measures. However, the divergence may occur in part because of gaps in communication across different levels of staff for what are currently low frequency events. We can observe this because less than 10% of staff were aware of a heat action plan in their school, while less than a third were aware of any heat warning. Attempting to address this communication gap by encouraging the systematic development of action plans involving the heat warning alert system could be a way of starting to bridge this gap. This is especially relevant as Dunlop et al. [72] identify that in schools in areas exposed to >40C temperatures during the 2022 heatwave only 85 schools had (publicly available) policies addressing extreme weather, of which only 23 had reference to extreme heat, 17 had reference to heat as a health and safety concern, but only 2 had policy documentation indicating tangible risk management actions.

A predetermined action plan is a suitable starting point, either at the level of individual schools or more broadly, because research has shown that high risk perception will not necessarily lead to risk mitigation behaviours [73] without actionable knowledge that individuals believe they can perform. The development of a suitable plan can act as a decision-support tool whereby schools are forced to learn about their risks and what they can do about it and how they can communicate this knowledge back and forth to their staff, pupils and parents and carers. This creates a learning environment for self-governance, examples of which can be seen in Okada [74]. However, it must be noted that understanding this threat is likely outside of the regular capacity of school managers and what they are familiar with assessing. A potential method of correcting this would be the provision of a structured template to guide school leadership through the process of developing the action plan after assessing their vulnerabilities, in collaboration with school staff, and with associated professional development from a trusted organisation to support schools to identify the most effective actions they can take in their own environments. Engaging with a decision-support tool can bring a range of benefits, an additional benefit is that given the large number of schools and wide variety of lived experiences a relatively standardised template with suitable guidance and guidelines can widely be shared between schools, education authorities and unions. However, we must be careful of promoting school staff to be aware of the range of problems they face without building the wider capacity to act.

Drawing on a review of literature, McLoughlin et al. [75] identify a number of characteristics to facilitate adaptive responses to heat. These include: ensuring messages are research informed, tailoring and targeting of the message, focusing on those in positions of authority, communicating the personal threat of impacts, include solutions, appeal to action, and highlight social norms, identifying perceived benefits of action, appealing to a sense of self-efficacy, attribution to and concern about climate change and the use of images that communicate the risk rather than happy images. Warning systems of this nature, alongside research in the effectiveness of risk management actions used by schools, are needed to create a greater understanding of how best to mitigate the effects of extreme heat in schools. Integrating this sort of informational exercise into a school's risk assessment process could bring additional benefits towards other extreme weather conditions where early warning or alert systems are in place.

When considering what adaptive measures and strategies schools implement, an additional consideration must be given to their relative effectiveness. While the results of this study indicate that school staff perceive the measures to be effective, we could not study their objective effectiveness. While the effectiveness will be difficult to establish due to the problems of establishing a suitable counterfactual, it can be expected that structural and behavioural measures will impact the comfort of both staff and pupils to different extents. For example, Dawkins et al. [19] indicate that classrooms could overheat for significant portions of the academic year depending on the degree of climate change. Therefore, under these conditions the more ‘passive’ structural measures may be able to more successfully manage the impact of overheating on educational outcomes (see, e.g., Ref. [76]) by reducing the risk (similar to how a levee reduces flood risk) as compared to the behavioural measures aiming to mitigate the extent of impacts by reducing discomfort during the experience. Though this consideration also clashes with the extent of the legacy build estate of the educational sector combined with a UK trend of reduced real terms expenditure [77] the extent to which these measures can be implemented is questionable. Therefore, the behavioural measures may represent a set of 'second best' actions that while not the most optimal response at least mitigate the full extent of the problem until wider resources can be made available for large scale retrofit and redesign (with the potential for further disruption to education). Moreover, shifting the relative focus to behavioural measures, with a supplementary focus on structural measures, can allow for schools to adapt their risk management strategies towards their specific context and needs. For example, temperatures can vary across a building and this nuance requires specific knowledge of classrooms and the activities that take place within them. Therefore, overall risk management plans should be developed in conjunction with decision support tools that enable schools to act upon a set of principles rather than a check-list of actions.

### 4.2. Research implications for wider risk management

While the PMT and PADM models are frequently applied to individual household adaptations they are less often applied to hierarchical organisations and how the perceptions/capacities differ across the actors within the organisation. Our results suggest that the school environment introduces hierarchical constraints that alter the expected behavioural pathways, which may be like the internal workings of organisations such as businesses who will also have to adapt to changing patterns of heat.

The main way that our results indicate that the hierarchical nature of an organisation influences behaviour is through the prevalence of maladaptive thinking processes that we can infer from the answers of teaching staff. Therefore, we would argue that these results suggest that in organisational settings, self-efficacy must be conceptually expanded to include institutional efficacy or authorisation as an individual's knowledge of what should be done is insufficient if they lack the organisational agency to enact it. Within the PADM model this can be considered as a failure of informational cues indicating the increased complexity and potential breakdown occurring within the early stages of the PADM thinking process. The main organisational cue that could aid this would be formal heat action plans which are largely absent or invisible to staff.

Overall, the observed 'preparedness gap' not only occurs because of negative contextual factors (e.g., lack of resources) but for the potential cognitive process for protective action becoming inhibited because of clashes in where and how action is authorised and permitted. Therefore, currently we could infer that the transition from risk perception to protective action is implemented on relatively ad-hoc individual initiative, which is highly variable and less effective than coordinated action. While coordination on building level infrastructure will be beyond the capacity of teaching staff to collaborate on, there will be more room for collaboration on the behavioural interventions to align the perspectives of all staff groups within a school by engaging in a joint 'sensemaking' endeavour. However, until then we argue that we should not treat 'school' as a unitary actor in climate risk management as the relevant appraisals may be stratified across roles and future modelling work and studies must account for this potential intra-organisational dissonance, where the decision-makers and the implementers operate within different risk realities.

### 4.3. Research limitations

The research conducted employed an approach that was valid for its overall objective of establishing a baseline stocktake. However, there are caveats to the sampling and analysis. The first is the potential influence of self-selection into the voluntary participation of the survey. This may result in an upward bias of the risk perceptions of staff members and their overall degree of concern as identified in this study. Similarly, staff perceptions of heatwave experiences may be influenced by availability bias, where responses are likely to be weighted towards the most recent and memorable experiences (e.g., the 2024, 2023, or 2022 heatwaves). However, the significance of this caveat is also limited by observing that the UK overall has a limited perception of heat risk that is only slowly changing [78] as temperature extremes start to become more common. Therefore, while we do not know if the responses gathered are representative of schools in the UK, it at least shows this increasing recognition is present within a grouping of the staff that can pressure for the changes that they feel they can implement but are inhibited from implementing. However, it must be noted that the sample over-represents England compared to the UK as information from BESA [79] indicates that roughly 70% of all schools in the UK are in England while our sample is 90% English, 3% Scottish versus an estimated 23%, 4% Welsh compared to an estimated 4%, and 1% Northern Irish compared to an estimated 3%. Therefore, the extent to which we can generalise to the whole of the UK is limited, but the research objective of this paper was to help establish a baseline of information that provides directions for future policy and research.

A second perceived limitation can be the use of self-stated behaviour and questionnaires rather than through observed behaviour. This perceived limitation is a known problem that can lead to behaviour intention gaps (i.e., people state specific intentions but do not actually follow up) as well as measurement error through people selecting responses to send a specific message rather than a response that reflects their actual behaviour and perceptions. While this clash does lead to potential measurement error and inaccuracy that must be acknowledged, the implicit suitability of survey based research to explore risk perceptions and adaptive behaviour is well trod ground. However, there is a possible interaction between this and the observed stocktake as individual respondents may be misremembering or misattributing specific actions to heat specific adaptations.

A third potential limitation is that the sample composition, and similarly sample size, was limited. This in turn prevented a deep analysis of different perceptions of stakeholders within a school and how these differences add to the complexity of school level action. Understanding differences across stakeholders is important not only because of differing degrees of experience with the threat posed by heatwaves but with respect to how their capacity to act creates different incentives for action. The interaction of these incentives will result in different adaptation strategies being prioritised compared to other activities that schools need to undertake. The interaction between the various actors within a school will be an important consideration for the development of school level climate action plans, and as such is a viable area of future research whereby we look at how the relationships within an organisation of differing power levels and capacities to act need to be brought into consensus rather than assuming a school is a singular entity. A related limitation was the restriction of inferential statistics to that of t-tests and similar inferential statistical tests that explore differences in the mean of two groups or the shape of their distribution. This narrower focus was done in part because of the sample composition and size, but also based on the observation that more complex inferential statistics were not required because of our focus on determining an initial baseline of research for the UK that later studies can advance upon. Similarly, as the focus of the paper was on the perceptions, actions, and beliefs of school staff we did not consider the wider influence that devolution may have on the capacity of schools to act. Therefore, there is scope for future research to address this difference.

## 5. Conclusion

Due to anthropogenic sources, we are seeing an overall increase in average global temperatures, which in turns leads to worsening temperature extremes. We are seeing this manifest through increasingly frequent and worse heatwaves. In countries such as the UK where the traditional extreme temperature threat was the winter cold, a lengthening and worsening summer heatwave period poses an increasing threat to schools in the UK and beyond. The impacts of heatwaves can be manifold on health and educational outcomes, which in turn can have long term implications. Therefore, more proactive and strategic adaptation is required.

We find that UK school staff have an overall high level of risk perception (with an acknowledgment that this may be driven by sample selection issues). However, this has apparently not been translated into higher levels of adaptation because most of the identified building level precautionary measures were not implemented, and while behavioural measures were implemented by teachers, we saw a reliance on measures that could be considered within a classroom teacher's sphere of influence. This in turn is complicated by the observation that school staff recognise the perceived benefits of proactive adaptation, however, they do not perceive themselves to have the self-efficacy required to implement these measures. The lack of self-efficacy could be explained by the observation that schools overall do not have a plan nor are aware of warning communication channels. This can lead to maladaptive thinking. Therefore, the first step in adapting UK schools to changing patterns of extreme heat is to reduce the presence of maladaptive thinking and develop effective plans for responding to extreme heat. Micro-climates and urban heat islands can mean that extreme temperatures can be unevenly distributed within schools, and may be quite different to the outdoor air temperature. A first step in developing a heat action is to determine how heat is distributed in schools and proactively decide what protocols should come into play in the event of extreme heat. Developing a plan and protocol surrounding heat warnings, as a low-cost action within the authority and budgetary bounds of schools, would be a way of addressing the mismatch between threat and coping appraisals that inhibits future action. While this would be an additional burden on school leadership teams, a gathering of information by teaching unions or the Department for Education would reduce this hurdle by providing a template of points and actions to consider and identify a starting point for an integrated adaptation strategy.

Unless we proactively present and understand the current basis of this growing threat in a ‘colder’ country, the academic literature will struggle to guide the development of policy-responses drawn from an understanding of its own place-based context, rather than being reliant on results from ‘warmer’ countries which may not transfer successfully. Therefore, we would argue that it is important to have research such as this to provide legitimacy and pave the way for future research and policy action deeper into the emergent threat.

## CRediT authorship contribution statement

**Paul Hudson:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **Lynda Dunlop:** Writing – review & editing, Writing – original draft, Investigation, Data curation, Conceptualization. **Maria Turkenburg-van Diepen:** Writing – review & editing, Writing – original draft, Data curation.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix. Figure data tables

**Table A1**
Summary of Heatwave risk perceptions & perceived impacts (Fig. 1)

| | Perceived probability of experiencing a heatwave in the next three months (July to October) [n = 197] |
|---|---|
| Extremely likely | 21% |

(continued on next page)

**Table A1** (*continued*)

| | Perceived probability of experiencing a heatwave in the next three months (July to October) [n = 197] | |
|---|---|---|
| Somewhat likely | 44% | |
| Neither likely nor unlikely | 12% | |
| Somewhat unlikely | 16% | |
| Extremely unlikely | 8% | |
| | Perceived impact personally [n = 196] | Perceived impact on pupils [n = 197] |
| Very positively | | 0.5% |
| Somewhat positively | 5% | 5% |
| Neither positive nor negative | 16% | 3% |
| Somewhat negative | 46% | 38% |
| Extremely negative | 32% | 56% |

**Table A2**
Summary of building level precautionary measures (Fig. 2)

| | Implemented | Planned | Would not be possible | Not implemented | Don't know | N |
|---|---|---|---|---|---|---|
| High cost | | | | | | |
| Automated night ventilation | 7 (4%) | 0 (0%) | 24 (13%) | 104 (58%) | 43 (24%) | 178 |
| Installation of an air conditioning system | 32 (18%) | 6 (3%) | 19 (11%) | 109 (61%) | 12 (7%) | 178 |
| Wall and roof insulation | 41 (23%) | 4 (2%) | 17 (10%) | 50 (28%) | 66 (37%) | 178 |
| Green roofs and/or walls | 3 (2%) | 4 (2%) | 16 (9%) | 128 (72%) | 26 (15%) | 177 |
| Having a cooling centre | 26 (15%) | 4 (2%) | 12 (7%) | 100 (57%) | 34 (19%) | 176 |
| Medium cost | | | | | | |
| Unsealing currently sealed surfaces | 0 (0%) | 1 (1%) | 13 (7%) | 127 (72%) | 36 (20%) | 177 |
| Thermal insulation glazing or window protection films | 34 (19%) | 9 (5%) | 9 (5%) | 92 (52%) | 32 (18%) | 176 |
| Greening school grounds | 54 (30%) | 15 (8%) | 9 (5%) | 65 (37%) | 35 (20%) | 178 |
| Low cost | | | | | | |
| Installation of fans | 80 (45%) | 9 (5%) | 5 (3%) | 71 (40%) | 11 (6%) | 176 |
| Sun protection devices/darkening rooms | 117 (65%) | 8 (4%) | 1 (1%) | 39 (22%) | 14 (8%) | 179 |
| Providing shady areas | 95 (53%) | 16 (9%) | 2 (1%) | 44 (25%) | 22 (12%) | 179 |

Notes: The potential measurement error in the “planned” category for structural measures as many of the respondents would not be in place to make the decision on whether to implement them or not vs. being aware that the school had already planned such an intervention. The displayed percentages may not sum to 100% due to rounding.

**Table A3**
Summary of behavioural precautionary measures (Fig. 3)

| | Have done in the past | Would do | Have not done | Would not be possible | N |
|---|---|---|---|---|---|
| Environmental control | | | | | |
| Close curtains/blinds in rooms that face the sun | 132 (73%) | 38 (21%) | 3 (2%) | 7 (4%) | 180 |
| Close windows if humid and warm outside | 95 (53%) | 41 (23%) | 39 (22%) | 5 (3%) | 180 |
| Switch off devices | 39 (22%) | 35 (20%) | 49 (28%) | 54 (31%) | 177 |
| Hydration and nutrition | | | | | |
| Drink plenty of fluids | 132 (73%) | 46 (25%) | 1 (1%) | 1 (1%) | 180 |
| Maintain access to water | 122 (68%) | 45 (25%) | 2 (1%) | 10 (6%) | 179 |
| Avoid drinks high in sugar | 66 (37%) | 62 (35%) | 45 (25%) | 4 (2%) | 177 |
| Pay attention to how cool and hydrated others are | 87 (48%) | 71 (39%) | 17 (9%) | 5 (3%) | 180 |
| Eat light foods | 66 (37%) | 70 (39%) | 36 (20%) | 6 (3%) | 178 |
| Protective clothing | | | | | |
| Change uniform code | 106 (60%) | 48 (27%) | 17 (10%) | 7 (4%) | 178 |
| Apply and maintain sunscreen | 103 (57%) | 58 (32%) | 10 (6%) | 9 (5%) | 180 |
| Wear hats | 85 (48%) | 59 (33%) | 26 (15%) | 7 (4%) | 177 |
| Activity management | | | | | |
| Avoid directing fans at people when hotter than 32 °C | 29 (16%) | 56 (32%) | 84 (47%) | 8 (5%) | 177 |
| Keep in shade | 102 (47%) | 57 (32%) | 8 (4%) | 13 (7%) | 180 |
| Keep out of sun (11am-3pm) | 98 (55%) | 58 (32%) | 10 (6%) | 13 (7%) | 179 |
| Avoid physical exertion at hotter times of day | 101 (56%) | 57 (32%) | 12 (7%) | 10 (6%) | 180 |
| Timetable adjustments | | | | | |
| Increased number of breaks | 30 (17%) | 44 (25%) | 65 (36%) | 40 (22%) | 179 |
| Change in working hours | 16 (9%) | 20 (11%) | 70 (39%) | 73 (41%) | 179 |

Notes: The displayed percentages may not sum to 100% due to rounding.

**Table A4**
Summary of knowledge and preparedness appraisals (Fig. 4)

(continued on next page)

**Table A4** (*continued*)

| | How well prepared to deal with the consequences of a heatwave in your school do you feel? (1 = Not well at all, 5 = Extremely well) | How well prepared to deal with the consequences of a heatwave outside of your school do you feel? (1 = Not well at all, 5 = Extremely well) | How well informed do you feel about heat adaptation in general? (1 = Not well at all, 5 = Extremely well) | How well would you rate your knowledge of what to do to prevent the negative impacts of extreme heat during a heatwave? (1 = not knowledgeable at all, 5 = Extremely knowledgeable) |
|---|---|---|---|---|
| | How well prepared to deal with the consequences of a heatwave in your school do you feel? (1 = Not well at all, 5 = Extremely well) | How well prepared to deal with the consequences of a heatwave outside of your school do you feel? (1 = Not well at all, 5 = Extremely well) | How well informed do you feel about heat adaptation in general? (1 = Not well at all, 5 = Extremely well) | How well would you rate your knowledge of what to do to prevent the negative impacts of extreme heat during a heatwave? (1 = not knowledgeable at all, 5 = Extremely knowledgeable) |
| 1 | 58% | 14% | 26% | 6% |
| 2 | 24% | 30% | 28% | 36% |
| 3 | 13% | 39% | 33% | 43% |
| 4 | 4% | 13% | 11% | 13% |
| 5 | 2% | 3% | 2% | 3% |
| N | 194 | 195 | 194 | 195 |

**Table A5**
Summary of coping appraisals (Fig. 5)

| | There are things that I can do to significantly reduce the negative impacts of heat stress. | I feel able to implement individual adaptation measures for myself and my pupils in my current school environment. | Individual adaptation is too difficult in terms of, e.g., money, time, effort etc. |
|---|---|---|---|
| Strongly Agree | 13% | 6% | 15% |
| Somewhat Agree | 54% | 44% | 33% |
| Neither agree or disagree | 14% | 12% | 21% |
| Somewhat disagree | 13% | 25% | 26% |
| Strongly disagree | 6% | 13% | 6% |
| N | 180 | 180 | 180 |

## Data availability

Data will be made available on request.

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