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Prevalence of occupational heat stress across the seasons and its management amongst healthcare professionals in the UK

S.L. Davey [a,*], B.J. Lee [a], Timothy Robbins [b,c], C.D. Thake [a]

[a] Occupational and Environmental Physiology Group, Centre for Physical Activity, Sport & Exercise Sciences, Research Institute for Health and Wellbeing, Coventry University, Coventry, UK
[b] University Hospitals Coventry & Warwickshire NHS Trust, Coventry, UK
[c] Institute of Digital Healthcare, WMG, University of Warwick, Coventry, UK

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ABSTRACT

Occupational heat stress (OHS) is an issue in healthcare facilities (HCFs) in the United Kingdom (UK). The aims of this study were to evaluate perceived levels of OHS during two seasons and its perceived consequences on healthcare professionals (HCPs) and to assess the efficacy of heat stress management (HSM) policies. An anonymous online survey was distributed to HCPs working in HCFs in the UK. The survey returned 1014 responses (87% women). Descriptive statistics and content analysis of survey data identified that OHS in HCFs is frequently experienced throughout the year and concerned most HCPs. Over 90% perceived OHS impairs their performance and 20% reported heat-related absenteeism. Awareness of HSM policies was poor and 73% deemed them not adequate. To help reduce the financial loss and impact on staff performance, health and well-being and patient safety, it is recommended that revisions and widespread dissemination of HSM policies are made.

1. Introduction

The thermal environment (temperature, relative humidity [RH], radiant heat) and ventilation are key elements of indoor environment quality and can have a direct impact on occupants' health and well-being and productivity (including absenteeism) (Xiang et al., 2015; Zander et al., 2015). Indoor environment quality is therefore an important factor to consider when designing and managing healthcare facilities (HCFs) (Lan et al., 2011; Wyon and Wargocki, 2013). Evidence based guidelines (e.g., ASHRAE 170:2017 (ASHRAE-170, 2017); British Standards EN 16798–1:2019 (BSI, 2019)) have been developed to provide thermal environments that are conducive for: (1) patient comfort; (2) patient well-being; (3) patient satisfaction with care; (4) enhancing patient recovery; and (5) decreasing the spread of certain infections (Eijkelenboom and Bluyssen, 2019; Shajahan et al., 2019; Tang et al., 2006). These recommendations may be suitable for patient comfort and well-being, but not always for healthcare professionals (HCPs) (Eijkelenboom and Bluyssen, 2019; Hashiguchi et al., 2005; Van Gaever et al., 2014). Additionally, most thermal comfort studies in HCFs have focused on patients' thermal comfort, with fewer studies considering the perceptions of HCPs (Eijkelenboom and Bluyssen, 2019).

Whilst patients are generally sedentary, HCPs are mostly considered healthy, have a higher metabolic rate and wear clothing of differing thermal properties; all of which may impact the level of heat stress and thermal comfort that HCPs' experience. Consequently, HCPs have been demonstrated to experience thermal discomfort within the workplace (Derks et al., 2018; Hashiguchi et al., 2005; Jankowski and Młynarczyk, 2016; Khodakarami and Knight, 2008; Van Gaever et al., 2014), especially in cases of overheating in HCFs (Derks et al., 2018; Jain et al., 2021) and when personal protective equipment (PPE) is worn (Davey et al., 2021; Melhado et al., 2006; Messeri et al., 2021). This is of concern as thermal discomfort has been associated with sick building syndrome (Smajlović et al., 2019), impaired cognition (Gaoua et al., 2012) and reduced work productivity and/or performance (Flouris et al., 2018; Kjellstrom et al., 2009).

During 2021–2022, ~45% of National Health Service (NHS) hospital trusts reported at least one incident of overheating (defined as room temperatures exceeding 26 °C), and 5% of trusts reported over 50 incidents with one trust reporting over 690 incidents (NHS Digital, 2022). This figure has been estimated to rise as global temperatures and incidences of heat waves increase (Gupta and Du, 2013). The SARS-CoV-2 virus (i.e. COVID-19) pandemic led to an increased usage of PPE across multiple roles within the NHS, which, due to PPE limiting the ability to

* Corresponding author. Centre for Physical Activity, Sport & Exercise Sciences, Occupational and Environmental Physiology Group, Coventry University Priory Street, Coventry, CV1 5FB, UK.
E-mail address: ad4782@coventry.ac.uk (S.L. Davey).

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Abbreviations

HCP – Healthcare professional
HCF – Healthcare facility
HVAC – Heating, ventilation, and air conditioning
HSM - Heat stress management
NHS – National Health Service
NIOSH – National Institute for Occupational Safety and Health
OHS – Occupational heat stress
PHE – Public Heath England
PPE – Personal protective equipment
RH – Relative humidity
WBGT – Wet bulb globe temperature

dissipate heat, can further increase the level of heat stress experienced by HCPs (Davey et al., 2021; McLellan et al., 2013). It is well established that wearing PPE can compromise performance, physical capacity, and well-being of HCPs with potentially negative consequences for patients (Castle et al., 2010; Davey et al., 2021; Hignett et al., 2020).

In comparison to other occupations, established international guidelines to protect HCPs from heat stress especially when wearing PPE are limited (Bose-O'Reilly et al., 2021; Global Heat Health Information Network, 2020). In recent years NHS England has recognised heat stress as an issue within HCFs, and in response, has published guidelines for individual NHS hospital trusts to more effectively manage and mitigate heat stress (Leicestershire Partnership NHS Trust LPT). NHS employees are also referred to guidance produced by the NHS for the general public (NHS Direct, 2019). The increased requirement to wear PPE due to COVID-19 has also led to guidance being published by Public Health England (PHE) on managing heat stress when PPE is worn in health care settings (Public Health England PHE, 2020). Even though heat stress is being recognised as an issue within HCFs, there is limited evidence available on the incidence of heat stress experienced by HCPs within NHS HCFs (Davey et al., 2021; Jain et al., 2021) and, similarly, whether the policies and guidelines produced by the NHS for their employees are effective in mitigating heat stress within the workplace (Brooks et al., 2023).

Therefore, the aim of this study was to evaluate the prevalence of heat stress experienced in NHS HCFs and its effect on HCPs': (1) physical and cognitive performance; (2) health and well-being; and (3) absenteeism. As a seasonal effect has been recognised to occur within HCPs experience of thermal discomfort (Skoog et al., 2005), the effect of seasons (summer vs winter) alongside other individual factors such as age, ethnicity, sex, job-related role, wearing PPE, work pattern, medical conditions were also assessed. This study also aimed to assess the level of awareness and adherence to certain heat stress management policies/procedures produced and implemented within NHS trusts.

2. Methods

2.1. Questionnaire design and development

An online anonymous survey was constructed from a scoping review of current literature. Face validity and readability of the survey was tested by asking healthcare professionals (1 male, 2 female) to complete the survey with a member of the research team. Comprehension was checked by asking each volunteer to verbalise their thought process during the survey completion using a 'Think-Aloud' protocol (Fonteyn et al., 1993). Ethical approval for this work was obtained from the Coventry University Research Ethics Committee and NHS Health Authority (IRAS 315547). The survey was distributed to healthcare professionals by several participating NHS trusts (Supplementary material, S1) via newsletters, e-mails and news e-bulletins and also via social media (Twitter, LinkedIn) between 01st May and 31st August 2022.

2.2. Survey content

To meet the aims of the study, the survey contained 27 questions separated into 5 items: (1) consent (4 questions); (2) prevalence of heat stress and awareness of mitigation strategies within the workplace (15 questions); (3) demographic and employment information (9 questions); (4) relevant medical information (2 questions); (5) additional information (1 Question). Both quantitative (nominal and ordinal) and qualitative (open ended questions) were included in the survey. The survey was published on Qualtrics®XM. The survey is available as supplementary material (S2).

2.3. Sample size calculation

Based on a population size of 1,327,892, a confidence interval of 0.95, a precision of 0.01, and an estimated actual prevalence of 0.5, the sample size to estimate a simple proportion (i.e., scores to the questionnaire) a sample of 9604 would be required. Considering current NHS employment demographics, an approximately 75/25 percentage split between females and males was also required. Therefore, the total sample target would be composed of 7203 females and 2401 males.

2.4. Analysis

2.4.1. Statistical

Data values are presented as mean ± SD or percentage of respondents. As some of the questions were only displayed if specific conditions were met (e.g., if respondents has taken time off work due to symptoms of heat stress), the number of total responses for each question differed from the overall number of survey participants. To account for this variation, each question was analysed separately, and the number described the proportion of the cohort represented in each question. Relationships between the categorical measures of age and gender with items in the section of 'Prevalence of heat stress and awareness of mitigation strategies within the workplace' were assessed using the Pearson Chi Square test. Effect size was assessed using Cramer's V. Commonly used interpretations of Cramer's V is to refer to effect sizes as small (0.1–0.3), medium (0.3–0.5) and large (0.5–1.0) (Cohen, 1988). Multiple pairwise comparisons were conducted using the z statistic. A Bonferroni adjustment was completed for all multiple pairwise comparisons. All statistical procedures were performed using the Statistical Package for the Social Sciences 25.0 for Windows (SPSS Inc., Chicago, IL, USA) with the alpha level set at 0.05. Graphical data were produced using GraphPad Prism (GraphPad Prism version 9.0 for Windows, GraphPad Software, San Diego, California, USA).

2.4.2. Qualitative

The additional information (Item 5 and all questions where a free-text comment was included and optional) were analysed by one researcher using directed content analysis (Hsieh and Shannon, 2005). For each free-text question, the comments were analysed up to the point of code saturation (Hennick et al., 2017). Once meaning saturation had been reached, codes were assessed for shared meaning and collapsed into overarching themes. All outputs were reviewed independently by a second researcher and all concurring themes between researchers are presented.

3. Results

The initial response to the survey was 0.09% (n = 1203) of ~1,327,892 (NHS Digital, 2021) HCPs employed by the NHS in the UK. Consent was not provided by 189 respondents. A total of 1014 respondents' data were analysed (i.e. 0.08%) which is lower than the sample size necessary to represent the whole population of HCPs employed by the NHS. During the period the survey was open, the average UK monthly temperatures collected by local weather stations between May to August 2022 ranged between 11.8 and 16.7 °C and the maximum monthly temperatures ranged between 27.5 °C (~21.6 °C WBGT, 48% RH) and 40.3 °C (~28.3 °C WBGT, 20% RH) with August being the 5th warmest August in UK history. The average monthly temperature during the 'Winter' months, i.e. October 2021 to April 2022, were generally higher than the average temperature recorded over the period of 1991–2020 (i.e. 0.2–1.5 °C) and ranged between 4.7 and 10.9 °C with the maximal monthly temperatures ranging from 16.3 °C (~12.5 °C WBGT, 48% RH) to 23.4 °C (~18.34 °C WBGT, 47% RH) (Met office, 2022). Unfortunately, it was not possible to obtain measurements of the indoor thermal environments of participating NHS trusts. However, for reference, the majority of HCFs are required to comply with certain thermal parameters (i.e. 21°C–26 °C, 30–60% RH, air velocity: 0.24 m s^{-1} to 0.35 m s^{-1}) with the mean indoor temperature being dependent upon the function of the facility e.g. operating theatre vs. neonatal ward (ASHRAE 170:2017; British Standards EN 16798–1:2019). In addition, it has been demonstrated that the maximum indoor temperature of the required range can be exceeded during summer months (Derks et al., 2018; Gough et al., 2019).

3.1. Demographics

Full demographic data are provided in Supplementary Tables 1–6 (S3). Only a proportion of respondents (n = 861, 84.9%) provided information about their demographics, job and relevant medical information. Of the 861 respondents 87.1% were female. Ages were 30–39 years = 23.9%, 40–49 years = 20.8%, 50–59 years = 35.8%. There were more females in the 50–59 age category compared to males (38.0% vs. 20.2%, $p < 0.05$).

Most respondents were White English (76.0%) and worked in either nursing roles (Nursing Specialist, 14.6%, Staff Nurse, 13.0%) or administrative roles (13.1%). Consequently, most of the respondents worked in either a General Ward (22.1%) or an Office (25.9%). Nearly half of the respondents (46.3%) had worked for 2–5 years in their current working environment. Over two-thirds (69.0%) worked Full-Time with a work pattern of approximately an 8 h day shift.

Forty six percent of the respondents (n = 392/852) had one or more of the medical conditions listed. Of this percentage, 42.4% were Peri-, Post- or Menopausal (Peri-menopause = 12.1%, Menopausal = 20.3%, Post-menopause = 10.0%). In addition, 31.2% (265/852) were taking medication with 24.2% of this proportion (n = 206) taking anti-depressants and 7.7% (n = 66) taking medication indicative of a vascular condition (e.g. Beta blockers, ACE inhibitors).

3.2. Heat stress within the workplace

3.2.1. 'Uncomfortably hot' during summer and winter

During the summer (June to September) most respondents (n = 847/1014, 83.6%) felt 'Uncomfortably Hot' at work either 'Often' or 'Always', with proportionally more females feeling 'Always' 'Uncomfortably Hot' compared to males with no difference occurring between the age groups (Table 1). On average the respondents (n = 968) felt 'Uncomfortably Hot' approximately 2/3 of the time (68.83 ± 27.1%) during these months.

During other months of the year (October to May) respondents felt 'Uncomfortably Hot' less frequently than during the summer months with 80.9% (n = 775/958) feeling 'Uncomfortably Hot' either 'Often' or 'Occasionally'. Proportionally, more males compared to females advised 'Never' feeling hot (13.5% vs. 6.4%) and those aged between 50 and 59 years reported feeling 'Uncomfortably Hot' 'Occasionally' more often than those in the 18–29 age group; otherwise there were no other differences between the age groups (Table 1). On average the respondents (n = 951) felt 'Uncomfortably Hot' approximately 1/3 of the time (38.31 ± 27.9%) during these months.

3.2.2. Personal protective equipment

Ninety four percent of respondents (n = 887/944) perceived that wearing PPE increased the frequency of feeling 'Uncomfortably Hot' within their workplace (i.e. 33.7% = 'Slight Increase' and 60.3% = 'Large Increase'). There was no difference between Type 1 (i.e. fluid resistant surgical mask, plastic apron, gloves, possibly additional eye protection such as a visor) and Type 2 (i.e. FFP3 mask, eye protection goggles, visor, eye shield, long sleeved fluid repellent gown, gloves) PPE on the increase in the frequency of feeling 'Uncomfortably Hot' at work, both being greater than that of the 'mask only' and 'other'. Females (64.8%) were more likely to perceive that wearing PPE 'Largely' increased the frequency of feeling 'Uncomfortably Hot' in the workplace than males (39.4%), whereas males were more likely perceive that it 'Slightly' increased the frequency of feeling 'Uncomfortably Hot' (52.9% vs. 30.4%). There were no differences between the age groups on how PPE affected the frequency of feeling 'Uncomfortably Hot'.

3.2.3. Cognitive performance

Ninety-two percent of respondents (n = 918) advised that when they felt 'Uncomfortably Hot' they perceived it affected their cognitive performance. From the list provided, the cognitive attributes perceived to

Table 1
Prevalence of feeling 'Uncomfortably Hot' during summer or winter within selected categories of age, sex and medical condition.

	Summer				Winter			
Category	Never	Occasionally	Often	Always	Never	Occasionally	Often	Always
Male (n = 104)	1 (1.0%)	29 (27.9%)	47 (45.2%)	27 (26.0%)$^{\beta}$	14 (13.5%)$^{\beta}$	59 (56.7%)$^{¥}$	28 (26.9%)	3 (2.9%)
Female (n = 750)	7 (0.9%)	91 (12.1%)	335 (44.7%)	317 (42.3%)	48 (6.4%)	385 (51.3%)$^{¥}$	264 (35.2%)	53 (7.1%)
18–29 years (n = 93)	0 (0.0%)	11 (11.8%)	41 (44.1%)	41 (44.1%)	5 (5.4%)	60 (64.5%)	25 (26.9%)	3 (3.2%)
30–39 years (n = 206)	1 (0.5%)	28 (13.6%)	92 (44.7%)	85 (41.3%)	17 (8.3%)	113 (54.9%)	64 (31.1%)	12 (5.8%)
40–49 years (n = 179)	1 (0.6%)	29 (16.2%)	76 (42.5%)	73 (40.8%)	11 (6.1%)	95 (53.1%)	61 (34.1%)	12 (6.7%)
50–59 years (n = 308)	5 (1.6%)	40 (13.0%)	141 (45.8%)	122 (39.6%)	25 (8.1%)	136 (44.2%)*	124 (40.3%)	23 (7.5%)
60+ years (n = 75)	1 (1.3%)	14 (18.7%)	34 (45.3%)	26 (34.7%	5 (6.7%)	44 (58.7%)	19 (25.3%)	7 (9.3%)
Diabetes (n = 33)	0 (0.0%)	3 (9.1%)	19 (57.6%)	11 (33.3%)	3 (9.1%)	19 (57.6%)	9 (27.3%)	2 (6.1%)
Peri-menopause (n = 103)	0 (0.0%)	10 (9.7%)	49 (47.6%)	44 (42.7%)	6 (5.8%)	49 (47.6%)	41 (39.8%)	7 (6.8%)
Menopause (n = 173)	1 (0.6%)	18 (10.4%)	75 (43.4%)	79 (45.7%)	6 (9.7%	69 (39.9%)	81 (46.8%)	17 (9.8%)
Post-menopause (n = 85)	2 (2.4%)	10 (11.8%)	44 (51.8%)	29 (34.1%)	7 (8.2%)	44 (51.8%)	23 (27.1%)	11 (12.9%)
Obese (n = 73)	0 (0.0%)	4 (5.5%)	40 (54.8%)	29 (39.7%)	3 (4.1%)	42 (57.5%)	26 (35.6%)	2 (2.7%)
Totals	**19**	**287**	**993**	**883**	**150**	**1115**	**765**	**152**

The first value is the number of respondents selecting that option within the category (first column). The second value represents the proportion of respondents selecting that option within that category. The totals in the last row are from a total of all responses and provided for a reflection of the frequency the respondents felt uncomfortably hot during summer and winter. significantly lower than the other age groups apart from 40 to 49 years, $p < 0.05$. β = significant difference between males and females, $p < 0.05$. ¥ Significantly more respondents felt 'occasionally' hot than the other categories of 'Never', 'Often' and 'Always', $p < 0.05$. Respondents declared whether they had been diagnosed with these medical conditions. No criteria was provided as what is determined as being diagnosed.

be the most affected were: Attentional Focus (93.4%); Complex Decision Making (63.4%); Processing Complex Information (64.2%); Short Term Memory and Complex Problem Solving (53.0%), Fig. 1A.

3.2.4. Physical performance

Ninety-one percent of respondents (n = 895) advised that when they felt 'Uncomfortably Hot' they perceived it affected their physical performance. From the list provided, respondents perceived the following physical characteristics to be the most affected: Increased fatigue/ reduced energy levels (96.6%); Headaches (88.8%); Negative effects on mood (76.4%) and Feelings of drowsiness (71.6%), Fig. 1B.

3.2.5. Absenteeism

Twenty percent of respondents (173/885) had taken days off or stopped work prematurely due to feeling 'Uncomfortably Hot' with no difference between the sexes. With the exception of 60 years plus, where there are fewer respondents, in comparison to other age groups 18–29 year olds more likely to have taken a day off or stopped work prematurely (i.e. 34.4%) (Fig. 2A). Obese and diabetic individuals were proportionally more likely to take days off (i.e. both 30.3%) than both the average of all respondents and menopausal women (range 17.5%–25.5%). Of those who had taken days off work (10.3%, 91/885), an average of 2.2 ± 4.5 days were taken. Of those who had stopped worked prematurely (15.0%, 133/885), this occurred on 4 ± 6 occasions.

3.2.6. Concerns about the heat

The majority of respondents advised they felt 'Sometimes' concerned about their workplace being too hot (36.4%, 317/873) with 29% expressing they felt concerned 'Most of the Time'. Males were more likely than females to 'Never' feel concerned about the workplace being too hot (3.7% vs. 15.4%) (Fig. 2B). Of these respondents (n = 870), 38.6% reported their concerns to members of their management team. Males were less likely to report their concerns than females (15.1% vs. 29.8%).

3.3. Heat stress mitigation strategies

Twenty-four percent of respondents (207/880) were aware of specific heat stress management advice/plans/policies in their workplace. From the list provided, the most common method of respondents (n = 287) receiving this information was via e-mail from management (46.7%), verbally from manager (18.2%) and other (17.8%) with intranet being the most common method other than those listed.

In a free-text question, respondents had the option to provide more details on the mitigation strategies they have been advised to adopt when their working environment is uncomfortably hot or during heat

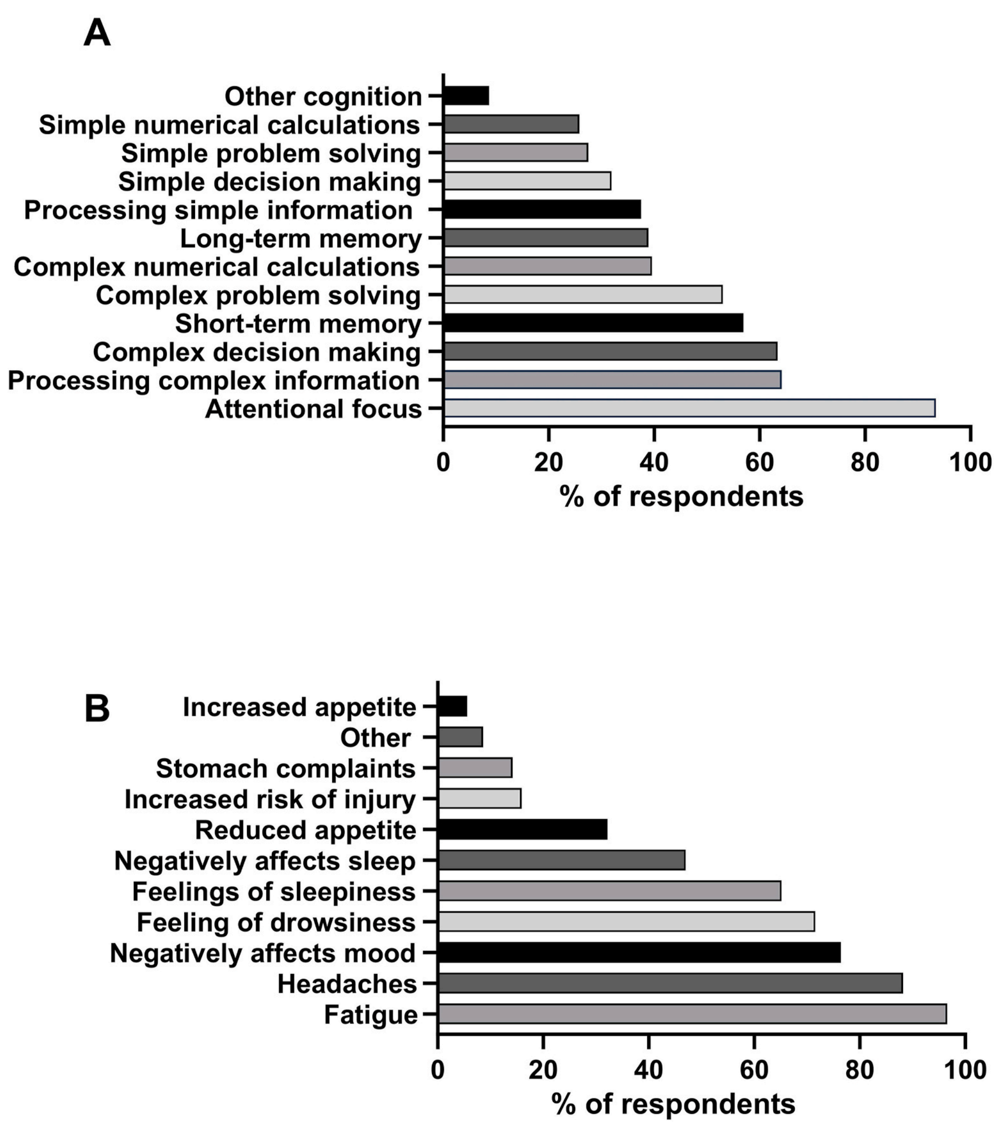

Fig. 1. The cognitive (A) and physical (B) attributes respondents felt were affected when feeling 'uncomfortably hot' within their workplace.

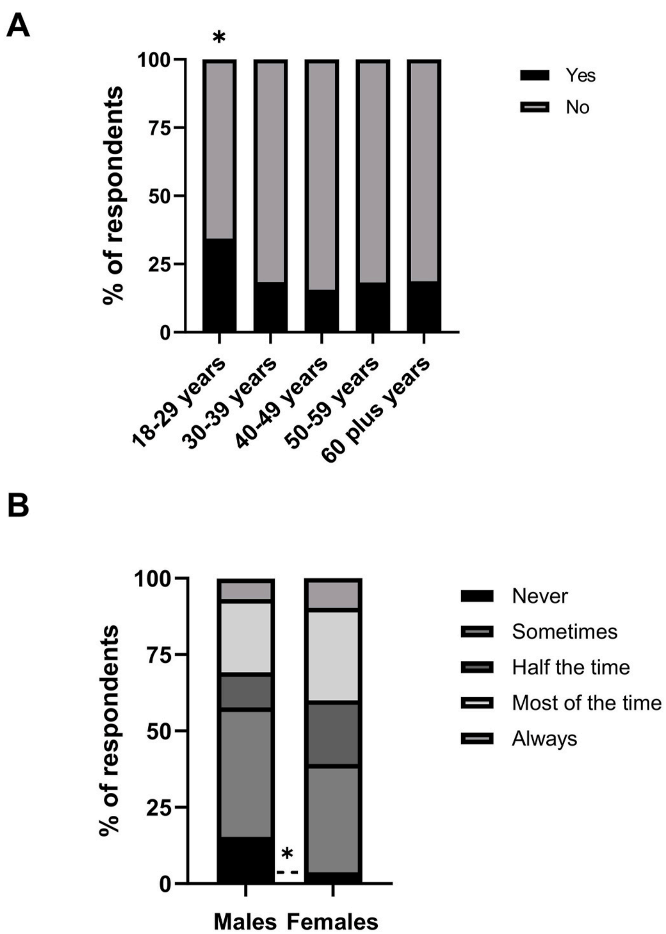

Fig. 2. A. The proportion of respondents according to age group who have taken days off work or stopped work prematurely due to experiencing symptoms of heat illness/exhaustion (e.g. headache, loss of appetite or nausea, vomiting, diarrhea, fatigue, tiredness, fainting, dizziness, confusion, fast breathing or heart rate, very thirsty, cramps in the arm, legs or stomach). * = $p < 0.05$ between the 18–29 years age group and the other age groups. **B.** The proportion and frequency of male and females who felt concerned about their workplace being too hot. * = significant difference between males and females in 'never' feeing concerned $p < 0.05$.

wave incidents. Responses from respondents who opted to provide more details are summarised in Table 2.

When asked if these policies were adequate (n = 202) the responses were evenly spread between 'Extremely Inadequate' to 'Somewhat Adequate' (i.e. 'Extremely Inadequate = 19.8%, 'Somewhat Inadequate' = 30.7%, 'Neither' = 22.3%, 'Somewhat Adequate' = 24.8%, 'Extremely Adequate' = 2.5%). However, when categorised by sex, males were more likely to perceive the policies to be 'Somewhat Adequate' than females, Fig. 3A.

The most common strategies employed of those listed were 'Drink more fluids' (22.8%); 'Open a window' (18.65%); 'Drink cool/cold fluids' (16.1%); 'Turn on an electric fan' (15.2%), Fig. 3B.

Respondents had the option to provide comments on what changes they would like to see implemented in their working environment to manage or mitigate heat stress. A total of 850 responses were collated and are summarised in Fig. 4.

Additional information

In another free-text question respondents had the option to provide additional comments on their experiences of heat stress within their workplace and how it may have impacted their experience at work that they feel had not been covered within the survey. A total of 273 responses were collated and are summarised in Fig. 5. Supplementary S5 provides all the quotes that have been categorised into the different themes and sub-themes.

4. Discussion

The results from this study provide new information on the extent HCPs frequently experience occupational heat stress during both the summer (June–September) and winter (October–May) months. Of

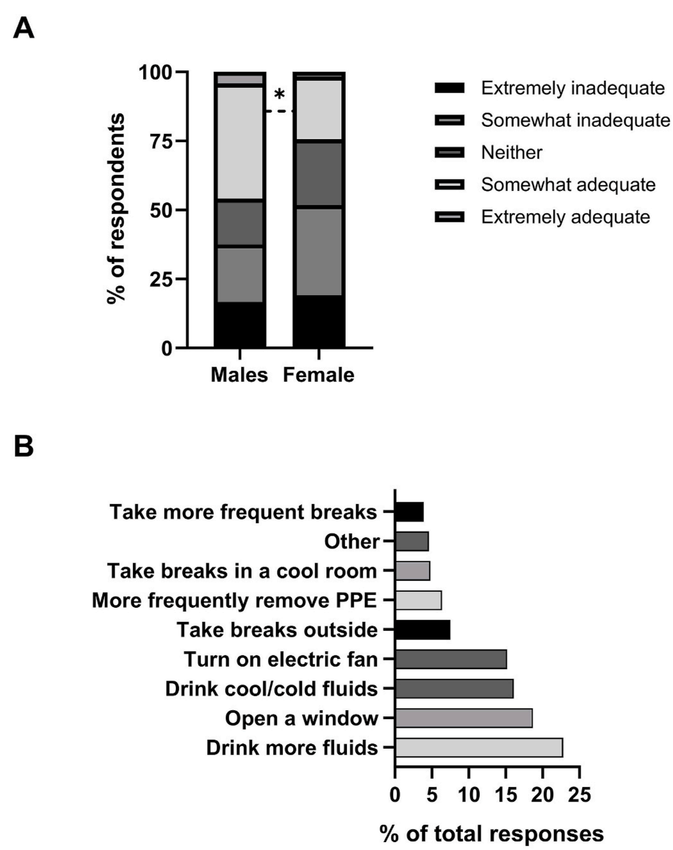

Fig. 3. A. The proportion of male and female respondents perceptions of the adequacy of the heat stress policies implemented in their workplace. * = significant difference between males and females perceiving their heat stress policies to be adequate, $p < 0.05$. **B.** The proportion of total responses declaring what heat stress mitigation strategy they employ when their workplace gets 'Uncomfortably Hot'.

Table 2
General themes of 'other' mitigation strategies respondents stated they employ. Total responses equals 151. Only responses with over 5 respondents is shown.

Mitigation strategy	Description	No of Respondents
Air conditioning	Advised to use air conditioning	9
Blinds	Advised to use blinds to stop solar radiation entering building	9
Breaks	Advised to increase the number of breaks	16
Fans	Advised to use fans that are available	15
Hydration	Advised to increase consumption of fluids	36
Open windows	Advised to open windows where available	16
Temperature monitoring	Advised to monitor the temperature of the room and report where available	6
Uniform	Advised to wear uniform or clothing that is enhances heat loss or reduces heat gain	22

Themes have been compiled from a question asking respondents to identify what advise was contained in the heat stress policy they received and section D.

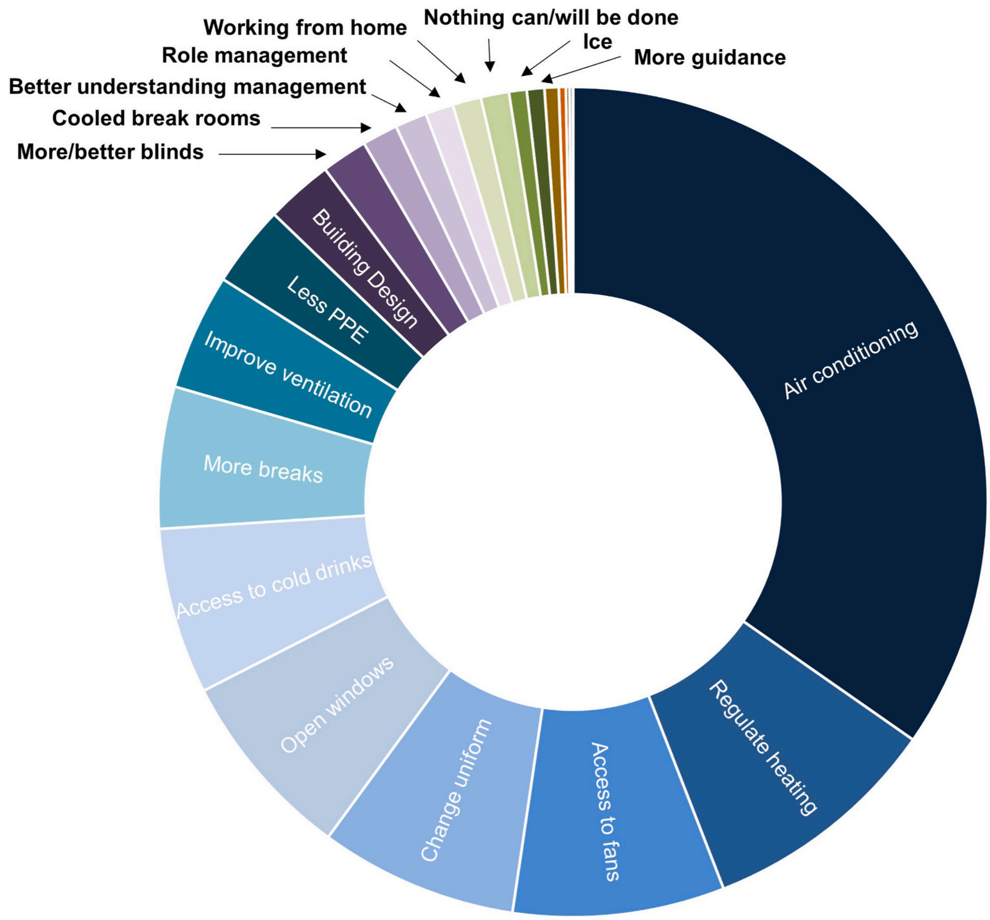

Fig. 4. Sunburst displaying proportionally the types of changes respondents would want implemented to mitigate heat stress within their workplace.

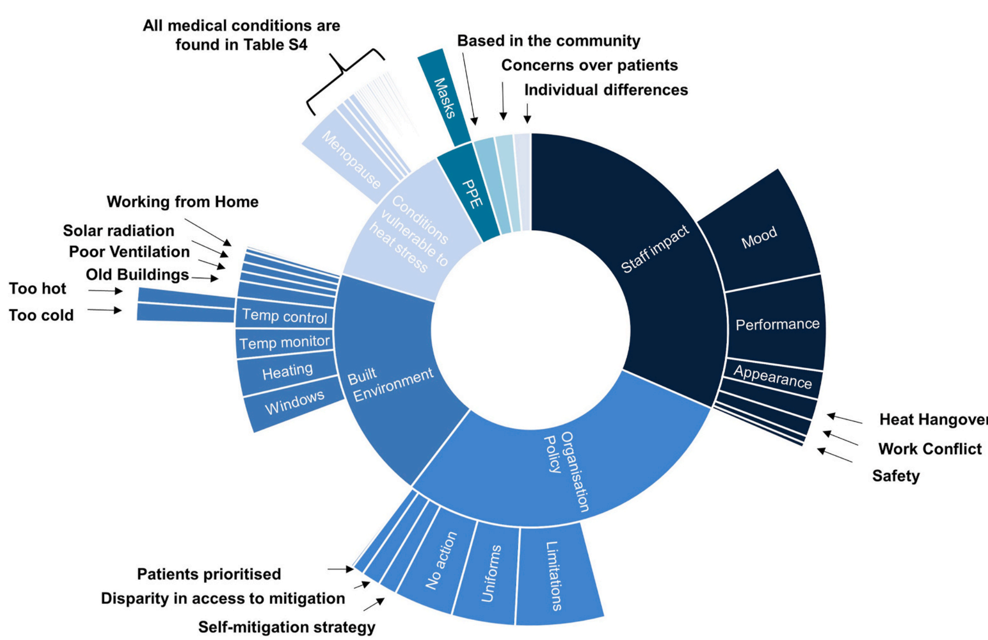

Fig. 5. Sunburst displaying proportionally respondents comments (n = 273) related to the types of experiences of occupational heat stress within respondents' workplace and how it may have impacted their experience at work not covered within the survey'.

critical importance is the observation that more than ninety percent felt their cognitive and physical performance was impaired when experiencing occupational heat stress, with approximately one fifth of respondents reporting absence and/or leaving work prematurely due to experiencing symptoms of heat stress. These observations could potentially have negative consequences for patient care, especially during future heat wave events. Although both NHS England and PHE have tried to introduce policy/guidance to mitigate heat stress within the workplace, our data indicate only a quarter of staff (24%) surveyed were aware of current heat stress management policy/guidance. Of those who were aware of the guidelines, 51% regarded them as inadequate. These data suggests that improvements need to be made in both communicating existing mitigation policy/guidance and the existing policy/guidance themselves. Existing policies/guidance could be improved by incorporating the needs of HCPs across HCFs and HCP roles; some of which are highlighted by this study.

4.1. Occurrence of occupational heat stress

The large proportion of HCPs experiencing occupational heat stress (represented by the feeling of being 'uncomfortably hot') and the influence of PPE on the frequency and/or severity of occupational heat stress reported in this study concurs with previous studies examining heat stress experienced amongst HCPs in the UK, Europe, Asia and Australasia (Azizpour et al., 2013; Bonell et al., 2021; Davey et al., 2021; de Korte et al., 2021; Hunt et al., 2023; Messeri et al., 2021; Yau and Chew, 2009). Illustrating that occupational heat stress amongst HCPs is an ongoing worldwide issue.

The frequency in which HCPs surveyed in the present investigation experience occupational heat stress throughout the year (i.e. two thirds of the time during the summer and one-third of the time during the winter) may be considered to be quite large. This frequency may partly be explained by the international guidelines on the environmental parameters that should be adhered to in HCFs being patient centric and not accounting for PPE or other thermal factors such as radiant heat load (Van Hoof, 2008). However, several other factors, may also be responsible.

Respondents in this study highlight that several features of the built environment make a HCF, or certain wards/rooms within a HCF, prone to overheating, with some respondents reporting that their working environment can often exceed 30 °C in the summer months (S5). One such feature is the type and efficiency of heating, ventilation and air-conditioning (HVAC) systems utilised by HCFs' buildings, which varies greatly based on the age of the HCF and how it is managed. For example, it has been acknowledged that 'overheating' incidents in the summer months may be more prevalent in older hospitals (built <1960's) (Lomas and Giridharan, 2012). A lack of air-conditioning, being poorly insulated and often containing over-glazed windows have been accounted for this increased prevalence (Lomas and Giridharan, 2012); features that are mentioned by respondents in this study to be a cause of occupational heat stress.

The HVAC systems being centrally managed can also create issues as it limits local control of the room/ward temperature. Several respondents in this study expressed their frustration in not being able to control the HVAC and described concerns of the heating being turned on too early in the Winter (e.g. October) and turned off too late in the Spring (e.g. March/April) causing indoor temperatures to be too high in both seasons (S5). Brooks et al. (2023) highlight that this lack of adaptability can be accentuated by the ownership of HCFs' buildings, property management and maintenance, being outsourced. Similar to the current study, Brooks et al. (2023) also describe how equipment inside a room/ward such as MRIs, computers and refrigerators can increase room temperatures; a problem that could be resolved if local room temperatures could be controlled.

The type and control of HVAC system may also explain the seasonal effect in thermal discomfort expressed in this study. Seasonal differences have previously been recognised with thermal discomfort being either greater in the winter (Skoog et al., 2005), or greater in the summer (Derks et al., 2018; Jain et al., 2021). Both heat acclimation (Skoog et al., 2005) and greater clinic/ward temperatures experienced in the summer months (Derks et al., 2018; Jain et al., 2021) were identified causes for this difference. To account for the effect of heat acclimation, some HVAC systems are integrated with 'adaptive thermal comfort models' that allow recommended indoor temperatures for thermal comfort to increase in relation to increasing outdoor temperatures (McCartney and Nicol, 2002). Adopting these models may eliminate the inappropriate use of HVAC systems described by the respondents in this study. However, it is unknown how many UK based HCFs utilise these thermal comfort models.

Certain mitigation strategies commonly used in workplaces to lower indoor temperatures when the outdoor temperature is high, such as air conditioning, electric fans, and opening windows, are restricted in certain HCFs. These strategies are restricted either due to policies associated with infection control, reducing carbon emissions, to ensure the safety of patients (e.g. no windows allowed to be open in a psychiatric ward), or as highlighted by the respondents in this study due to financial constraints and certain HCP roles having time constraints that limit the ability to employ suggested strategies. However, as illustrated in this study, the restriction of these strategies are not consistent amongst NHS trusts and clinical areas within HCFs; a disparity that was also evident in the study by Brooks et al. (2023). As alluded to by respondents in this study, this disparity can lead to staff members feeling marginalised (Fig. 5, S5).

The results also suggest that female HCPs are more likely to feel uncomfortably hot (i.e. thermal discomfort) than their male counterparts in both summer and winter. A sex difference in thermal discomfort has been documented elsewhere where females report to feel 'cooler' or 'warmer' and 'less satisfied' with the air temperature compared to males when exposed to temperatures that are outside neutrality (Del Ferraro et al., 2015; Karjalainen, 2007; Uścinowicz et al., 2023). Sex-related differences in metabolic rate, anthropometry and differing requirements in work clothing are suggested to be mainly responsible for females being more sensitive to temperature changes (Wang et al., 2018).

The sex difference in thermal discomfort reported in this study may also be explained by females between the ages of 50–59 years (33% of all respondents) being over represented in this study. Females within this age bracket are often going through the menopausal transition in which a large proportion of females experience vasomotor symptoms or 'hot flushes' (McKinlay et al., 1992). Forty two percent of respondents who declared having a medical 'condition' (35% of all respondents) stated they were going through the menopause transition or are menopausal. Vasomotor symptoms include sudden feelings of warmth, flushing of the skin, perspiration, rapid heartbeat, dizziness, change in mood and lack of concentration; symptoms reported by some respondents in this study to be exacerbated when exposed to higher air temperatures or when PPE is worn. Menopausal women also have been observed to have a lower air temperature threshold for the thermal acceptability and preference for cooler conditions (~1 °C lower) compared to pre-menopausal women (Carter et al., 2023).

4.2. The impact of occupational heat stress on HCPs

4.2.1. Occupational performance and productivity

This study highlights how occupational heat stress may impact HCPs' ability to perform job-related tasks as the majority (>90%) of respondents perceive their physical and cognitive performance is impaired when they feel 'uncomfortably hot'. Physically, respondents mainly reported experiencing fatigue/reduced energy levels, headaches and feelings of drowsiness which has been previously reported before in healthcare settings without (Berg et al., 2015) and with the use of PPE (Karahan et al., 2022; Lee et al., 2020; Maynard et al., 2016; Messeri et al., 2021; Tabah et al., 2020). The cognitive tasks that were mostly reported to become impaired when feeling 'uncomfortably hot' are in agreement with previous research with 'attention' and the more complex cognitive tasks (i.e. complex decision making, processing complex information, complex problem solving) being largely affected (Davey et al., 2021; López-Sánchez and Hancock, 2018).

Reductions in performance or productivity by HCPs due to thermal discomfort have been reported in previous survey-based questionnaires (Hunt et al., 2023; Karahan et al., 2022; Lee et al., 2020; Messeri et al., 2021). However, there is limited evidence on the direct effect of heat stress on objective measures of clinical performance without being confounded by the wearing of PPE that can compromise performance due to other ergonomic factors such as reduced dexterity and range of motion (Chen et al., 2016; Kim et al., 2016; Rissanen et al., 2008). In the limited studies where PPE is controlled for, the results suggest that in raised air temperatures (e.g. 19 °C vs. 26 °C) the ability to proficiently complete clinical based tasks may not be compromised, but the time and the physical effort required to complete these tasks is increased as well as the likelihood of being distracted (Berg et al., 2015). Unfortunately, these studies involve short exposures to raised temperatures (e.g. 15–60 min) and therefore may not depict how performance and productivity is impacted over a shift. Consequently, to provide a better understanding of the self-reported reduction in performance, controlled research studies are required to quantify the effect of heat stress on objective measures of clinical based performance over extended exposures to air temperatures typically found within HCFs over the course of a year. These exposures should be completed with and without PPE.

This study may not provide direct information on how HCPs' productivity is impacted, but it does provide an insight to the heat-induced labour productivity loss experienced in healthcare through self-reported absenteeism. Ten percent of respondents who answered questions related to this topic advised they had taken an average of 2.2 days off work in the past 12 months as a consequence of heat stress. A higher rate of absenteeism was reported amongst individuals diagnosed as obese and/or diabetic; conditions that can make individuals more vulnerable to heat stress (Kenny et al., 2010, 2016). Taking into consideration the average salary of a NHS HCP (i.e. £22,556), if this rate of absenteeism was to be extrapolated to the current NHS workforce (i.e. 10% of ~1, 327,892 staff), the cost of this possible rate of heat-related absenteeism to the NHS is ~£23 million per year or £17 or US$22 per person per year. This cost does not take into account the partial hours lost in a day from stopping working prematurely due to feeling uncomfortably hot, which 15% of respondents stated occurred on 4 occasions, or the heat-related reduction in productivity possibly experienced by the majority of respondents due to a decline in their physical and cognitive performance when they feel 'uncomfortably hot'. This cost does also not incorporate employment overhead costs to the employer.

The rate of absenteeism reported in this study is slightly higher than the self-reported heat-related sick leave by HCPs during the COVID-19 pandemic in India and Singapore (Lee et al., 2020), but slightly lower than another self-reported survey administered across a number of industries in Australia (Zander et al., 2015). The latter study estimated 7% of Australia's workforce annually lost ~4.4 work days and 70% were less productive on more than one day due to heat stress. By combining the cost of heat-related absenteeism and presentism, the estimated heat-related annual productivity loss per working person in Australia's workforce was US$655, which is much higher than an estimated cost of heat-related annual productivity loss per working person per year in Germany (US$7–70) (Hübler et al., 2008). A number of factors may be responsible for the differences in estimates of productivity losses due to heat-related absenteeism and presentism observed in these studies such as regional climatic conditions, the type of industry, and inaccuracies caused by misreporting (generally underreporting) of incidences of heat-related absenteeism and presenteeism (Johns and Miraglia, 2015).

4.3. Well-being

The majority of respondents advised they felt concerned about their workplace being too hot with approximately a third expressing they felt concerned most of the time and females more likely to feel concerned than their male counterparts. The factors already discussed on how HCPs are physically and cognitively impacted by heat stress provides some understanding of these concerns, the additional comments provided by respondents offers further understanding (Fig. 5, S5).

In one of the themes established from the comments (i.e. effects of heat stress on mood) respondents describe how heat stress evokes emotions such as irritability, increased stress levels, agitation and anxiety. Both heat stress and dehydration are known to cause mood disturbances that have been associated with impaired cognition (Benton and Young, 2015) and reductions in physical performance (Saldaris et al., 2020). Heat-related mood disturbances have been described before to be experienced amongst HCPs (Brooks et al., 2023; Lee et al., 2020). However, the HCPs in this study do not only describe how these mood disturbances can impair performance, but also adversely impact relationships with both colleagues and patients. Similar findings are demonstrated in other occupations where it has been identified that relationships can become strained not only in the workplace but also at home (Carter et al., 2020; Venugopal et al., 2016). Concerns about their appearance when it is hot (i.e. clothes saturated with perspiration, smell of perspiration, hot and sweaty face and skin) are also expressed with respondents describing their appearance as being less professional and feeling embarrassed by their appearance which sometimes evokes reductions in self-esteem. Whatever the drivers behind these concerns are, these concerns may cause or add to work-related stress that can potentially affect both physical and mental well-being ((Health and Safety Executive, 2023)). This is really important to acknowledge as it has been demonstrated NHS hospital admissions are increased during periods of air temperatures above 30 °C. For example, it has been estimated that a day of extreme heat (>30 °C) can cause a 6% increase in usual hospital admissions (Rizmie et al., 2022). These additional admissions can lead to extra pressures at work and work-related stress that may only be exacerbated if the HCPs are suffering from heat stress as highlighted by Brooks et al. (2023).

4.4. Heat mitigation policies

This study demonstrates that awareness of heat stress policies amongst HCPs is poor, supporting the findings of Brooks et al. (2023). Brooks et al. (2023) explain that this lack of awareness may be due to HCPs not accessing e-mails that communicate key information, which the respondent's in this study highlight as the main mode of receiving this information. A large majority of respondents who did access the policies/guidance viewed them as inadequate. The restrictions explained previously in implementing some of these policies within HCFs or within certain HCP roles, may largely explain this view.

The most common mitigation strategy respondents would like to have available is air conditioning. However, this strategy does not align with the NHS target of reaching net zero carbon emissions by 2040 (NHS England, 2022). Other desired strategies include more effective regulation of heating, access to fans and 'summer' uniforms; which interestingly are some of the most commonly used strategies further demonstrating the disparity in access to mitigation strategies. Regardless, these strategies are more carbon friendly but may conflict with infection control and patient comfort illustrating the complexity of implementing heat-stress mitigation strategies. More research is required to determine what are the most effective, yet pragmatic and environmental friendly, strategies that can be employed based on: (1) the type of HCF or area within a HCF; (2) the role of the HCP; (3) any conditions, medications or physical changes that make an individual more vulnerable to heat stress.

4.5. Limitations

Several limitations of the present study should be acknowledged. Firstly, the size of the sample population did not meet the criteria required limiting the generalisability of findings to HCPs employed within the NHS, especially for male HCPs. Secondly, this study includes self-reported data and therefore may include individual biases and elements of inaccuracy due to memory recall. Thirdly, the survey asked respondents to reflect upon their experiences during the summer and a period that included some of the hottest days recorded in the UK. These limitations may have caused biases in the data and findings to not represent HCPs typical experience of occupational heat stress across a year. However, alternatively, it could also be considered that the findings do represent HCPs working in the NHS experiences of occupational heat stress as global temperatures increase.

5. Conclusion

The present study highlights the extent HCPs experience occupational heat stress across a year and the impact it has on HCPs' health and well-being and possibly patient safety; all of which have an economic cost to the NHS. The results also suggest current heat-stress management policies utilised in the NHS have some limitations in their implementation and therefore are globally ineffective within the NHS. The main limitations in implementation can be categorised into either: (1) lack of awareness of policies; (2) conflicts with infection control and patient safety measures; (3) conflicts with policies of reducing carbon emissions; (4) design of the built environment; and (5) finance. Some of these limitations are experienced worldwide in healthcare and therefore a global approach could be utilised to better understand which pragmatic strategies are the most cost effective in mitigating heat stress in HCFs. In the short term, locally the NHS could increase the awareness of the signs and symptoms of occupational heat stress especially within HCP populations vulnerable to heat stress and increase the awareness of the heat stress management policies already in circulation. The complexity of mitigating this issue is acknowledged, however, progress in alleviating occupational heat stress needs to occur as the issue may only worsen as global temperatures continue to rise.

Declaration of interest statement

The authors declare the following conflicts of interest.

TR has a direct family member employed by MACE Cost Consultancy, that individual had no involvement in this work or this manuscript. Otherwise, we report no other conflicts of interest.

CRediT authorship contribution statement

S.L. Davey: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft. **B.J. Lee:** Writing – review & editing. **Timothy Robbins:** Methodology, Writing – review & editing. **C.D. Thake:** Methodology, Writing – review & editing.

Declaration of competing interest

TR has a direct family member employed by MACE Cost Consultancy, that individual had no involvement in this work or this manuscript.

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Appendix A. Supplementary data

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Further reading

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