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Short Report

Heat stress and PPE during COVID-19: impact on healthcare workers' performance, safety and well-being in NHS settings

S.L. Davey^{a,*}, B.J. Lee^a, T. Robbins^{b,c}, H. Randeva^b, C.D. Thake^a

^a Occupational and Environmental Physiology Group, Centre for Sport, Exercise and Life Sciences, Faculty of Health and Life Sciences, 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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SUMMARY

Personal protective equipment (PPE) can potentiate heat stress, which may have a negative impact on the wearer's performance, safety and well-being. In view of this, a survey was distributed to healthcare workers (HCWs) required to wear PPE during the coronavirus disease 2019 pandemic in the UK to evaluate perceived levels of heat stress and its consequences. Respondents reported experiencing several heat-related illness symptoms, and heat stress impaired both cognitive and physical performance. The majority of respondents stated that wearing PPE made their job more difficult. These, and additional, responses suggest that modification to current working practices is required urgently to improve the resilience of HCWs to wearing PPE during pandemics.

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Introduction

Healthcare workers (HCWs) within the National Health Service (NHS) workforce are required to wear personal protective equipment (PPE) to reduce the risk of contracting or

transmitting coronavirus disease 2019 (COVID-19). The impermeable, encapsulating nature of some PPE impedes heat loss, which, when combined with the additional weight of PPE and restricted mobility, can increase the level of heat stress and, consequently, thermal strain (i.e. raised skin and core temperatures) in HCWs [1].

Heat stress increases the risk of heat-related disorders and is often associated with impaired cognition, particularly in complex mental tasks [2]. Combining these factors with reduced dexterity and impaired visibility through wearing PPE

* Corresponding author. Address: Occupational and Environmental Physiology Group, Centre for Sport, Exercise and Life Sciences, Faculty of Health and Life Sciences, Coventry University, RC421 Richard Crossman Building, Jordan Well, Coventry CV1 5RW, UK.

E-mail address: ad4782@coventry.ac.uk (S.L. Davey).

Table 1
Demographics of respondents, type of personal protective equipment (PPE) used, duration of wearing PPE, top four heat-related illness symptoms and cognitive tasks adversely affected when wearing PPE (N=224)

	N	%
Sex		
Female	192	85.7
Male	32	14.4
Age (years)		
18–29	55	24.6
30–39	65	29.0
40–49	50	22.3
50–59	43	19.2
≥60	11	4.9
Ethnicity		
English/Welsh/Scottish/Northern Irish/British	187	83.5
Mixed ethnic background	7	3.1
Indian	7	3.1
Chinese	5	2.2
African	6	2.7
Other	12	5.4
Role		
Allied health practitioner ^a	48	21.4
Medic ^b	30	13.4
Nurse/sister	78	34.8
Healthcare assistant	40	17.9
Admin/managerial/research	16	7.1
Other ^c	12	5.4
Type of PPE ensemble		
Type 1	63	28.1
Type 2	161	71.9
Duration of wearing PPE (h)		
0–4	60	26.8
4–8	76	33.9
8–11	74	33.0
≥12	14	6.3
Heat-related illness symptom		
Dizziness	90	40.2
Fatigue	142	63.4
Headache	177	79.0
Profuse sweating	122	54.5
Cognitive task		
Making decisions	50	22.3
Solving complex problems	60	26.8
Retrieving information from short-term memory	45	20.1
Attentional focus	134	59.8

^a Includes physiotherapists, physiotherapist assistants and occupational therapists.

^b Includes medical students, junior doctors, consultants, surgeons and general practitioners.

^c Includes radiographers, psychiatrists and dieticians (all patient-facing roles).

[3,4] jeopardizes the safety, performance and well-being of HCWs. In addition, PPE-related discomfort experienced by HCWs has caused concern around adherence to wearing PPE and the appropriate doffing procedures as it endangers infection control [5]. Although these issues were highlighted as an area of concern during the Ebola virus disease outbreak [4], the same issues are clearly evident during the current COVID-19

pandemic. This study aimed to evaluate perceived levels of heat stress and its consequences in HCWs required to wear PPE during the COVID-19 pandemic in NHS healthcare settings, with the objective to inform future interventions designed to mitigate the level of heat stress experienced.

Methods

An online anonymous questionnaire-based survey was distributed within University Hospital Coventry and Warwickshire NHS trust and other NHS settings (via social media: LinkedIn, Twitter) between May and August 2020. Both type 1 (i.e. filtering face piece class 3 respirator, disposable fluid-repellent coverall/long-sleeved gown, full face shield/visor and disposable gloves) and type 2 (i.e. fluid-resistant surgical mask/surgical mask with no integrated visor, full face shield/visor/polycarbonate safety spectacles or equivalent, disposable plastic apron and gloves) PPE were assessed.

Perceptions of the level of heat stress experienced were evaluated by assessing, retrospectively, temperature sensation and thermal comfort when PPE was worn, and comparing the change in sweating when PPE was worn with when PPE was not worn. The level and consequence of heat stress experienced by HCWs when wearing PPE was assessed by: (1) the number and type of heat-related illness symptoms experienced; (2) the number and type of cognitive tasks that were perceived to be adversely affected; (3) whether, and to what degree, physical performance at work was impaired; (4) whether PPE made their job easier or more difficult; and (5) whether, and how often, PPE was removed during a shift due to feelings of discomfort or overheating. All perceptions were assessed using Likert scales. The questionnaire also contained a free-text option where the respondent could provide additional information of their experience of wearing PPE. The questionnaire is available as online [supplementary material](#). Ethical approval was provided by Coventry University Ethics Committee. Data values are presented as median ± interquartile range (IQR), range or percentage.

Results

The survey received 230 responses. As six of the respondents reported wearing a protective face mask (PFM) alone, 224 responses were included in the categorical data analysis (see [Table 1](#) for demographic information).

[Table 1](#) shows the type of PPE used and how long the ensemble was worn. Whilst wearing PPE, 72.3% of respondents perceived that they felt 'hot', with 89.7% feeling 'very uncomfortable' or 'uncomfortable', and 98.7% experienced an increase in sweating. A median of three (IQR 2–5, range 0–9) heat-related illness symptoms were reported, with headache being the most common symptom, followed by fatigue ([Table 1](#)). During a shift, 76.8% of respondents reported that they had removed their PPE in order to relieve discomfort or overheating. Of these respondents, 32.6% reported that they had removed the ensemble on five or more occasions over the course of a shift.

Of the respondents, 76.2% reported that PPE impaired their physical performance at work. A median of one (IQR 0–3, range 0–8) of the listed cognitive tasks was perceived to be affected. Attentional focus was affected most frequently, followed by

solving complex problems (Table I). On the whole, 91.5% of respondents reported that PPE made their job more difficult.

The additional comments highlighted issues related to individual items of PPE (i.e. the PFM and the visor negatively impacting breathing, visibility and communication with patients and colleagues, especially vulnerable groups such as the elderly), and how heat stress was exacerbated by the level of PPE worn and by higher ambient temperatures of the working environment (such as the heatwaves experienced in the UK during the COVID-19 pandemic). The comments also drew attention to the severity of heat-related illness symptoms being higher in certain populations vulnerable to heat stress, such as menopausal women. Several themes emerged on how these issues affected the working lives of respondents, such as increasing the difficulty in performing certain procedures (e.g. cannulation, cardiopulmonary resuscitation and conducting physiotherapy assessments), contact dermatitis in the facial region and eye irritation due to wearing a PFM or visor for an extended period of time. Further themes related to operating procedures or policies regarding the use of PPE in healthcare settings [i.e. scheduling longer breaks, wearing less thermally stressful ensembles, increasing the opportunity to hydrate, working in cooler environments (Figure 1)].

Discussion

Although the majority of respondents provided responses based on the use of type 2 PPE, which is less thermally challenging, the survey identified a high prevalence of heat stress which had a negative impact on respondents' performance, health and well-being. In addition, to relieve feelings of overheating or discomfort, approximately 77% of respondents

reported removing their PPE during a shift, potentially increasing their risk of infection if not doffed and possibly donned again appropriately [5]. Unfortunately, it is not known which item of PPE was removed most frequently, and this may influence the level of risk of infection.

Approximately 65% of respondents reported that one or more cognitive tasks were impaired when wearing PPE. This impairment in cognition may not only affect performance, but also compromises the health and safety of HCWs and patients. The prevalence of occupational heat stress has been strongly associated with workplace accident rates, with the majority of accidents reported in certain workplaces found to occur in wet-bulb globe temperatures $>25^{\circ}\text{C}$ [6].

In this study, respondents reported that PPE impaired their physical performance at work (~76%) and made their job more difficult (~92%). Previous studies have highlighted that the performance of medical tasks can be adversely affected when PPE is worn, with the length of time taken to complete the task affected more often than successful completion of the task [7]. The increase in time taken to complete a task generally occurs as individuals regulate their working pace to a lower intensity to reduce heat production and/or due to cognition being impaired by heat stress. Regardless, if tasks take longer to complete, the productivity of HCWs will be compromised.

PFMs and visors appeared to be the most problematic items of PPE in the present study, with compromised communication being the main complaint, especially when treating patients from vulnerable populations. The issues highlighted in this study associated with wearing a PFM or visor over a long period of time (i.e. thermal discomfort, contact dermatitis, reduced visibility) have been documented previously, and can be associated with increased levels of heat stress, temperature and/or

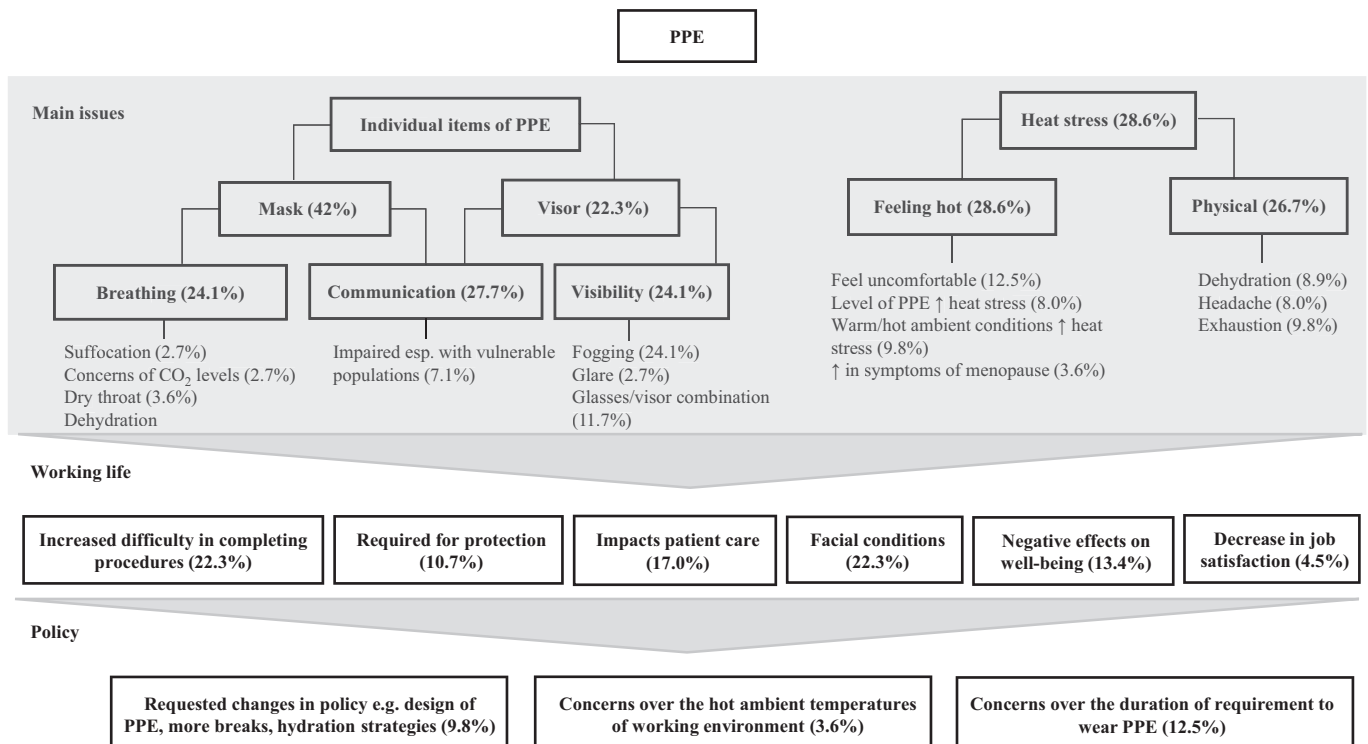


Figure 1. Main themes generated from the additional information provided regarding respondents' experiences of wearing personal protective equipment (PPE), and how these experiences may have impacted their working lives ($N=112$).

relative humidity of the PFM microclimate [3,4]. Increased levels of thermal discomfort with the use of a PFM can be explained by the facial region being recognized as highly thermosensitive [8]. Therefore, modifications in the design of PFMs to improve the PFM microclimate may assist in reducing both overall discomfort and contact-dermatitis-related issues.

The comments provided by the respondents highlight the impact of wearing PPE on the health and well-being of HCWs. Chronic exposure to heat stress (i.e. over a working day/week) has been associated with medical conditions such as acute kidney disease, especially if chronically dehydrated [6]. 'Hangover-like' symptoms have also been reported to occur amongst workers who are chronically exposed to thermally stressful conditions, which have the potential to affect an individual's sleep, appetite, and relationships with friends and family [9]. Some respondents stated that they 'dreaded going to work' due to the requirement to wear PPE, and some were unsure if they could cope with a subsequent wave in the COVID-19 pandemic if changes were not made to the PPE usage policy.

This study had a number of limitations. The more thermally challenging PPE ensemble (i.e. type 1) was under-represented in the sample population, so the extent of the associated heat stress experienced and its impact on HCWs may not be evident. In addition, it is not known whether respondents adhered to certain policies designed to alleviate heat stress when wearing PPE, which may have influenced their responses. Males were also under-represented in the sample population. It is acknowledged that sex-related differences in thermoregulatory responses are present when PPE is worn [10], so the experiences of male HCWs may differ to those represented in the present study.

In conclusion, the survey responses highlight that modifications to current PPE designs or policies on the use of PPE are required urgently to reduce the level of heat stress and the prevalence of other issues that jeopardize the performance, safety and well-being of HCWs with potential consequences for patients. This requirement is reinforced by some HCWs indicating limited resilience to respond to another pandemic or a second wave in the current COVID-19 pandemic. Modifications to the design, or use, of PFMs and visors; modifying the length of time that PPE is required to be worn during a shift; or providing a cooler working environment could alleviate some of the discomfort and impaired performance experienced by HCWs when wearing PPE.

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Conflict of interest statement

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jhin.2020.11.027>.

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