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Frontline healthcare workers' experiences with personal protective equipment during the COVID-19 pandemic in the UK: a rapid qualitative appraisal

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Frontline healthcare workers' experiences with personal protective equipment during the COVID-19 pandemic in the UK: a rapid qualitative appraisal

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Competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Contributors

CVP designed the study, contributed to data collection, supervised data collection, analysis, and reviewed different iterations of the manuscript. KH, LM, ND and SLJ contributed to the interviews. KH, LM and SLJ conducted the policy review. LJA contributed to mass media data collection. SM and SV contributed to social media monitoring, data collection and analyses. KH conducted data analysis of all data and wrote the first draft of the manuscript. ND supervised data analysis and reviewed different iterations of the manuscript. All authors edited the manuscript and approved the final version.

Transparency statement

The lead author and guarantor (KH) affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Patient and Public Involvement

The study protocol and study materials were reviewed by the team's internal patient and public involvement panel. The panel's feedback was used to make changes in the research questions and study materials.

Ethical approval

This study was approved by the Health Research Authority (HRA) and Health and Care Research Wales (HCRW) and the R&D offices of the hospitals where the study took place.

IRAS project ID: 282069

Trial registration details

Not applicable as this was not a clinical trial.

Dissemination statement

We plan to disseminate the results to study participants.

Data sharing statement

All data relevant to the study are included in the article or uploaded as supplementary information.

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ABSTRACT

Objectives

To report frontline healthcare workers' (HCWs) experiences with personal protective equipment (PPE) during the COVID-19 pandemic in the UK. To understand HCWs' fears and concerns surrounding PPE, their experiences following its guidance and how these affected their perceived ability to deliver care during the COVID-19 pandemic.

Design

A rapid qualitative appraisal study combining three sources of data: semi-structured in-depth telephone interviews with frontline HCWs (n=46), media reports (n=39 newspaper articles and 145,000 social media posts) and government PPE policies (n=25).

Participants

HCWs interviewed were purposively sampled from from Intensive Care Units, Intensive Therapy Units, emergency departments, primary care and community clinics across the UK.

Results

A major concern was running out of PPE, putting HCWs and patients at risk of infection. Following national-level guidance was often not feasible when there were shortages, leading to re-use and improvisation of PPE. Frequently changing guidelines generated confusion and distrust. PPE was reserved for high-risk secondary care settings and this translated into HCWs outside these settings feeling inadequately protected. Participants were concerned about inequitable access to PPE for community, lower seniority, female and ethnic minority HCWs. Participants continued delivering care despite the physical discomfort, practical problems and communication barriers associated with PPE use.

Conclusion

This study found that frontline HCWs persisted in caring for their patients despite multiple challenges including inappropriate provision of PPE, inadequate training and inconsistent guidance. In order to effectively care for patients during the COVID-19 pandemic, frontline HCWs need appropriate provision of PPE, training in its use, as well as comprehensive and consistent guidance. These needs must be addressed in order to protect the health and well-being of the most valuable healthcare resource in the COVID-19 pandemic: our HCWs.

STRENGHTS AND LIMITATIONS OF THE STUDY

- This is the first study to qualitatively explore healthcare workers' (HCWs) experiences with PPE in the UK during the COVID-19 pandemic.
- The study combined three sources of data (interviews, policies and media) collected at different stages of the pandemic (pre-peak, during the first peak and post-peak).
- The interview study sample was limited in its representation of the experiences of HCWs from Black, Asian and Minority Ethnic (BAME) groups, lower seniority and community hospitals.
- Due to restrictions accessing hospital sites during the pandemic, the study was not able to directly capture practices associated with PPE use.

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INTRODUCTION

The provision of personal protective equipment (PPE) for frontline healthcare workers (HCWs) has become a defining problem of the Coronavirus disease 2019 (COVID-19) pandemic.[1] The demand for PPE has put global supply chains under unprecedented strain.[2] By March 2020, the World Health Organisation (WHO) called for rational PPE use and for global PPE manufacturing to be scaled up by 40%.[3] This has led to widespread concerns regarding inadequate provision of PPE and its impact on the protection of frontline HCWs. In an international survey in April 2020, over half of HCWs that responded had experienced PPE shortages, nearly a third were reusing PPE and less than half had adequate fit-testing.[4] In the United Kingdom (UK), a third of respondents from a Royal College of Nurses (RCN) survey[5] and over half from a British Medical Association (BMA) survey[6] said they felt pressure to work without adequate PPE. Both surveys also raised concerns that Black, Asian and Minority Ethnic (BAME) and female HCWs may be disproportionately affected by PPE shortages. Additional concerns over impaired communication, physical discomfort, overheating and dehydration associated with PPE have also been raised.[7] As of 20 July 2020, 313 HCWs had died from COVID-19 in the UK.[8]

Knowledge from previous epidemics highlights the importance of PPE for frontline HCWs to reduce the spread of disease, safeguard HCWs' health and well-being, and maintain a sustainable health workforce to curb the outbreak.[9] Adequate provision of PPE, as well as clear guidance and training in its use help HCWs feel confident and prepared to deliver care.[10] Previous epidemic research also highlights the value of understanding HCWs' fears and concerns in order to support them on the frontline of an outbreak.[11] Qualitative research methodologies are increasingly being used to inform response efforts. In the 2014 Ebola and 2015-16 Zika outbreaks, qualitative research helped generate context-specific, real-time recommendations to improve the planning and implementation of response efforts.[12]

Research on the appropriate level of PPE for COVID-19 is still ongoing.[13] Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) is thought to be transmitted via respiratory, contact and airborne transmission.[14] Respiratory and contact precautions recommended by Public Health England (PHE) when caring for suspected cases include a Fluid-Resistant (Type IIR) Surgical Face Mask (FRSM), apron, gloves, and eye protection upon risk assessment.[15] Airborne precautions recommended when caring for patients requiring aerosol generating procedures (AGPs) are higher and include a filtering facepiece 3 (FFP3) respirator, long-sleeved disposable fluid-repellent gown, gloves and eye protection.[15]

PPE has become a critical issue for frontline HCWs in the COVID-19 pandemic but studies capturing HCWs' experiences with PPE are lacking.[16] The aims of this study were to determine (a) frontline HCWs' experiences following local level (e.g. Trust) and national level (e.g. government) PPE guidance; (b) concerns and fears among HCWs regarding PPE in the context of the COVID-19 pandemic; and (c) how these experiences and concerns affected HCWs' perceived ability to deliver care during the pandemic.

METHODS

Design

This study was part of a larger ongoing study on frontline HCWs' perceptions and experiences of care delivery during the UK COVID-19 pandemic.[17] We utilised a rapid appraisal methodology with three sources of data, including telephone interviews with frontline staff, a policy review, and media analysis (see Table 1). A rapid qualitative appraisal is an iterative approach to data collection and analysis, which triangulates findings between multiple sources

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of data to develop an understanding of a situation.[18] It was chosen for its ability to generate targeted research in a timely manner in order to help inform response efforts to complex health emergencies.[12] The use of an intensive, team-based approach with multiple sources of data helped to increase insight and validity of results.[19]

Sampling and recruitment

Participants were purposively sampled (see Table 2). They had a variety of experience, ranging from newly qualified to over 40 years working in the National Health Service (NHS). Participants were approached by clinical leads in their Trusts to gather verbal consent for the research team to contact them via email. Participants were provided with a participant information sheet and after filling out a consent form, had a telephone interview arranged.

Data collection

Table 1 details data collection methods.

Interviews

46 in-depth, semi-structured telephone interviews with frontline HCWs were carried out using a broad topic guide (see Appendix 2). A multidisciplinary research team (including CVP, KH, LM and SLJ) conducted the interviews. Informed, written consent was obtained from all participants. Interviews were audio recorded, transcribed verbatim and all data anonymised. Emerging findings were summarised in the form of Rapid Assessment Process (RAP) sheets[18] to increase familiarisation and engagement with the data.[20] Interviews were included until data reached saturation, determined by no new themes emerging from RAP sheets.[21]

Policies

A review of 25 UK government policies and guidelines relating to PPE was carried out to contextualise HCWs' experiences following PPE guidance using Tricco et al.'s framework.[22] SLJ, LM and KH selected policies that met the inclusion criteria (see Appendix 1), cross-checked and extracted data into Excel.

Media

A rapid evidence synthesis of 39 newspaper articles and 145,000 English language Twitter posts meeting the inclusion criteria (see Appendix 1) was carried out utilising the same methodology as the policy review.[22] LJA screened titles and full texts of mass media data with exclusions cross-checked by another researcher. SM and SV utilised the media monitoring software Meltwater[23] to collect social media data using keyword searches on Twitter.

Data analysis

The study was informed by a theoretical framework derived from anthropological perspectives on the material politics of epidemic responses.[24] All streams of data were analysed using the Framework Method,[25] as this type of analysis has been effective for rapid qualitative appraisals in previous epidemics.[12] Social media data underwent additional demographic, discourse and sentiment analysis using the software TalkWalker.[26] All sources of data were coded with the same analytical framework to triangulate findings between the different streams of data.

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RESULTS

Table 1: Methods of data collection and analysis.

Type of data	Method of collection	Included sample	Method of analysis
Interviews	In-depth, semi-structured telephone interviews with frontline staff.	46 interviews conducted between 19 March 2020 and 7 July 2020.	Emerging findings summarised as RAP sheets. Verbatim transcripts were coded and data analysed using framework analysis.
Policies	PPE policies were selected from legislation.gov.uk, https://www.england.nhs.uk (NHS England) and https://www.gov.uk/ (Public Health England, Department of Health and Social Care).	25 policies published between 1 December 2019 and 5 June 2020.	Data were extracted into Excel by hand, cross-checked by another researcher and analysed using the analytical framework.
Media	Mass media data collected through the LexisNexis database and hand searching.	39 newspaper articles published between 15 March 2020 and 5 June 2020.	Data were extracted into Excel using the software Research Electronic Data Capture (REDCap), cross-checked by a reviewer and analysed using the analytical framework.
	Social media data collected through the software Meltwater[23] and Talkwalker.[26]	145,000 English language social media posts made between 1 December 2019 and 31 May 2020.	Data were selected, coded and analysed, then integrated into the analytical framework.

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Participants

Participants represented a range of HCWs. The majority were doctors and nurses working in hospital settings and one non-HCW was included for their expertise in IPC services. (Table 2).

Table 2: Participant demographics

	Sample (n=46)	Percentage total (%)
Role		
Doctor	28	60.87%
Nurse	8	17.39%
Healthcare practitioner	3	6.52%
Pharmacist	2	4.35%
Physician associate	1	2.17%
Dietician	1	2.17%
Speech and language therapist	1	2.17%
Healthcare assistant	1	2.17%
Infection Prevention and Control Service	1	2.17%
Sector		
Secondary care (hospital)	40	87.0%
Primary care (general practice)	4	8.7%
Specialist community services	2	4.3%
Ethnicity		
White	40	86.96%
BAME	6	13.04%
Total	46	100%

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Table 3: Summary of themes from all streams of data

Main themes	Sub-themes	Policy review	Media analysis	Representative interview quotes
Theme 1: PPE guidance and training - "We weren't prepared enough"	**Inconsistent guidance**	PHE guidance changed on March 6 2020 to advise FRSM masks be used instead of FFP3 respirators when assessing or caring for suspected COVID-19 patients.[27]	Newspaper reports of HCWs expressing concerns about caring for suspected cases with FRSMs instead of FFP3 respirators.	*"What is really difficult for staff is that they're being told to use a certain level of PPE for suspected patients but they might be watching the television and seeing, either from our country or other countries, people looking after patients wearing complete gear - total hazmat suits - covered from top to toe. Then they're saying, 'I'm being given much less than that to go see patients.'" (Doctor, Consultant)* *"Some staff felt messages of what PPE is required, in what situations, that there was a little bit of distrust…If the advice keeps changing, are we getting the right message? And is this message safe? Which caused a bit of worry and anxiety for some of the staff because at the same time they were hearing on the press that colleagues in other hospitals were getting sick." (Charge nurse)* *"The guidelines are created within an emergency context…but I think that at local level, there should be an interest into tailoring those guidelines to needs." (General practitioner)*
	The training gap	On 2 March 2020, all NHS organisations advised to provide HCWs with fit-	Newspaper reports of HCWs working in PPE without having received training.	*"I haven't had any training…some other nurses have been trained to use ventilators but there hasn't been any PPE training or anything else at all." (Nurse)* *"PPE training happened because of local engagement of clinicians*

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		testing and PPE training.[28]		*rather than coming from the management…it is clinicians who have been coming knocking on the door saying we need to prepare and perform these trainings – that was strange, why didn't that change come from the top?" (Doctor, Consultant)*
Theme 2: PPE supply - **"If we're not protected, we can't protect the public"**	**Shortages (PPE size, level and quality)**	On 17 April 2020 PHE guidance changed to approve the re-use of PPE where there were acute shortages and it was safe to do so.[29]	Newspaper reports of inadequate access to PPE, especially for BAME, female and community HCWs.	*"So, there were times, for instance, where you needed to go to the loo, but you didn't want to waste PPE." (Doctor, Registrar)* *"What I don't think was good was the PPE situation, begging for personal protective equipment, feeling guilty for asking for it, feeling guilty for raising our voices." (Healthcare practitioner)* *"Some of the scrubs, there weren't enough small ones…and well, you wouldn't expect a six-foot man to wear something that would fit me."([Female] Doctor)* *"We didn't have family members coming in wearing PPE and seeing their relatives to say goodbye before they die, and we should have been able to facilitate that." (Doctor, Consultant)*
	Procurement	In a letter to Trust chief executives on 17 March 2020, NHS England stated that there are local distributio n issues despite an	HCWs using the 'panorama' hashtag on Twitter (n=2000 tweets) which referred to the BBC investigatio n on whether the government failed to	*"I think the one thing that's probably been the biggest challenge has been sourcing PPE…That was probably the single biggest anxiety-inducing thing for staff on the ground. We never got to the point where we ran out but there was always this sense that we don't know where next week's is coming from. And the Trust always did manage to find it, but it was complex." (Doctor, Consultant)*

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		adequate national supply of PPE.[30]	purchase PPE for the national stockpile in 2009.	*"So there has been provision of PPE but not necessarily always PPE that is as secure as it could be." (Charge Nurse)*
	Risk of exposure	PHE guidance from 14 March 2020 advised HCWs who came into contact with a COVID-19 patient while not wearing PPE could remain at work unless they developed symptoms .[31]	News reports attributing a lack of PPE to frontline HCWs falling ill and dying.	*"They were saying that we were the ones that really should be using [PPE] and anyone who was in the room but is further away doesn't need it, because they're not at the mouth of the patient…you were begging to have more…you'd have to really make a stand and say well, 'everybody in my team is wearing it.'" (Healthcare practitioner)* *"The first thing to do is making sure the healthcare professional feels that they are not jeopardizing the life of their own families…don't make them feel like a pawn in a bigger game, because sometimes we feel like we are obliged to do stuff to save the rest, but we are part of the rest too." (Doctor, Consultant)* *"It was really scary because, it's not just the patients…it's the attitude towards the staff as well. They were treating anybody like you had it. I had an anaesthetist in the early days, when we weren't being given PPE, it was just like 'don't come in, keep away from me', and it was really difficult to work keeping apart from someone. It was like the way they treated you as well, as though you're infected so don't come near me." (Healthcare practitioner)*

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Theme 3: Challenges of delivering care in PPE - "It's necessary but it makes everything more difficult"	**Physical effects**	PHE guidance states that HCWs should remain hydrated and be trained to recognise dehydration, fatigue and exhaustion while wearing PPE.[29]	Staff nurse in a news report describes taking minimal breaks during their 12-hour shift to avoid changing out of PPE to access water or toilets.	*"It's hot, it's sweaty, it's inconvenient" (Doctor, Consultant)* *"The effort staff made for the patients, even though they were uncomfortable, overall was remarkable really." (Charge nurse)*
	Practical problems	On March 12 2020, PHE guidance stated that FFP3 respirator, long-sleeved disposable fluid-repellent gown, gloves and eye protection must be worn for APGs.[32]	Consultant in a news report describes how PPE made treating patients significantly more difficult, obscuring their vision.	*"It makes it more difficult to go between patients. So, for example if there is an emergency in the non-coronavirus bay you can't just leave. You have to take off all the PPE in a particular way to make sure you don't contaminate yourself and then go to see what the emergency is. It causes a small delay that probably doesn't make a difference, but psychologically it feels more stressful because you feel like it's taking a lot longer." (Doctor, Registrar)*
	Communication and connection	On 24 April 2020, PHE IPC guidance advised Trusts that "visiting should be restricted to those assessed as able to wear PPE."[15]	Positive news reports of HCWs using PPE portraits (disposable photos of their faces on top of PPE) to overcome rapport problems with patients.	*"I think it does make you feel very …dehumanized because you can't recognize any of your colleagues." (Senior clinical pharmacist)* *"When you've got patients on the ward and they are stuck in a room on their own and everyone in the room is dressed in PPE and they can't have their relatives visiting them that's actually really frightening and stressful and will create problems for people." (Doctor, Consultant)*

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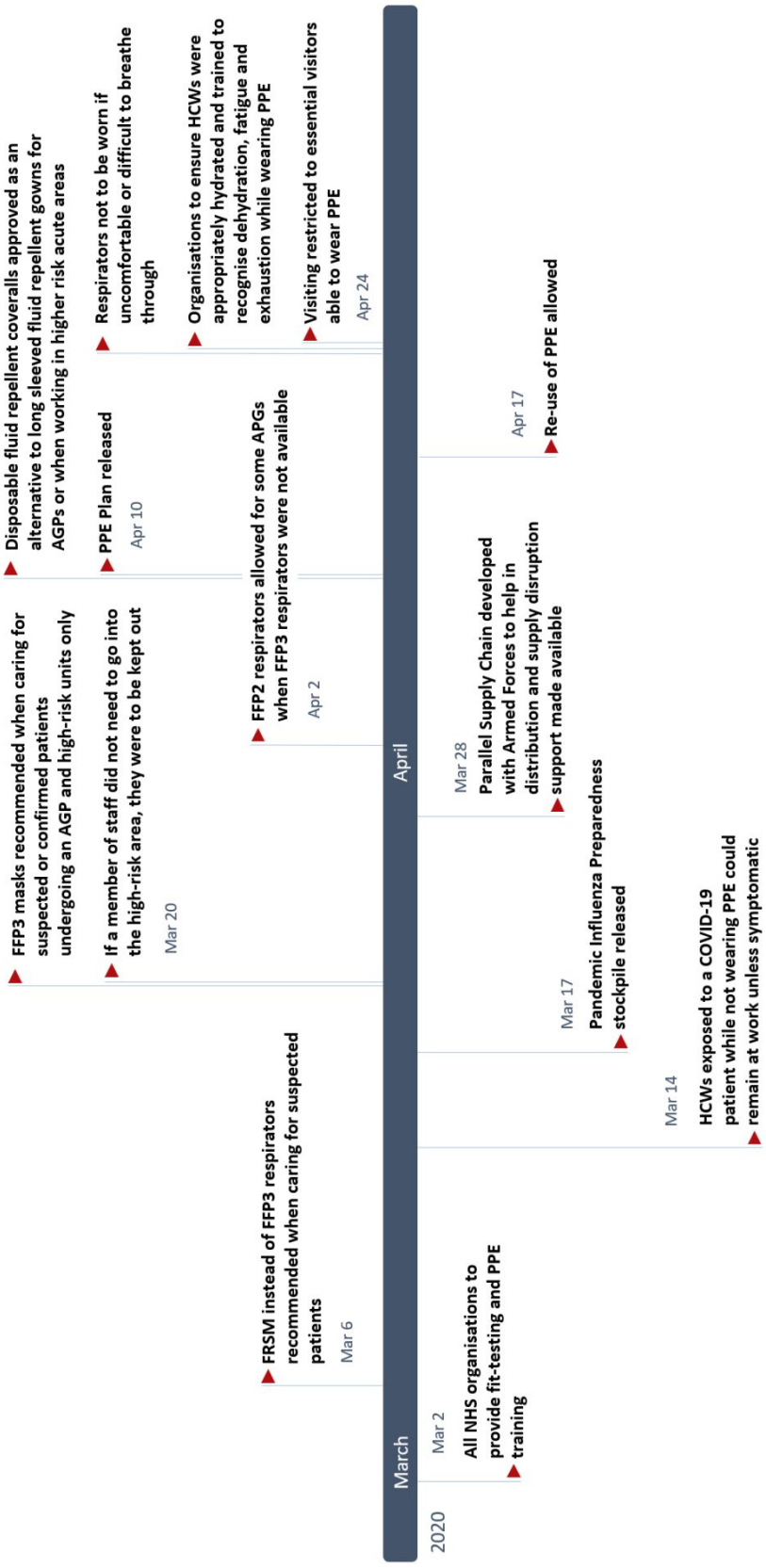
Figure 1: Timeline of changes to national PPE guidance



AGP;Aerosol Generating Procedures, FFP3; Filtering facepiece 3, FRSM; Fluid-Resistant (Type IIR) Surgical Face Mask, HCW; Healthcare worker, High-risk area; ICU, ITU, HDU

Theme 1: PPE guidance and training - "We weren't prepared enough"

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Inconsistent guidance

Towards the start of the outbreak, interviewed HCWs reported limited PPE guidance leading them to care for suspected COVID-19 patients without appropriate PPE. All streams of data analysis found that national PHE and Trust-level PPE guidance changed frequently (see Figure 1), with of daily changes reported in early April 2020. Inconsistent guidance led to confusion, distrust and a lack of confidence in the messaging.

On 6 March 2020, PHE recommended that FRSMs were to be used instead of FFP3 respirators when caring for suspected patients.[27] On 20 March 2020, guidance stated that FFP3 respirators were only needed when managing suspected or confirmed patients, requiring one of their listed "potentially infectious AGPs" and in high risk units such as the ICU, ITU and high-dependency unit (HDU).[33] On 2 April 2020, guidance changed to advise that if FFP3 respirators were not available, FFP2 respirators could be used instead for some AGPs.[34] HCWs were concerned that this level of PPE was inadequate. Media analysis showed reports of HCWs being advised to wear single-layer paper surgical masks, instead of FRSMs or FFP3 masks whilst caring for suspected patients. HCWs felt PHE's list of potentially infectious AGPs[15] was not comprehensive enough, missing important potential AGPs, such as administering medication via nebulisation and performing chest compressions. HCWs were concerned about the change in PHE guidance on 10 April 2020,[35] which allowed the use of coveralls with a disposable plastic apron for APGs instead of full-length fluid-repellent gowns. Reports of PPE shortages in interviews and media analyses coincided with the 17 April 2020 PHE guidance which changed to approve the re-use of PPE when there were acute shortages and it was deemed safe to do so.[29] Having to re-use PPE was distressing, especially when sharing with colleagues. HCWs were concerned that the down-grading and frequent changes to guidance were grounded in supply problems.

As the pandemic progressed, some HCWs felt overwhelmed by increasing amounts of guidance from multiple sources. They felt that having a dedicated team to sort through the information would have increased its clarity. HCWs from community health services found interpreting PPE guidance catered towards hospital-based settings challenging. Senior HCWs were often involved in interpreting national guidance in the context of their local Trust, liaising between staff and management. Some nurses felt as though their voices were not heard in the decision-making processes surrounding PPE guidance and supply on the ward. This was difficult for them as they spent most of their shifts in PPE. HCWs in interviews and the media were concerned about the UK guidance in comparison to other countries, where they felt higher levels of PPE were being provided to HCWs.

The training gap

Most interviewed HCWs on ICU, ITU and A&E reported adequate PPE training on how to safely don and doff PPE. However, some HCWs felt there was a "training gap" and expressed the need for earlier, more accessible training available for a wider range of HCWs. A few HCWs reported having had PPE training during past epidemics, but most were unfamiliar with the PPE required for COVID-19 patients. On 2 March 2020, NHS England advised all organisations to provide HCWs with PPE training.[28] Interviewed HCWs felt PPE training was less accessible to HCWs working outside of high-risk units, such as general wards, surgery, and primary care. Media analysis found training was lacking for HCWs working in the community and in care homes. HCWs took initiative in teaching themselves to safely use PPE when training was not available nor provided early enough. Having training available during both day and night shifts, as well as online materials helped to make PPE training more accessible.

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Theme 2: PPE supply - "If we're not protected, we can't protect the public"

Shortages (PPE size, level and quality)

HCWs in the media expressed concerns about PPE stockpiles running low from the beginning of March 2020. All streams of data analysis found reports of PPE shortages from across the UK, most notably in care homes, community health facilities and general practice. Visors, full-length fluid-repellent gowns and fluid-repellent facemasks were especially in short supply. One interviewed HCW described PPE being locked in an office with someone monitoring its use. In comparison to intensive care staff, interviewed HCWs from general wards and those from smaller, less prominent hospitals reported greater barriers in access to PPE. Negative sentiment social media posts were mainly related to PPE shortages and a member of parliament (MP) who reported that care homes had adequate PPE. The positive social media were related to deliveries and donations. Informal help and resources advising on appropriate PPE use and how to adapt to limited supplies, was shared on social media.

PHE guidance stated that respirators needed to be the correct size, fit-tested before use, and that HCWs were not to proceed if a "good fit" could not be achieved.[36] Many HCWs reported failing their respirator fit-test and a lack of alternatives meant that they proceeded caring for COVID-19 patients with these masks or used a lower level of protection. This was especially the case for female HCWs who experienced a lack of small sized masks and scrubs. Media analysis found reports of greater PPE supply problems for BAME HCWs. Powered air purifying respirator (PAPR) hoods (an alternative for HCWs with beards unable to shave for religious reasons) were especially lacking. Concerns were raised that HCWs of lower seniority, including nurses, healthcare assistants and physician associates faced greater barriers accessing PPE. HCWs were also concerned about the quality of PPE. Media analysis found that Trusts, particularly in primary care, received shipments of out-of-date PPE. The policy review found that NHS England stated these shipments of outdated PPE had "passed stringent tests that demonstrate they are safe."[37]

HCWs reported several adaptions to delivering care in order to preserve PPE, such as the use of open bays with multiple COVID-19 patients, and fewer HCWs seeing patients on ward rounds. Verbal prescriptions were used more frequently to avoid entering the COVID-19 bay and wasting PPE to write a prescription. The policy review found guidance on 20 March 2020 in response to concerns about mask shortages that stated, "if a member of staff does not need to go into the risk area, they should be kept out."[33] On 24 April 2020, PHE guidance advised that visiting should be restricted to essential visitors able to wear PPE.[15] Some HCWs were concerned that PPE supply was a contributing factor limiting families visiting critically ill patients.

Procurement

On 17 March 2020, the Department of Health and Social Care (DHSC) announced that there were local PPE distribution problems despite a "currently adequate national supply."[30] On 10 April 2020, PHE released their PPE plan which explained that "there is enough PPE to go around, but it's a precious resource and must be used only where there is a clinical need to do so."[38] They emphasised the importance of following national PPE guidance to reduce the significant pressure the supply chain was under. HCWs in interviews and media reported their facilities sourcing PPE at higher costs than usual. Some HCWs resorted to privately purchasing PPE and some Trusts received PPE donations, including 3D printed masks and visors. Extreme examples from the media included HCWs improvising PPE using children's safety goggles, cooking aprons and bin liners. On social media these concerns were

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expressed by HCWs using the "panorama" hashtag on Twitter (n=2000 tweets) which referred to the BBC investigation on whether the government failed to purchase PPE for the PIP stockpile in 2009. Even for interviewed HCWs that did not experience PPE shortages, the incremental basis of procurement was concerning for them. HCWs highlighted that facilities should have had prepared larger stockpiles and argued in favour of international collaboration on global PPE supply chains. Clear communication about PPE procurement and reassurance that stocks were adequate helped alleviate fears.

Risk of exposure

Interviewed HCWs feared that a lack of PPE increased their risk of exposure to COVID-19, especially for HCWs that had underlying conditions or were male, BAME, pregnant or been redeployed from retirement. Concerns were compounded by media reports of HCWs in other facilities catching COVID-19 due to insufficient PPE and subsequent exposure to high viral loads. This uncertainty was in the context of a lack of testing for HCWs, causing worries that they were spreading the virus between colleagues, patients and the public. Some HCWs described concerns regarding nosocomial transmission and a change in attitude between colleagues when there was a lack of PPE. A lack of cleaning and changing facilities meant HCWs would wear potentially contaminated clothes home. HCWs expressed concerns about exposing vulnerable household or family members. The policy review found that on 14 March 2020, PHE advised that HCWs who came into contact with COVID-19 patients while not wearing PPE could remain at work unless they developed symptoms.[31] This policy was subsequently withdrawn on 29 March 2020. HCWs with infectious disease experience, working with adequate provision of PPE and those that had already been ill with COVID-19 reported less fear of exposure. As data collection progressed, HCWs became increasingly used to their new working environments, more familiar with using PPE and less afraid of catching COVID-19.

Theme 3: The challenges of delivering care in PPE – "It's necessary but it makes everything more difficult"

Physical effects

Interviewed HCWs described PPE to be tiring and uncomfortable to wear, making it more difficult to deliver care. The effects were pronounced for nurses who spent most of their shifts in PPE, and older HCWs with underlying conditions. Tight masks caused facial pain, marks and bruises, rashes, dry skin as well as difficulties breathing, headaches and irritability. HCWs persisted in delivering care despite these effects, often against the PHE advice from 24 April 2020 that respirators "should be discarded and replaced, and not be subject to continued use" when uncomfortable or difficult to breathe through.[15] For some HCWs, the effects were so severe that they asked to be reassigned to non-COVID wards. Full-length gowns were hot and sweaty, causing overheating and dehydration. Conditions were exacerbated by HCWs fasting during Ramadan and warm weather. HCWs expressed the importance of breaks but often found it difficult to take them, especially on busy wards with shortages of staff and PPE. Wasting PPE on breaks generated feelings of guilt. Drinking less water to avoid having to take breaks made it difficult to follow guidance to remain "appropriately hydrated during prolonged use."[15] HCWs expressed the importance of breaks but often found it difficult to take them, especially on busy wards with shortages of staff and PPE.

Practical procedures

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HCWs found delivering care in PPE to be cumbersome. Donning and doffing PPE contributed to a slower delivery of care, and palpation during physical examinations was less effective with multiple layers of gloves. Goggles fogging up whilst performing procedures, such as intubation and administration of anaesthesia, was frustrating and stressful. Being in PPE restricted HCWs' movements between patients and wards. Junior HCWs, for example, found that, when in full PPE, they found they were less able to ask for help from seniors outside the COVID-bay not in PPE. HCWs needed to be more prepared than usual when going to see a patient requiring PPE, as they would be unable to leave without doffing and re-donning PPE.

Communication and connection

HCWs found it more difficult to build rapport with patients as PPE limited facial expressions, physical touch, and time spent with patients. Being in full PPE could be intimidating, especially for delirious patients. Some HCWs found it difficult to recognise colleagues and often had to shout to be heard through facemasks. Communication problems arose with patients that were elderly and hard of hearing as they relied heavily upon lipreading. HCWs in PPE found alternative forms of communication with colleagues outside of COVID bays, such as portable radios. Some HCWs reported removing their masks when speaking about important topics, such as gaining consent or breaking bad news. HCWs in interviews and media described overcoming rapport problems through use of disposable photos of themselves on their PPE (i.e. disposable photos of their faces attached to gowns).

DISCUSSION

The findings of this study highlight that HCWs faced multiple challenges delivering care in PPE. HCWs reported similar effects of PPE being hot, tiring, time-consuming and restrictive in previous epidemics.[39, 40] Singh et al.[41] found that 21% of COVID-19 HCWs they sampled took a leave of absence due to PPE-associated skin problems. In addition to the implications for the workforce, they also raised concerns that skin breaches, irritation and increased touching of the face could act as a source of SARS-CoV-2 exposure. Participants in this study expressed the value of taking breaks to combat the physical effects of PPE but often found it difficult to do so as a result of staff shortages, heavy workloads and guilt over wasting PPE.

PPE reduced HCWs' ability to develop rapport with patients by masking facial expressions and impairing non-verbal and verbal communication. "PPE portraits" have re-emerged in the COVID-19 pandemic after first being used in the 2014 Ebola outbreak to re-humanise care delivery and have positive anecdotal evidence from HCWs and patients.[42] Reducing the number of staff on COVID-19 wards to reduce PPE demand raised concerns about increased workloads and quality of care.

Some participants felt PPE training was not always easily accessible nor implemented early enough. A third of HCWs that responded to a survey by the Royal College of Nurses (RCN) reported on the 8th of May that they had not received PPE training.[5] Studies on HCWs' perceptions of working during previous infectious disease outbreaks highlight the importance of PPE training for HCWs to feel confident and prepared.[43, 44] Incorrect use of PPE exacerbates shortages and puts HCWs at higher risk of infection.[45] Participants in this study described difficulties accessing training sessions between long shifts and raised concerns that HCWs outside of high-risk settings may experience less training. Previous research has also highlighted that during outbreaks, community HCWs tend to receive less PPE training and face greater difficulties following national guidance often directed towards hospital settings.[46, 47]

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There have been widespread reports of UK HCWs experiencing PPE shortages during the COVID-19 pandemic.[48] Actual and perceived shortages were a major source of anxiety for participants. They advocated for adequate PPE provision to protect their own health and safety. HCWs in China also experienced fears of self-infection and transmission to colleagues, patients and household members due to a lack of PPE.[7] Evidence on the safety of PPE reuse and extended use is limited, but suggests that it can increase the risk of HCW self-infection and hospital transmission.[45] This is particularly the case in the absence of clear guidance, protocols and a limited evidence-base on best practice.[49]

Participants in this study were concerned by the downgrade in guidance from recommending FFP3 respirators to FRSMs,[27] as well as fluid-resistant full-length gowns to coveralls.[35] They felt these changes were grounded in supply issues rather than safety measures. Current national guidance may be underestimating the risk of HCWs' exposure to COVID-19 outside of high-risk settings, potentially resulting in inadequate protection for those HCWs.[49] Prioritising higher levels of PPE for HCWs in high risk areas is thought to have contributed to lower death rates amongst anaesthetists and intensivists.[50] However, such an approach may be jeopardising the health and safety of HCWs working in lower-risk areas.[51] PHE guidance recommending FRSMs is lower compared to countries recommending higher level respirator masks (N95, FFP2 or FFP3), such as Australia, USA, China, Italy, Spain, France and Germany.[49] UK HCWs working on COVID-19 wards following current PHE PPE guidance had nearly three times higher rates of asymptomatic infection compared to HCWs not in COVID-19 areas.[52] Whilst there are many possible explanations for these findings, an inadequate level of PPE was considered a contributing factor. A key challenge is that research on the transmission of SARS-CoV-2 and the lowest effective level of PPE is ongoing.[53] Overuse of PPE uses up supplies and may increase risk of transmission through frequent changing, instilling a false sense of safety and potentially reducing the use of other important IPC measures.[54, 55] However, a recent systematic review and meta-analysis suggests that FFP3 respirators provide a higher level of protection against infection than FRSMs, even in the absence of AGPs.[56] HCWs in a study in China experienced no infections with SARS-CoV-2 when provided with appropriate PPE training and supply, including "protective suits, masks, gloves, goggles, face shields, and gowns."[13]

Participants in this study raised concerns that community, lower seniority, female and ethnic minority HCWs may face greater barriers accessing PPE than colleagues. During the 2015 MERS outbreak in Korea, female HCWs had similar experiences with oversized masks and coveralls.[57] Despite only making up 21% of the NHS workforce, BAME HCWs have been overrepresented in the proportion of HCW deaths from COVID-19 in the UK, accounting for 63% of nurses and 95% medical staff deaths.[58] Official inquiries into the underlying causes of these trends are ongoing.[59] However, a recent study found that lack of access to PPE was perceived by BAME HCWs in the UK as a major factor contributing to the higher death rates.[60] Recent studies suggest that in addition to being at greater risk of catching COVID-19, BAME HCWs are more likely to experience inadequate provision and reuse of PPE.[45] A BMA survey found that only 40% of UK BAME HCWs working in primary care felt they had adequate PPE compared to 70% of white HCWs.[6] The same survey found that 64% of BAME HCWs felt pressure to work in AGP areas without adequate PPE compared to 33% of white HCWs.[6]

PPE provision for frontline HCWs has become a priority for response efforts across the world. The need for international collaboration to create sustainable and equitable global PPE supply chains is evident. In the UK, PPE procurement issues existed before the COVID-19 pandemic. The national stockpile was missing critical equipment, such as gowns, which have been short in supply during the pandemic.[61] A delayed national response, limited domestic PPE manufacturing and exclusion from the EU commission procurement initiatives to secure PPE for its member states left the UK especially vulnerable to shortages.[61] Knowledge from past

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epidemics highlights the importance of centralised procurement systems, monitoring PPE use and distributing according to need.[62]

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Appendices

Appendix 1: Inclusion criteria and search terms

Inclusion criteria	**Newspaper data**	1) Published between 15 March 2020 and 5 June 2020; 2) Aimed at healthcare delivery; 3) Related to the COVID-19 pandemic; 4) Related to personal protective equipment.
	Social media data	1) Published between 1 December 2019 and 31 May 2020.; 2) Aimed at healthcare delivery; 3) Related to the COVID-19 pandemic; 4) Related to personal protective equipment.
	Policy data	1) Published between 1 December 2019 and 5 June 2020.; 2) Aimed at healthcare delivery; 3) Related to the COVID-19 pandemic; 4) Related to personal protective equipment.
Search terms	**Media and policy data**	COVID-19 OR coronavirus OR corona
	Social media data	((bio:"healthcare professional" OR bio:"healthcare worker" OR bio:"doctor" OR bio:"NHS" OR bio:"nurse" OR bio:"physio*" OR bio:"Paramedic" OR bio:"Ambulance work*" OR bio:"Ambulance driver*") AND ("coronavirus" OR "#coronavirus" OR “corona” OR "COVID-19" OR "COVID 19" OR "COVID19" OR "#COVID19" OR "COVID_19" OR "COVID" OR "severe acute respiratory syndrome coronavirus 2" OR "severe acute respiratory syndrome coronavirus 2" OR "2019-nCoV" OR "SARS-CoV-2" OR "2019nCoV" OR "physio*" OR "PPE") OR ("i am" OR "as a" OR "source: I" OR "I'm a") near/5 ("doctor" OR "nurse" OR "doctors" OR "nurses" OR "Paramedic" OR "Ambulance worker" OR "Ambulance driver") AND ("coronavirus" OR "#coronavirus" OR “corona” OR "COVID-19" OR "COVID 19" OR "COVID19" OR "#COVID19" OR "COVID_19" OR "severe acute respiratory syndrome coronavirus 2" OR "severe acute respiratory syndrome coronavirus 2" OR "2019-nCoV" OR "SARS-CoV-2" OR "2019nCoV" OR "physio*" OR "PPE") NOT ("I am not" OR "I'm not"))

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Appendix 2: Interview Topic Guide

INTERVIEW GUIDE: HEALTHCARE WORKERS (HCWs)

Date:

Respondent Information

"The interview takes about 20-25 minutes on average, but it can go on longer depending on how much you want to say"

First, I want to ask you about your work and the services you provide.

1. Background: Can you tell me about your role?

- *Can you tell me a bit about your role? (e.g. Daily tasks, department, responsibilities)*
-

2. Have you been in contact with patients who had suspected and/or confirmed COVID- 19?

Probes:

- *In what capacity?*
- *How have you found working around these patients?*
- *PPE physical effects? (E.g. dehydration, discomfort, restriction in movement, difficulties communicating)*
- *How has PPE impacted the type of care you provide patients?*
- *What psychological/emotional impact did this have on you?*

3. How has the COVID-19 outbreak affected health services in your department?

Probes:

- *How has this affected your normal daily tasks/responsibilities? Change of role?*
- *Impact of COVID-19 on the delivery of services to non-COVID-19+ patients (i.e. cancellation of elective surgeries)*
- *What tasks are you able to do more or less effectively?*
- *How do you manage the isolation of suspected cases and confirmed cases?*
- *Has there been appropriate transfer of patients within and out of hospital?*
- *Has there been an impact on staff's ability to make diagnoses and act on them?*
- *Has the supply of drugs, equipment and PPE been affected?*
- *Have staff been redeployed from or within your health facility*

4. What were the preparedness strategies implemented locally (department, hospital or Trust)?

- *Did you feel these strategies were enough?*
- *What do you feel was particularly successful?*
- *Should the Trust have prepared differently?*
- *Did you receive any training? (including but not limited to PPE training such as mental health and well-being training)*
- *Did you have access to guidance on PPE?*

5. Do you currently have any concerns or fears in relation to ...

- *Work (response efforts, PPE, services)*
- *The national effort*

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6. Over the past months, have you experienced any problems with aspects of your daily life such as sleeping, eating, concentration, or additional worries or anxiety?

7. Mental health support (to address risk of moral injury, trauma and developing severe mental health problems)

- *Are you aware of any support available for staff wellbeing and mental health?*
- *Have you had the opportunity to talk about your mental health with your supervisor/team leader?*
- *Have you had worrying experiences in the last week? Did you receive support after? If so, what type of support? (including formal and informal support)*
- *Interactions between peers: Do you have time to socialise with your team? What has changed with COVID-19?*

8. Have you been involved in caring for patients who are dying or expected to die soon?

If YES: Can you please tell me about your experience caring for these patients (e.g. what have you done, what were your responsibilities)?

Prompt: Advanced care planning, Symptom management/comfort, End of life decision making or Communicating with families.

- *How have you found these tasks?*
- *What difficulties or challenged have you faced in delivering this type of care?*
- *Do you feel this has had an emotional impact on you?*
- *Was this part of your normal role prior to COVID-19?*
- *Was there training or support available relating to this?*
- *Have you had to communicate with family members, how has that been?*
- *How does this differ to normal palliative care?*
- *How much choice do patients have?*
- *What are the rules/policies relating to this? Do you feel these are suitable?*

9. What do you feel is most important to offer COVID-19 patients at end of life and their families?

- *What is working well?*
- *What can we improve?*
- *What support do we need to offer HCW delivering palliative care?*
- *Are you able to offer bereavement support to families?*

10. OTs/PTs and others in charge of rehab: What are your main concerns about the impact of COVID-19 to the body (e.g. muscle degeneration, dexterity, impact to the lungs etc.)?

- *What resources do you have to deliver rehabilitation care? - ask their opinions on the Mary Seacole rehab hospital*
- *Is there a difference in resources for COVID-19 and non-COVID-19 patients?*

11. (If relevant based on previous discussion) Can you please tell me about the rehabilitation care tasks you are involved in with recovered COVID-19 patients?

- *Have you received any guidance on how to deliver rehabilitation services to recovered COVID-19 patients?*
- *OT: How does this differ from normal rehabilitation care e.g. delivering care at home?*
- *OT: How has COVID-19 impacted your contact with patients?*

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- *Has the pandemic impacted the flow of your patients through hospital e.g. are more or less patients being discharged to homes and bed-based rehab? - What is the impact of this?*
- *How do you think your role will be impacted as a growing number of people will need rehabilitation? Any concerns?*

General reflections

12. How have health services been strengthened, or how could they be strengthened during the outbreak?

Probes:

- *Support to HCWs from the health system and partners?*
- *Capacity for rapid response*
- *Policies? e.g. Guidance and emergency protocols?*
- *What would help HCWs to maintain normal services as well as COVID related services?*
- *If GP: Health promotion and community engagement. How?*
- *If GP: Linkage to other support organisations, e.g. charities, schools?*

13. Is there anything you feel should be changed to make health services more effective in future emergencies?

Probes:

- *Support to HCWs? From whom and How?*
- *Coordination and official guidance of COVID-19 response.*
- *Early detection and reporting.*
- *On-going health promotion and community education. E.g. potential sources of infection, safe practice?*
- *Mobilisation? E.g. identifying and coordinating trusted community volunteers and support?*
- *Disease outbreak control activities?*
- *Testing (public and staff)*

14. Do you feel your experience has been different from other HCWs? Does gender play a role? How about race or ethnicity?

15. How has your life at home been impacted by COVID-19?

16. Do you have any caring responsibilities, such as children or elderly family members?

If yes:

a. How are you managing care during the COVID-19 pandemic?
b. *(If they have children)* How has being a HCW during the pandemic impacted your ability to parent? ***time/experiences with your children??*
c. What fears, worries, or emotions arise from the responsibility of caring for others during this time?

18. Is there anything else you would like to mention that you feel is important?

Thank you for your time and for sharing your opinions and experiences with us.

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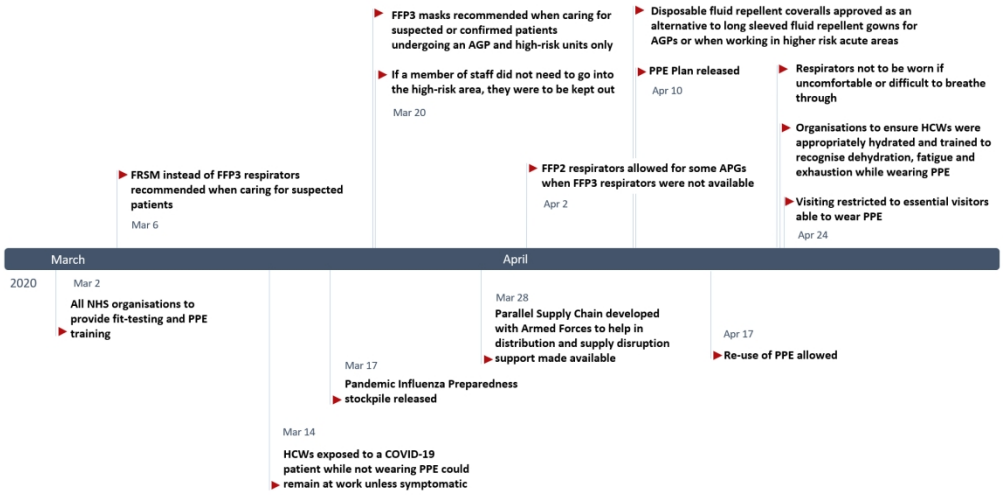

Figure 1: Timeline of changes to national PPE guidance

INTERVIEW GUIDE: HEALTHCARE WORKERS (HCWs)

Date:

Respondent Information

Gender	Age	Time in service (mm/yy)	Education level	Role/position	Ethnicity	Sector and type of facility	Location of facility	Follow-up?

"The interview takes about 20-25 minutes on average, but it can go on longer depending on how much you want to say"

First, I want to ask you about your work and the services you provide.

1. **Background: Can you tell me about your role?**
   - *Can you tell me a bit about your role? (e.g. Daily tasks, department, responsibilities)*

2. **Have you been in contact with patients who had suspected and/or confirmed COVID-19?**

Probes:
- *In what capacity?*
- *How have you found working around these patients?*
- *PPE physical effects? (E.g. dehydration, discomfort, restriction in movement, difficulties communicating)*
- *How has PPE impacted the type of care you provide patients?*
- *What psychological/emotional impact did this have on you?*

3. **How has the COVID-19 outbreak affected health services in your department?**

Probes:
- *How has this affected your normal daily tasks/responsibilities? Change of role?*
- *Impact of COVID-19 on the delivery of services to non-COVID-19+ patients (i.e. cancellation of elective surgeries)*
- *What tasks are you able to do more or less effectively?*
- *How do you manage the isolation of suspected cases and confirmed cases?*
- *Has there been appropriate transfer of patients within and out of hospital?*
- *Has there been an impact on staff's ability to make diagnoses and act on them?*
- *Has the supply of drugs, equipment and PPE been affected?*
- *Have staff been redeployed from or within your health facility*

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4. What were the preparedness strategies implemented locally (department, hospital or Trust)?

- *Did you feel these strategies were enough?*
- *What do you feel was particularly successful?*
- *Should the Trust have prepared differently?*
- *Did you receive any training? (including but not limited to PPE training such as mental health and well-being training)*
- *Did you have access to guidance on PPE?*

5. Do you currently have any concerns or fears in relation to ...

- *Work (response efforts, PPE, services)*
- *The national effort*

6. Over the past months, have you experienced any problems with aspects of your daily life such as sleeping, eating, concentration, or additional worries or anxiety?

7. Mental health support (to address risk of moral injury, trauma and developing severe mental health problems)

- *Are you aware of any support available for staff wellbeing and mental health?*
- *Have you had the opportunity to talk about your mental health with your supervisor/team leader?*
- *Have you had worrying experiences in the last week? Did you receive support after? If so, what type of support? (including formal and informal support)*
- *Interactions between peers: Do you have time to socialise with your team? What has changed with COVID-19?*

8. Have you been involved in caring for patients who are dying or expected to die soon?
If YES: Can you please tell me about your experience caring for these patients (e.g. what have you done, what were your responsibilities)?
Prompt: Advanced care planning, Symptom management/comfort, End of life decision making or Communicating with families.

- *How have you found these tasks?*
- *What difficulties or challenged have you faced in delivering this type of care?*
- *Do you feel this has had an emotional impact on you?*
- *Was this part of your normal role prior to COVID-19?*
- *Was there training or support available relating to this?*
- *Have you had to communicate with family members, how has that been?*
- *How does this differ to normal palliative care?*
- *How much choice do patients have?*
- *What are the rules/policies relating to this? Do you feel these are suitable?*

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9. **What do you feel is most important to offer COVID-19 patients at end of life and their families?**

- *What is working well?*
- *What can we improve?*
- *What support do we need to offer HCW delivering palliative care?*
- *Are you able to offer bereavement support to families?*

10. **OTs/PTs and others in charge of rehab: What are your main concerns about the impact of COVID-19 to the body (e.g. muscle degeneration, dexterity, impact to the lungs etc.)?**

- *What resources do you have to deliver rehabilitation care? - ask their opinions on the Mary Seacole rehab hospital*
- *Is there a difference in resources for COVID-19 and non-COVID-19 patients?*

11. **(If relevant based on previous discussion) Can you please tell me about the rehabilitation care tasks you are involved in with recovered COVID-19 patients?**

- *Have you received any guidance on how to deliver rehabilitation services to recovered COVID-19 patients?*
- *OT: How does this differ from normal rehabilitation care e.g. delivering care at home?*
- *OT: How has COVID-19 impacted your contact with patients?*
- *Has the pandemic impacted the flow of your patients through hospital e.g. are more or less patients being discharged to homes and bed-based rehab? - What is the impact of this?*
- *How do you think your role will be impacted as a growing number of people will need rehabilitation? Any concerns?*

General reflections

12. **How have health services been strengthened, or how could they be strengthened during the outbreak?**

Probes:

- *Support to HCWs from the health system and partners?*
- *Capacity for rapid response*
- *Policies? e.g. Guidance and emergency protocols?*
- *What would help HCWs to maintain normal services as well as COVID related services?*
- *If GP: Health promotion and community engagement. How?*
- *If GP: Linkage to other support organisations, e.g. charities, schools?*

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13. Is there anything you feel should be changed to make health services more effective in future emergencies?

Probes:
- *Support to HCWs? From whom and How?*
- *Coordination and official guidance of COVID-19 response.*
- *Early detection and reporting.*
- *On-going health promotion and community education. E.g. potential sources of infection, safe practice?*
- *Mobilisation? E.g. identifying and coordinating trusted community volunteers and support?*
- *Disease outbreak control activities?*
- *Testing (public and staff)*

14. Do you feel your experience has been different from other HCWs? Does gender play a role? How about race or ethnicity?

15. How has your life at home been impacted by COVID-19?

16. Do you have any caring responsibilities, such as children or elderly family members?

If yes:

a. How are you managing care during the COVID-19 pandemic?
b. *(If they have children)* How has being a HCW during the pandemic impacted your ability to parent? ***time/experiences with your children??*
c. What fears, worries, or emotions arise from the responsibility of caring for others during this time?

17. Are you pregnant?

a. If so, how has this impacted your work and experience as a HCW during the COVID-19 pandemic?

18. Is there anything else you would like to mention that you feel is important?

Thank you for your time and for sharing your opinions and experiences with us.

Standards for Reporting Qualitative Research (SRQR) checklist

O'Brien B.C., Harris, I.B., Beckman, T.J., Reed, D.A., & Cook, D.A. (2014). Standards for reporting qualitative research: a synthesis of recommendations. *Academic Medicine, 89(9)*, 1245-1251.

No.	Topic	Item	Included? (yes/no)	Location in manuscript
Title and abstract				
S1	Title	Concise description of the nature and topic of the study identifying the study as qualitative or indicating the approach (e.g., ethnography, grounded theory) or data collection methods (e.g., interview, focus group) is recommended	Yes	Page 1
S2	Abstract	Summary of key elements of the study using the abstract format of the intended publication; typically includes objective, methods, results, and conclusions	Yes	Page 2
Introduction				
S3	Problem formulation	Description and significance of the problem/phenomenon studied; review of relevant theory and empirical work; problem statement	Yes	Page 3
S4	Purpose or research question	Purpose of the study and specific objectives or questions	Yes	Page 3, Page 4
Methods				
S5	Qualitative approach and research paradigm	Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., positivist, constructivist/interpretivist) is also recommended	Yes	Page 4
S6	Researcher	Researchers' characteristics	Yes	Page 4, Page 22

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characteristics and reflexivity	that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, or transferability		
S7 Context	Setting/site and salient contextual factors; rationale[a]	Yes	Page 4
S8 Sampling strategy	How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling saturation); rationale[a]	Yes	Page 4
S9 Ethical issues pertaining to human subjects	Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues	Yes	Page 23 (ethics committee) Page 4-5 (participant consent)
S10 Data collection methods	Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources/methods, and modification of procedures in response to evolving study findings; rationale[a]	Yes	Page 4-5
S11 Data collection instruments and technologies	Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study	Yes	Page 4-5, Page 31 (Appendix 2: Interview Topic Guide)
S12 Units of study	Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)	Yes	Page 4, Page 7
S13 Data processing	Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and	Yes	Page 4-5

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	anonymization/deidentification of excerpts		
S14 Data analysis	Process by which inferences, themes, etc., were identified and developed, including researchers involved in data analysis; usually references a specific paradigm or approach; rationale[a]	Yes	Page 5
S15 Techniques to enhance trustworthiness	Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationale[a]	Yes	Page 4-5
Results/Findings			
S16 Synthesis and interpretation	Main findings (e.g., interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory	Yes	Page 14-18
S17 Links to empirical data	Evidence (e.g., quotes, field notes, text excerpts, photographs) to substantiate analytic findings	Yes	Page 8-12 (Table 3: Summary of themes from all streams of data) and Page 13 (Figure 1: Timeline of changes to national PPE guidance)
Discussion			
S18 Integration with prior work, implications, transferability, and contribution(s) to the field	Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application/generalizability; identification of unique contribution(s) to scholarship in a discipline or field	Yes	Page 18-21
S19 Limitations	Trustworthiness and limitations of findings	Yes	Page 22
Other			
S20 Conflicts of interest	Potential sources of influence or perceived influence on study conduct and conclusions; how these were managed	Yes	Page 23

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S21 Funding	Sources of funding and other support; role of funders in data collection, interpretation, and reporting	Yes	Page 24

[a]The rationale should briefly discuss the justification for choosing that theory, approach, method, or technique rather than other options available, the assumptions and limitations implicit in those choices, and how those choices influence study conclusions and transferability. As appropriate, the rationale for several items might be discussed together.

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BMJ Open

Frontline healthcare workers' experiences with personal protective equipment during the COVID-19 pandemic in the UK: a rapid qualitative appraisal

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Primary Subject Heading:	Public health
Secondary Subject Heading:	Global health, Health policy, Infectious diseases, Qualitative research, Health services research
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Frontline healthcare workers' experiences with personal protective equipment during the COVID-19 pandemic in the UK: a rapid qualitative appraisal

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Competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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Contributors

CVP designed the study, contributed to data collection, supervised data collection, analysis, and reviewed different iterations of the manuscript. KH, LM, ND and SLJ contributed to the interviews. KH, LM and SLJ conducted the policy review. LJA contributed to mass media data collection. SM and SV contributed to social media monitoring, data collection and analyses. KH conducted data analysis of all data and wrote the first draft of the manuscript. ND supervised data analysis and reviewed different iterations of the manuscript. All authors edited the manuscript and approved the final version.

Transparency statement

The lead author and guarantor (KH) affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Funding

This study received no external funding.

Ethical approval

This study was approved by the Health Research Authority (HRA) and Health and Care Research Wales (HCRW) and the R&D offices of the hospitals where the study took place.

IRAS project ID: 282069

Trial registration details

Not applicable as this was not a clinical trial.

Dissemination statement

We plan to disseminate the results to study participants.

Data sharing statement

All data relevant to the study are included in the article or uploaded as supplementary information.

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ABSTRACT

Objectives

To report frontline healthcare workers' (HCWs) experiences with personal protective equipment (PPE) during the COVID-19 pandemic in the UK. To understand HCWs' fears and concerns surrounding PPE, their experiences following its guidance and how these affected their perceived ability to deliver care during the COVID-19 pandemic.

Design

A rapid qualitative appraisal study combining three sources of data: semi-structured in-depth telephone interviews with frontline HCWs (n=46), media reports (n=39 newspaper articles and 145,000 social media posts) and government PPE policies (n=25).

Participants

Interview participants were HCWs purposively sampled from critical care, emergency and respiratory departments, as well as redeployed HCWs from primary, secondary and tertiary care centres across the UK.

Results

A major concern was running out of PPE, putting HCWs and patients at risk of infection. Following national-level guidance was often not feasible when there were shortages, leading to re-use and improvisation of PPE. Frequently changing guidelines generated confusion and distrust. PPE was reserved for high-risk secondary care settings and this translated into HCWs outside these settings feeling inadequately protected. Participants were concerned about differential access to adequate PPE, particularly for female and Black, Asian and Minority Ethnic (BAME) HCWs. Participants continued delivering care despite the physical discomfort, practical problems and communication barriers associated with PPE use.

Conclusion

This study found that frontline HCWs persisted in caring for their patients despite multiple challenges including inappropriate provision of PPE, inadequate training and inconsistent guidance. In order to effectively care for patients during the COVID-19 pandemic, frontline HCWs need appropriate provision of PPE, training in its use, as well as comprehensive and consistent guidance. These needs must be addressed in order to protect the health and well-being of the most valuable healthcare resource in the COVID-19 pandemic: our HCWs.

STRENGHTS AND LIMITATIONS OF THE STUDY

- This is the first study to qualitatively explore healthcare workers' (HCWs) experiences with PPE in the UK during the COVID-19 pandemic.
- The study combined three sources of data (interviews, policies and media) collected at different stages of the pandemic (pre-peak, during the first peak and post-peak).
- The interview study sample was limited in its representation of the experiences of BAME and community HCWs.
- Due to restrictions accessing hospital sites during the pandemic, the study was not able to directly capture practices associated with PPE use.

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INTRODUCTION

The provision of personal protective equipment (PPE) for frontline healthcare workers (HCWs) has become a defining problem of the Coronavirus disease 2019 (COVID-19) pandemic.[1] The demand for PPE has put global supply chains under unprecedented strain.[2] By March 2020, the World Health Organization (WHO) called for rational PPE use and for global PPE manufacturing to be scaled up by 40%.[3] This has led to concerns regarding inadequate provision of PPE and its impact on the protection of frontline HCWs. There have been widespread reports of HCWs across the world having to deliver care without adequate PPE.[4, 5] In an international survey in April 2020, over half of HCWs that responded had experienced PPE shortages, nearly a third were reusing PPE and less than half had adequate fit-testing.[6] In the United Kingdom (UK), a third of respondents from a Royal College of Nurses (RCN) survey[7] and over half from a British Medical Association (BMA) survey[8] said they felt pressure to work without adequate PPE. Both surveys also raised concerns that HCWs identifying as Black, Asian and Minority Ethnic (BAME) and female may be disproportionately affected by PPE shortages. Additional concerns over impaired communication, physical discomfort, overheating and dehydration associated with PPE have also been raised.[9] As of 20 July 2020, 313 HCWs had died from COVID-19 in the UK.[10]

Knowledge from previous epidemics highlights the importance of PPE for frontline HCWs to reduce the spread of disease, safeguard HCWs' health and well-being, and maintain a sustainable health workforce to curb the outbreak.[11] Adequate provision of PPE, as well as clear guidance and training in its use help HCWs feel confident and prepared to deliver care.[12] Previous epidemic research also highlights the value of understanding HCWs' fears and concerns in order to support them on the frontline of an outbreak.[13] Qualitative research methodologies are increasingly being used to inform response efforts. In the 2014 Ebola and 2015-16 Zika outbreaks, qualitative research helped generate context-specific, real-time recommendations to improve the planning and implementation of response efforts.[14]

Research on the appropriate level of PPE for COVID-19 is still ongoing.[15] Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) is thought to be transmitted via respiratory, contact and airborne transmission.[16] Respiratory and contact precautions recommended by Public Health England (PHE) when caring for suspected cases include a Fluid-Resistant (Type IIR) Surgical Face Mask (FRSM), apron, gloves, and eye protection upon risk assessment.[17] Airborne precautions recommended when caring for patients requiring aerosol generating procedures (AGPs) are higher and include a filtering facepiece 3 (FFP3) respirator, long-sleeved disposable fluid-repellent gown, gloves and eye protection.[17]

PPE has become a critical issue for frontline HCWs in the COVID-19 pandemic but studies capturing HCWs' experiences with PPE are lacking.[18] The aims of this study were to determine (a) frontline HCWs' experiences following local level (i.e. Trust) and national level (i.e. government) PPE guidance; (b) concerns and fears among HCWs regarding PPE in the context of the COVID-19 pandemic; and (c) how these experiences and concerns affected HCWs' perceived ability to deliver care during the pandemic.

METHODS

Design

This study was part of a larger ongoing study on frontline HCWs' perceptions and experiences of care delivery during the UK COVID-19 pandemic.[19] We utilised a rapid appraisal methodology with three sources of data, including telephone interviews with frontline staff, a policy review, and media analysis (see Table 1). A rapid qualitative appraisal is an iterative

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approach to data collection and analysis, which triangulates findings between multiple sources of data to develop an understanding of a situation.[20] It was chosen for its ability to generate targeted research in a timely manner in order to help inform response efforts to complex health emergencies.[14] The use of an intensive, team-based approach with multiple sources of data helped to increase insight and validity of results.[21]

Sampling and recruitment

We used purposive and snowball sampling to recruit HCWs from critical care, emergency and respiratory departments, as well as redeployed staff from primary, secondary and tertiary care settings (see Appendix 1). They had a variety of experience, ranging from newly qualified to over 40 years working in the National Health Service (NHS). Participants were approached by clinical leads in their Trusts to gather verbal consent for the research team to contact them via email. Participants were provided with a participant information sheet and after filling out a consent form, had a telephone interview arranged.

Patient and Public Involvement

The study protocol and study materials were reviewed by the team's internal patient and public involvement panel. The panel's feedback was used to make changes in the research questions and study materials.

Data collection

Interviews

46 in-depth, semi-structured telephone interviews with frontline HCWs were carried out using a broad topic guide focusing on HCWs' perceptions and experiences of the COVID-19 response effort with questions relating to PPE throughout (see Appendix 2). The use of interviews facilitated in-depth discussions and the broad topic guide allowed participants to focus on aspects that were important to them. It allowed participants to discuss their experiences with PPE on their own accord and in a variety of contexts. Interviews were carried out before, during and after the first peak of the pandemic, which allowed for experiences to be captured in real-time. Demographic data was also collected through interviews. A multidisciplinary research team (including CVP, KH, LM and SLJ) conducted the interviews. Informed, written consent was obtained from all participants. Interviews were audio recorded, transcribed verbatim and all data anonymised. Emerging findings were summarised in the form of Rapid Assessment Process (RAP) sheets[20] to increase familiarisation and engagement with the data.[22] Interviews were included until data reached saturation, determined by no new themes emerging from RAP sheets.[23]

Policies

A review of 25 UK government policies and guidelines relating to PPE was carried out to contextualise HCWs' experiences following PPE guidance using Tricco et al.'s framework.[24] SLJ, LM and KH selected policies that met the inclusion criteria (see Appendix 3), cross-checked and extracted data into Excel.

Media

A rapid evidence synthesis of 39 newspaper articles and 145,000 English language Twitter posts meeting the inclusion criteria (see Appendix 3) was carried out utilising the same methodology as the policy review.[24] LJA screened titles and full texts of mass media data with

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exclusions cross-checked by another researcher. SM and SV utilised the media monitoring software Meltwater[25] to collect social media data using keyword searches on Twitter.

Data analysis

The study was informed by a theoretical framework derived from anthropological perspectives on the material politics of epidemic responses.[26] All streams of data were analysed using the Framework Method,[27] as this type of analysis has been effective for rapid qualitative appraisals in previous epidemics.[14] Social media data underwent additional demographic, discourse and sentiment analysis using the software TalkWalker.[28] The interview data were initially coded by KH and codes were cross-checked by CVP and ND. We also underwent a process of member checking, whereby researchers shared emerging findings to cross-check interpretations. All sources of data were coded with the same analytical framework to triangulate findings between the different streams of data.

Table 1: Methods of data collection and analysis.

Type of data	Method of collection	Included sample	Method of analysis
Interviews	In-depth, semi-structured telephone interviews were carried out with frontline staff.	46 interviews conducted between 19 March 2020 and 7 July 2020.	Emerging findings summarised as RAP sheets. Verbatim transcripts were coded and data analysed using framework analysis. The coding framework was cross-checked by two researchers and we underwent a process of member checking.
Policies	PPE policies were selected from legislation.gov.uk, https://www.england.nhs.uk (NHS England) and https://www.gov.uk/ (Public Health England, Department of Health and Social Care) using search terms such as 'COVID-19' OR 'coronavirus' OR 'corona.'	25 policies published between 1 December 2019 and 5 June 2020.	Data were extracted into Excel by hand, cross-checked by another researcher and analysed using the same analytical framework.
Media	Mass media data were collected through the LexisNexis database (using search terms such as 'COVID-19' OR 'coronavirus' OR 'corona') and hand searching.	39 newspaper articles published between 15 March 2020 and 5 June 2020.	Data were extracted into Excel using the software Research Electronic Data Capture (REDCap), cross-checked by a reviewer and analysed using the same analytical framework.
	Social media data were collected through the software Meltwater[25] and Talkwalker.[28]	145,000 English language social media posts made between 1 December 2019 and 31 May 2020.	Data were selected, coded and analysed, then integrated into the same analytical framework.

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RESULTS

This section presents the participant demographics (see Table 2) and the main themes of the study summarised using examples from all streams of data (see Table 3).

Participants

Participants represented a range of HCWs. The majority were doctors and nurses working in hospital settings and one HCW not working on the frontline (management role) was included for their expertise in infection prevention and control (IPC) services.

Table 2: Participant demographics

	Sample (n=46)	Percentage total (%)
Role		
Doctor	28	60.87%
Nurse	8	17.39%
Medical associate professional[1]	4	8.70%
Pharmacist	2	4.35%
Dietician	1	2.17%
Speech and language therapist	1	2.17%
Clinical support staff	1	2.17%
Management	1	2.17%
Sector		
Secondary and tertiary care (general and specialist hospitals)	40	86.96%%
Primary care[2]	4	8.70%
Specialist community services[2]	2	4.35%
Secondary and tertiary care specialities		
Critical care and anaesthesia[3]	27	67.50%
Respiratory and COVID-19 wards	6	15.00%
Emergency medicine	4	10.00%
Cancer specialist services	1	2.50%
Palliative care	1	2.50%
Infection prevention and control services	1	2.50%
Redeployment status		
Redeployed	23	50.00%
Not redeployed	23	50.00%
Ethnicity[4]		
White	40	86.96%
Mixed or multiple ethnic groups	3	6.52%
Asian or Asian British	2	4.35%
Black, African, Caribbean or Black British	1	2.17%
Total	46	100%

[1] Including physician associates, anaesthesia associates and advanced critical care practitioners

[2] Redeployed or awaiting redeployment to secondary or tertiary care centres

[3] Including Intensive Care Unit (ICU), Intensive Therapy Unit (ITU), High-dependency Unit (HDU)

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[4] BAME is a term used in the UK to refer to individuals who identify as Black, Asian and from Minority Ethnic groups.

Table 3: Summary of themes from all streams of data

Main themes	Sub-themes	Policy review	Media analysis	Illustrative interview quotes
Theme 1: PPE guidance and training - "We weren't prepared enough"	**Inconsistent guidance**	PHE guidance changed on March 6 2020 to advise FRSM masks be used instead of FFP3 respirators when assessing or caring for suspected COVID-19 patients.[29]	Newspaper reports of HCWs expressing concerns about caring for suspected cases with FRSMs instead of FFP3 respirators.	*"What is really difficult for staff is that they're being told to use a certain level of PPE for suspected patients but they might be watching the television and seeing, either from our country or other countries, people looking after patients wearing complete gear - total hazmat suits - covered from top to toe. Then they're saying, 'I'm being given much less than that to go see patients.'" (Doctor, Consultant)* *"Some staff felt messages of what PPE is required, in what situations, that there was a little bit of distrust…If the advice keeps changing, are we getting the right message? And is this message safe? Which caused a bit of worry and anxiety for some of the staff because at the same time they were hearing on the press that colleagues in other hospitals were getting sick." (Senior nurse)* *"The guidelines are created within an emergency context…but I think that at local level, there should be an interest into tailoring those guidelines to needs." (General practitioner)*
	The training gap	On 2 March 2020, all NHS organisations	Newspaper reports of HCWs working in PPE without having	*"I haven't had any training…some other nurses have been trained to use ventilators but there hasn't been any PPE training or anything else at all." (Nurse)*

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		advised to provide HCWs with fit-testing and PPE training.[30]	received training.	*"PPE training happened because of local engagement of clinicians rather than coming from the management…it is clinicians who have been coming knocking on the door saying we need to prepare and perform these trainings – that was strange, why didn't that change come from the top?" (Doctor, Consultant)*
Theme 2: PPE supply - **"If we're not protected, we can't protect the public"**	**Shortages (PPE size, level and quality)**	On 17 April 2020 PHE guidance changed to approve the re-use of PPE where there were acute shortages and it was safe to do so.[31]	Newspaper reports of inadequate access to PPE, especially for BAME, female and community HCWs.	*"So, there were times, for instance, where you needed to go to the loo, but you didn't want to waste PPE." (Doctor, Registrar)* *"What I don't think was good was the PPE situation, begging for personal protective equipment, feeling guilty for asking for it, feeling guilty for raising our voices." (Medical associate professional)* *"Some of the scrubs, there weren't enough small ones…and well, you wouldn't expect a six-foot man to wear something that would fit me."([Female] Doctor)* *"We didn't have family members coming in wearing PPE and seeing their relatives to say goodbye before they die, and we should have been able to facilitate that." (Doctor, Consultant)*
	Procurement	In a letter to Trust chief executives on 17 March 2020, NHS England stated that	HCWs using the 'panorama' hashtag on Twitter (n=2000 tweets) which referred to the BBC	*"I think the one thing that's probably been the biggest challenge has been sourcing PPE…That was probably the single biggest anxiety-inducing thing for staff on the ground. We never got to the point where we ran out but there was always this sense that we don't know where*

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		there are local distributio n issues despite an adequate national supply of PPE.[32]	investigatio n on whether the government failed to purchase PPE for the national stockpile in 2009.	*next week's is coming from. And the Trust always did manage to find it, but it was complex." (Doctor, Consultant)* *"So there has been provision of PPE but not necessarily always PPE that is as secure as it could be." (Senior nurse)*
	Risk of exposure	PHE guidance from 14 March 2020 advised HCWs who came into contact with a COVID-19 patient while not wearing PPE could remain at work unless they developed symptoms .[33]	News reports attributing a lack of PPE to frontline HCWs falling ill and dying.	*"They were saying that we were the ones that really should be using [PPE] and anyone who was in the room but is further away doesn't need it, because they're not at the mouth of the patient…you were begging to have more…you'd have to really make a stand and say well, 'everybody in my team is wearing it.'" (Medical associate professional)* *"The first thing to do is making sure the healthcare professional feels that they are not jeopardizing the life of their own families…don't make them feel like a pawn in a bigger game, because sometimes we feel like we are obliged to do stuff to save the rest, but we are part of the rest too." (Doctor, Consultant)* *"It was really scary because, it's not just the patients…it's the attitude towards the staff as well. They were treating anybody like you had it. I had an anaesthetist in the early days, when we weren't being given PPE, it was just like 'don't come in, keep away from me', and it was really difficult to work keeping apart from someone. It was like the way they treated you as well, as though you're infected so*

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				don't come near me." (Medical associate professional)
Theme 3: Challenges of delivering care in PPE - "It's necessary but it makes everything more difficult"	**Physical effects**	PHE guidance states that HCWs should remain hydrated and be trained to recognise dehydration, fatigue and exhaustion while wearing PPE.[31]	Staff nurse in a news report describes taking minimal breaks during their 12-hour shift to avoid changing out of PPE to access water or toilets.	*"It's hot, it's sweaty, it's inconvenient" (Doctor, Consultant)* *"The effort staff made for the patients, even though they were uncomfortable, overall was remarkable really." (Senior nurse)*
	Practical problems	On March 12 2020, PHE guidance stated that FFP3 respirator, long-sleeved disposable fluid-repellent gown, gloves and eye protection must be worn for APGs.[34]	Consultant in a news report describes how PPE made treating patients significantly more difficult, obscuring their vision.	*"It makes it more difficult to go between patients. So, for example if there is an emergency in the non-coronavirus bay you can't just leave. You have to take off all the PPE in a particular way to make sure you don't contaminate yourself and then go to see what the emergency is. It causes a small delay that probably doesn't make a difference, but psychologically it feels more stressful because you feel like it's taking a lot longer." (Doctor, Registrar)*
	Communication and connection	On 24 April 2020, PHE IPC guidance advised Trusts that "visiting should be restricted to those assessed as able to wear PPE."[17]	Positive news reports of HCWs using PPE portraits (disposable photos of their faces on top of PPE) to overcome rapport problems	*"I think it does make you feel very …dehumanized because you can't recognize any of your colleagues." (Senior pharmacist)* *"When you've got patients on the ward and they are stuck in a room on their own and everyone in the room is dressed in PPE and they can't have their relatives visiting them that's actually really frightening and*

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			with patients.	*stressful and will create problems for people." (Doctor, Consultant)*

Figure 1: Timeline of changes to national PPE guidance (AGP; Aerosol Generating Procedures, FFP3; Filtering facepiece 3, FRSM; Fluid-Resistant (Type IIR) Surgical Face Mask, HCW; Healthcare worker, High-risk area; ICU, ITU, HDU).

Theme 1: PPE guidance and training - "We weren't prepared enough"

Inconsistent guidance

Towards the start of the outbreak, interviewed HCWs reported limited PPE guidance leading them to care for suspected COVID-19 patients without appropriate PPE. All streams of data analysis found that national PHE and Trust-level PPE guidance changed frequently (see Figure 1), with daily changes reported in early April 2020. Inconsistent guidance led to confusion, distrust and a lack of confidence in the messaging.

On 6 March 2020, PHE recommended that FRSMs were to be used instead of FFP3 respirators when caring for suspected patients.[29] On 20 March 2020, guidance stated that FFP3 respirators were only needed when managing suspected or confirmed patients, requiring one of their listed "potentially infectious AGPs" and in high-risk units such as the intensive care unit (ICU), intensive treatment unit (ITU) and high-dependency unit (HDU).[35] On 2 April 2020, guidance changed to advise that if FFP3 respirators were not available, FFP2 respirators could be used instead for some AGPs.[36] HCWs were concerned that this level of PPE was inadequate. Media analysis showed reports of HCWs being advised to wear single-layer paper surgical masks, instead of FRSMs or FFP3 masks whilst caring for suspected patients. HCWs felt PHE's list of potentially infectious AGPs[17] was not comprehensive enough, missing important potential AGPs, such as administering medication via nebulisation and performing chest compressions. HCWs were concerned about the change in PHE guidance on 10 April 2020,[37] which allowed the use of coveralls with a disposable plastic apron for APGs instead of full-length fluid-repellent gowns. Reports of PPE shortages in interviews and media analyses coincided with the 17 April 2020 PHE guidance which changed to approve the re-use of PPE when there were acute shortages and it was deemed safe to do so.[31] Having to re-use PPE was distressing, especially when sharing with colleagues. HCWs were concerned that the down-grading and frequent changes to guidance were grounded in supply problems.

As the pandemic progressed, some HCWs felt overwhelmed by increasing amounts of guidance from multiple sources. They felt that having a dedicated team to sort through the information would have increased its clarity. HCWs from community health services found interpreting PPE guidance catered towards hospital-based settings challenging. Senior HCWs were often involved in interpreting national guidance in the context of their local Trust, liaising between staff and management. Some nurses felt as though their voices were not heard in the decision-making processes surrounding PPE guidance and supply on the ward. This was difficult for them as they spent most of their shifts in PPE. HCWs in interviews and the media were concerned about the UK guidance in comparison to other countries, where they felt higher levels of PPE were being provided to HCWs.

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The training gap

Most interviewed HCWs in emergency medicine, critical care and anaesthesia reported adequate PPE training on how to safely don and doff PPE. However, some HCWs felt there was a "training gap" and expressed the need for earlier, more accessible training available for a wider range of HCWs. Some HCWs reported having had PPE training during past epidemics, but most were unfamiliar with the PPE required for COVID-19 patients. On 2 March 2020, NHS England advised all organisations to provide HCWs with PPE training.[30] Interviewed HCWs felt PPE training was less accessible to HCWs working outside of high-risk units, such as general wards, surgery, and primary care. Media analysis found training was lacking for HCWs working in the community and in care homes. HCWs took initiative in teaching themselves to safely use PPE when training was not available nor provided early enough. Having training available during both day and night shifts, as well as online materials helped to make PPE training more accessible.

Theme 2: PPE supply - "If we're not protected, we can't protect the public"

Shortages (PPE size, level and quality)

HCWs in the media expressed concerns about PPE stockpiles running low from the beginning of March 2020. All streams of data analysis found reports of PPE shortages from across the UK, most notably in care homes, community health facilities and general practice. Visors, full-length fluid-repellent gowns and fluid-repellent facemasks were especially in short supply. One interviewed HCW described PPE being locked in an office with someone monitoring its use. In comparison to critical care staff, interviewed HCWs from general wards and those from smaller, less prominent hospitals reported greater barriers in access to PPE. Negative sentiment social media posts were mainly related to PPE shortages and towards a member of parliament (MP) who reported that care homes had adequate PPE. The positive social media posts were related to deliveries and donations. Informal help and resources advising on appropriate PPE use and how to adapt to limited supplies, was shared on social media.

PHE guidance stated that respirators needed to be the correct size, fit-tested before use, and that HCWs were not to proceed if a "good fit" could not be achieved.[38] Many HCWs reported failing their respirator fit-test and a lack of alternatives meant that they proceeded caring for COVID-19 patients with these masks or used a lower level of protection. This was especially the case for female HCWs who experienced a lack of small sized masks and scrubs. Media analysis found reports of greater PPE supply problems for BAME HCWs. Powered air purifying respirator (PAPR) hoods (an alternative for HCWs with beards unable to shave for religious reasons) were especially lacking. Concerns were raised that nurses, healthcare assistants and physician associates faced greater barriers accessing PPE than doctors. HCWs were also concerned about the quality of PPE. Media analysis found that Trusts, particularly in primary care, received shipments of out-of-date PPE. The policy review found that NHS England stated these shipments of outdated PPE had "passed stringent tests that demonstrate they are safe."[39]

HCWs reported several adaptions to delivering care in order to preserve PPE, such as the use of open bays with multiple COVID-19 patients, and fewer HCWs seeing patients on ward rounds. Verbal prescriptions were used more frequently to avoid entering the COVID-19 bay and wasting PPE to write a prescription. The policy review found guidance on 20 March 2020 in response to concerns about mask shortages that stated, "if a member of staff does not need to go into the risk area, they should be kept out."[35] On 24 April 2020, PHE guidance advised that visiting should be restricted to essential visitors able to wear PPE.[17] Some HCWs were

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concerned that PPE supply was a contributing factor limiting families visiting critically ill patients.

Procurement

On 17 March 2020, the Department of Health and Social Care (DHSC) announced that there were local PPE distribution problems despite a “currently adequate national supply.”[32] On 10 April 2020, PHE released their PPE plan which explained that "there is enough PPE to go around, but it’s a precious resource and must be used only where there is a clinical need to do so."[40] They emphasised the importance of following national PPE guidance to reduce the significant pressure the supply chain was under. HCWs in interviews and media reported their facilities sourcing PPE at higher costs than usual. Some HCWs resorted to privately purchasing PPE and some Trusts received PPE donations, including 3D printed masks and visors. Extreme examples from the media included HCWs improvising PPE using children’s safety goggles, cooking aprons and bin liners. On social media these concerns were expressed by HCWs using the “panorama” hashtag on Twitter (n=2000 tweets) which referred to the BBC investigation on whether the government failed to purchase PPE for the Pandemic Influenza Preparedness (PIP) stockpile in 2009. Even for interviewed HCWs that did not experience PPE shortages, the incremental basis of procurement was concerning for them. HCWs highlighted that facilities should have had prepared larger stockpiles and argued in favour of international collaboration on global PPE supply chains. Clear communication about PPE procurement and reassurance that stocks were adequate helped alleviate fears.

Risk of exposure

Interviewed HCWs feared that a lack of PPE increased their risk of exposure to COVID-19, especially for HCWs that had underlying conditions or were male, BAME, pregnant or been redeployed from retirement. Concerns were compounded by media reports of HCWs in other facilities catching COVID-19 due to insufficient PPE and subsequent exposure to high viral loads. This uncertainty was in the context of a lack of testing for HCWs, causing worries that they were spreading the virus between colleagues, patients and the public. Some HCWs described concerns regarding nosocomial transmission and a change in attitude between colleagues when there was a lack of PPE. A lack of cleaning and changing facilities meant HCWs would wear potentially contaminated clothes home. HCWs expressed concerns about exposing vulnerable household or family members. The policy review found that on 14 March 2020, PHE advised that HCWs who came into contact with COVID-19 patients while not wearing PPE could remain at work unless they developed symptoms.[33] This policy was subsequently withdrawn on 29 March 2020. HCWs with infectious disease experience, working with adequate provision of PPE and those that had already been ill with COVID-19 reported less fear of exposure. As data collection progressed, HCWs became increasingly used to their new working environments, more familiar with using PPE and less afraid of catching COVID-19.

Theme 3: The challenges of delivering care in PPE – “It’s necessary but it makes everything more difficult”

Physical effects

Interviewed HCWs described PPE to be tiring and uncomfortable to wear, making it more difficult to deliver care. The effects were pronounced for nurses who spent most of their shifts in PPE, and older HCWs with underlying conditions. Tight masks caused facial pain, marks and bruises, rashes, dry skin as well as difficulties breathing, headaches and irritability. HCWs

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persisted in delivering care despite these effects, often against the PHE advice from 24 April 2020 that respirators "should be discarded and replaced, and not be subject to continued use" when uncomfortable or difficult to breathe through.[17] For some HCWs, the effects were so severe that they asked to be reassigned to non-COVID wards. Full-length gowns were hot and sweaty, causing overheating and dehydration. Conditions were exacerbated by HCWs fasting during Ramadan and warm weather. HCWs expressed the importance of breaks but often found it difficult to take them, especially on busy wards with shortages of staff and PPE. Wasting PPE on breaks generated feelings of guilt. Drinking less water to avoid having to take breaks made it difficult to follow guidance to remain "appropriately hydrated during prolonged use."[17]

Practical procedures

HCWs found delivering care in PPE to be cumbersome. Donning and doffing PPE contributed to a slower delivery of care, and palpation during physical examinations was less effective with multiple layers of gloves. Goggles fogging up whilst performing procedures, such as intubation and administration of anaesthesia, was frustrating and stressful. Being in PPE restricted HCWs' movements between patients and wards. Junior HCWs, for example, found that, when in full PPE, they were less able to ask for help from seniors outside the COVID-19 bay not in PPE. HCWs needed to be more prepared than usual when going to see a patient requiring PPE, as they would be unable to leave without doffing and re-donning PPE.

Communication and connection

HCWs found it more difficult to build rapport with patients as PPE limited facial expressions, physical touch, and time spent with patients. Being in full PPE could be intimidating, especially for delirious patients. Some HCWs found it difficult to recognise colleagues and often had to shout to be heard through facemasks. Communication problems arose with patients that were elderly and hard of hearing as they relied heavily upon lipreading. HCWs in PPE found alternative forms of communication with colleagues outside of COVID-19 bays, such as portable radios. Some HCWs reported removing their masks when speaking about important topics, such as gaining consent or breaking bad news. HCWs in interviews and media described overcoming rapport problems through use of disposable photos of themselves on their PPE (i.e. disposable photos of their faces attached to gowns).

DISCUSSION

This study found that HCWs faced multiple challenges delivering care including inadequate provision of PPE, inconsistent guidance and lack of training on its use. HCWs persisted delivering care despite the negative physical effects, practical problems, lack of protected time for breaks and communication barriers associated with wearing PPE. In the face of training, guidance and procurement gaps, HCWs improvised by developing their own informal communication channels to share information, trained each other and bought their own PPE.

To our knowledge, this is the first qualitative study reporting frontline HCWs' experiences with PPE during the COVID-19 pandemic in the UK. It offers first-hand experiences from the perspective of HCWs and contributes to the ongoing research on PPE for frontline HCWs during the COVID-19 pandemic. Although our sampling framework aimed to seek representation of participants across multiple professional backgrounds, our sample included a higher proportion of doctors. It was also limited in its representation of BAME and community HCWs' experiences. The term BAME, although widely used in the UK, is limited in its specificity and representation of wider ethnic groups.

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HCWs reported similar effects of PPE being hot, tiring, time-consuming and restrictive in previous epidemics.[41, 42] Singh et al.[43] found that 21% of COVID-19 HCWs they sampled took a leave of absence due to PPE-associated skin problems. In addition to the implications for the workforce, they also raised concerns that skin breaches, irritation and increased touching of the face could act as a source of SARS-CoV-2 exposure. Participants in this study expressed the value of taking breaks to combat the physical effects of PPE but often found it difficult to do so as a result of staff shortages, heavy workloads and guilt over wasting PPE.

PPE reduced HCWs' ability to develop rapport with patients by masking facial expressions and impairing non-verbal and verbal communication. "PPE portraits" have re-emerged in the COVID-19 pandemic after first being used in the 2014 Ebola outbreak to re-humanise care delivery and have positive anecdotal evidence from HCWs and patients.[44] Reducing the number of staff on COVID-19 wards to reduce PPE demand raised concerns about increased workloads and quality of care.

Some participants felt PPE training was not always easily accessible nor implemented early enough. A third of HCWs that responded to a survey by the Royal College of Nurses (RCN) reported on the 8th of May that they had not received PPE training.[7] Studies on HCWs' perceptions of working during previous infectious disease outbreaks highlight the importance of PPE training for HCWs to feel confident and prepared.[45, 46] Incorrect use of PPE exacerbates shortages and puts HCWs at higher risk of infection.[47] Participants in this study described difficulties accessing training sessions between long shifts and raised concerns that HCWs outside of high-risk settings may experience less training. Previous research has also highlighted that during outbreaks, community HCWs tend to receive less PPE training and face greater difficulties following national guidance often directed towards hospital settings.[48, 49]

Actual and perceived shortages were a major source of anxiety for participants in this study. They advocated for adequate PPE provision to protect their own health and safety. Similar fears of self-infection and transmission of SARS-CoV-2 to colleagues, patients and household members due to a lack of PPE have been reported amongst HCWs in China,[9] the United States[50] and Italy.[51] Evidence on the safety of PPE reuse and extended use is limited, but suggests that it can increase the risk of HCW self-infection and hospital transmission.[47] This is particularly the case in the absence of clear guidance, protocols and a limited evidence-base on best practice.[52]

Participants in this study were concerned by the downgrade in guidance from recommending FFP3 respirators to FRSMs,[29] as well as fluid-resistant full-length gowns to coveralls.[37] They felt these changes were grounded in supply issues rather than safety measures. Current national guidance may be underestimating the risk of HCWs' exposure to COVID-19 outside of high-risk settings, potentially resulting in inadequate protection for those HCWs.[52] Prioritising higher levels of PPE for HCWs in high risk areas is thought to have contributed to lower death rates amongst anaesthetists and intensivists.[53] However, such an approach may be jeopardising the health and safety of HCWs working in lower-risk areas.[54] PHE guidance recommending FRSMs is lower compared to countries recommending higher level respirator masks (N95, FFP2 or FFP3), such as Australia, USA, China, Italy, Spain, France and Germany.[52] UK HCWs working on COVID-19 wards following current PHE PPE guidance had nearly three times higher rates of asymptomatic infection compared to HCWs not in COVID-19 areas.[55] Whilst there are many possible explanations for these findings, an inadequate level of PPE was considered a contributing factor. A key challenge is that research on the transmission of SARS-CoV-2 and the lowest effective level of PPE is ongoing.[56] Overuse of PPE uses up supplies and may increase risk of transmission through frequent changing, instilling a false sense of safety and potentially reducing the use of other important IPC measures.[57, 58] However, a recent systematic review and meta-analysis suggests that FFP3

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respirators provide a higher level of protection against infection than FRSMs, even in the absence of AGPs.[59] HCWs in a study in China experienced no infections with SARS-CoV-2 when provided with appropriate PPE training and supply, including "protective suits, masks, gloves, goggles, face shields, and gowns."[15]

Participants in this study raised concerns that female and BAME HCWs may face greater barriers accessing adequate PPE than other colleagues. During the 2015 Middle East Respiratory Syndrome (MERS) outbreak in Korea, female HCWs faced similar challenges with oversized masks and coveralls.[60] Despite only making up 21% of the NHS workforce, BAME HCWs have been overrepresented in the proportion of HCW deaths from COVID-19 in the UK, accounting for 63% of nurses and 95% medical staff deaths.[61] Official inquiries into the underlying causes of these trends are ongoing.[62] However, a recent study found that lack of access to PPE was perceived by BAME HCWs in the UK as a major factor contributing to the higher death rates.[63] Recent studies suggest that in addition to being at greater risk of catching COVID-19, BAME HCWs are more likely to experience inadequate provision and reuse of PPE.[47] A BMA survey found that only 40% of UK BAME HCWs working in primary care felt they had adequate PPE compared to 70% of White HCWs.[8] The same survey found that 64% of BAME HCWs felt pressure to work in AGP areas without adequate PPE compared to 33% of White HCWs.[8]

PPE provision for frontline HCWs has become a priority for response efforts across the world. The need for international collaboration to create sustainable and equitable global PPE supply chains is evident. In the UK, PPE procurement issues existed before the COVID-19 pandemic. The national stockpile was missing critical equipment, such as gowns, which have been short in supply during the pandemic.[64] A delayed national response, limited domestic PPE manufacturing and exclusion from the EU commission procurement initiatives to secure PPE for its member states left the UK especially vulnerable to shortages.[64] Knowledge from past epidemics highlights the importance of centralised procurement systems, monitoring PPE use and distributing according to need.[65]

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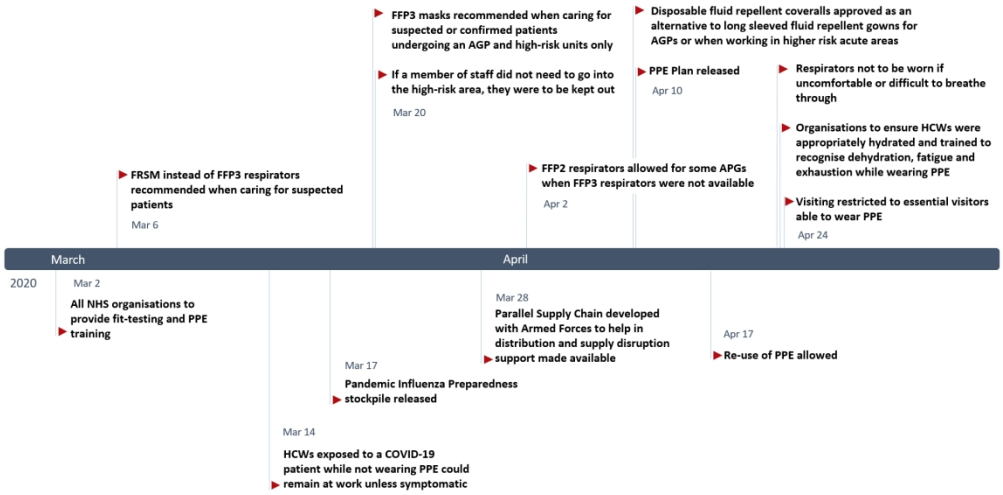

Figure 1: Timeline of changes to national PPE guidance

Appendix 1: Sampling strategy

This study used a combination of purposive and snowball sampling to recruit HCWs from a range of professional backgrounds. We targeted HCWs mainly from secondary and tertiary care centres within emergency, respiratory and critical care departments, including intensive care units (ICU), intensive treatment units (ITU) and high-dependency units (HDU). Participants included in our sample that were from primary care and community clinics were HCWs that had been redeployed or were awaiting redeployment to secondary or tertiary care centres. Our initial sample included 40 interviews. Purposive sampling allowed for six additional interviews to be included in the analysis in keeping with relevant emerging themes related to PPE and ethnicity.

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Appendix 2: Interview Topic Guide

INTERVIEW GUIDE: HEALTHCARE WORKERS (HCWs)

Date:

Gender	Age	Time in service (mm/yy)	Education level	Role/ position	Ethnicity	Sector and type of facility	Location of facility	Follow-up?

Respondent Information

"The interview takes about 20-25 minutes on average, but it can go on longer depending on how much you want to say"

First, I want to ask you about your work and the services you provide.

1. Background: Can you tell me about your role?

- *Can you tell me a bit about your role? (e.g. Daily tasks, department, responsibilities)*

2. Have you been in contact with patients who had suspected and/or confirmed COVID- 19?

Probes:

- *In what capacity?*
- *How have you found working around these patients?*
- *PPE physical effects? (E.g. dehydration, discomfort, restriction in movement, difficulties communicating)*
- *How has PPE impacted the type of care you provide patients?*
- *What psychological/emotional impact did this have on you?*

3. How has the COVID-19 outbreak affected health services in your department?

Probes:

- *How has this affected your normal daily tasks/responsibilities? Change of role?*
- *Impact of COVID-19 on the delivery of services to non-COVID-19+ patients (i.e. cancellation of elective surgeries)*
- *What tasks are you able to do more or less effectively?*
- *How do you manage the isolation of suspected cases and confirmed cases?*
- *Has there been appropriate transfer of patients within and out of hospital?*
- *Has there been an impact on staff's ability to make diagnoses and act on them?*
- *Has the supply of drugs, equipment and PPE been affected?*
- *Have staff been redeployed from or within your health facility*

4. What were the preparedness strategies implemented locally (department, hospital or Trust)?

- *Did you feel these strategies were enough?*
- *What do you feel was particularly successful?*
- *Should the Trust have prepared differently?*
- *Did you receive any training? (including but not limited to PPE training such as mental health and well-being training)*
- *Did you have access to guidance on PPE?*

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5. Do you currently have any concerns or fears in relation to ...

- *Work (response efforts, PPE, services)*
- *The national effort*

6. Over the past months, have you experienced any problems with aspects of your daily life such as sleeping, eating, concentration, or additional worries or anxiety?

7. Mental health support (to address risk of moral injury, trauma and developing severe mental health problems)

- *Are you aware of any support available for staff wellbeing and mental health?*
- *Have you had the opportunity to talk about your mental health with your supervisor/team leader?*
- *Have you had worrying experiences in the last week? Did you receive support after? If so, what type of support? (including formal and informal support)*
- *Interactions between peers: Do you have time to socialise with your team? What has changed with COVID-19?*

8. Have you been involved in caring for patients who are dying or expected to die soon?

If YES: Can you please tell me about your experience caring for these patients (e.g. what have you done, what were your responsibilities)?

Prompt: Advanced care planning, Symptom management/comfort, End of life decision making or Communicating with families.

- *How have you found these tasks?*
- *What difficulties or challenged have you faced in delivering this type of care?*
- *Do you feel this has had an emotional impact on you?*
- *Was this part of your normal role prior to COVID-19?*
- *Was there training or support available relating to this?*
- *Have you had to communicate with family members, how has that been?*
- *How does this differ to normal palliative care?*
- *How much choice do patients have?*
- *What are the rules/policies relating to this? Do you feel these are suitable?*

9. What do you feel is most important to offer COVID-19 patients at end of life and their families?

- *What is working well?*
- *What can we improve?*
- *What support do we need to offer HCW delivering palliative care?*
- *Are you able to offer bereavement support to families?*

10. OTs/PTs and others in charge of rehab: What are your main concerns about the impact of COVID-19 to the body (e.g. muscle degeneration, dexterity, impact to the lungs etc.)?

- *What resources do you have to deliver rehabilitation care? - ask their opinions on the Mary Seacole rehab hospital*
- *Is there a difference in resources for COVID-19 and non-COVID-19 patients?*

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11. (If relevant based on previous discussion) Can you please tell me about the rehabilitation care tasks you are involved in with recovered COVID-19 patients?

- *Have you received any guidance on how to deliver rehabilitation services to recovered COVID-19 patients?*
- *OT: How does this differ from normal rehabilitation care e.g. delivering care at home?*
- *OT: How has COVID-19 impacted your contact with patients?*
- *Has the pandemic impacted the flow of your patients through hospital e.g. are more or less patients being discharged to homes and bed-based rehab? - What is the impact of this?*
- *How do you think your role will be impacted as a growing number of people will need rehabilitation? Any concerns?*

General reflections

12. How have health services been strengthened, or how could they be strengthened during the outbreak?

Probes:

- *Support to HCWs from the health system and partners?*
- *Capacity for rapid response*
- *Policies? e.g. Guidance and emergency protocols?*
- *What would help HCWs to maintain normal services as well as COVID related services?*
- *If GP: Health promotion and community engagement. How?*
- *If GP: Linkage to other support organisations, e.g. charities, schools?*

13. Is there anything you feel should be changed to make health services more effective in future emergencies?

Probes:

- *Support to HCWs? From whom and How?*
- *Coordination and official guidance of COVID-19 response.*
- *Early detection and reporting.*
- *On-going health promotion and community education. E.g. potential sources of infection, safe practice?*
- *Mobilisation? E.g. identifying and coordinating trusted community volunteers and support?*
- *Disease outbreak control activities?*
- *Testing (public and staff)*

14. Do you feel your experience has been different from other HCWs? Does gender play a role? How about race or ethnicity?

15. How has your life at home been impacted by COVID-19?

16. Do you have any caring responsibilities, such as children or elderly family members?

If yes:

a. How are you managing care during the COVID-19 pandemic?
b. *(If they have children)* How has being a HCW during the pandemic impacted your ability to parent? ***time/experiences with your children?*

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c. What fears, worries, or emotions arise from the responsibility of caring for others during this time?

18. Is there anything else you would like to mention that you feel is important?

Thank you for your time and for sharing your opinions and experiences with us.

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Appendix 3: Inclusion criteria and search terms

Inclusion criteria	**Newspaper data**	1) Published between 15 March 2020 and 5 June 2020; 2) Aimed at healthcare delivery; 3) Related to the COVID-19 pandemic; 4) Related to personal protective equipment.
	Social media data	1) Published between 1 December 2019 and 31 May 2020.; 2) Aimed at healthcare delivery; 3) Related to the COVID-19 pandemic; 4) Related to personal protective equipment.
	Policy data	1) Published between 1 December 2019 and 5 June 2020.; 2) Aimed at healthcare delivery; 3) Related to the COVID-19 pandemic; 4) Related to personal protective equipment.
Search terms	**Media and policy data**	COVID-19 OR coronavirus OR corona
	Social media data	((bio:"healthcare professional" OR bio:"healthcare worker" OR bio:"doctor" OR bio:"NHS" OR bio:"nurse" OR bio:"physio*" OR bio:"Paramedic" OR bio:"Ambulance work*" OR bio:"Ambulance driver*") AND ("coronavirus" OR "#coronavirus" OR “corona” OR "COVID-19" OR "COVID 19" OR "COVID19" OR "#COVID19" OR "COVID_19" OR "COVID" OR "severe acute respiratory syndrome coronavirus 2" OR "severe acute respiratory syndrome coronavirus 2" OR "2019-nCoV" OR "SARS-CoV-2" OR "2019nCoV" OR "physio*" OR "PPE") OR ("i am" OR "as a" OR "source: I" OR "I'm a") near/5 ("doctor" OR "nurse" OR "doctors" OR "nurses" OR "Paramedic" OR "Ambulance worker" OR "Ambulance driver") AND ("coronavirus" OR "#coronavirus" OR “corona” OR "COVID-19" OR "COVID 19" OR "COVID19" OR "#COVID19" OR "COVID_19" OR "severe acute respiratory syndrome coronavirus 2" OR "severe acute respiratory syndrome coronavirus 2" OR "2019-nCoV" OR "SARS-CoV-2" OR "2019nCoV" OR "physio*" OR "PPE") NOT ("I am not" OR "I'm not"))

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Standards for Reporting Qualitative Research (SRQR) checklist

O'Brien B.C., Harris, I.B., Beckman, T.J., Reed, D.A., & Cook, D.A. (2014). Standards for reporting qualitative research: a synthesis of recommendations. *Academic Medicine, 89(9)*, 1245-1251.

No.	Topic	Item	Included? (yes/no)	Location in manuscript
Title and abstract				
S1	Title	Concise description of the nature and topic of the study identifying the study as qualitative or indicating the approach (e.g., ethnography, grounded theory) or data collection methods (e.g., interview, focus group) is recommended	Yes	Page 1
S2	Abstract	Summary of key elements of the study using the abstract format of the intended publication; typically includes objective, methods, results, and conclusions	Yes	Page 3
Introduction				
S3	Problem formulation	Description and significance of the problem/phenomenon studied; review of relevant theory and empirical work; problem statement	Yes	Page 4
S4	Purpose or research question	Purpose of the study and specific objectives or questions	Yes	Page 4, Page 5
Methods				
S5	Qualitative approach and research paradigm	Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., positivist, constructivist/interpretivist) is also recommended	Yes	Page 5
S6	Researcher	Researchers' characteristics	Yes	Page 5

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characteristics and reflexivity	that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, or transferability		
S7 Context	Setting/site and salient contextual factors; rationale[a]	Yes	Page 5
S8 Sampling strategy	How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling saturation); rationale[a]	Yes	Page 5
S9 Ethical issues pertaining to human subjects	Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues	Yes	Page 5
S10 Data collection methods	Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources/methods, and modification of procedures in response to evolving study findings; rationale[a]	Yes	Page 5
S11 Data collection instruments and technologies	Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study	Yes	Page 5, Appendix 2: Interview Topic Guide
S12 Units of study	Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)	Yes	Page 5, Page 7
S13 Data processing	Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and	Yes	Page 5-6

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	anonymization/deidentification of excerpts		
S14 Data analysis	Process by which inferences, themes, etc., were identified and developed, including researchers involved in data analysis; usually references a specific paradigm or approach; rationale[a]	Yes	Page 5-6
S15 Techniques to enhance trustworthiness	Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationale[a]	Yes	Page 4-5
Results/Findings			
S16 Synthesis and interpretation	Main findings (e.g., interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory	Yes	Page 12-15
S17 Links to empirical data	Evidence (e.g., quotes, field notes, text excerpts, photographs) to substantiate analytic findings	Yes	Page 8-11 (Table 3: Summary of themes from all streams of data), Figure 1: Timeline of changes to national PPE guidance
Discussion			
S18 Integration with prior work, implications, transferability, and contribution(s) to the field	Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application/generalizability; identification of unique contribution(s) to scholarship in a discipline or field	Yes	Page 15-17
S19 Limitations	Trustworthiness and limitations of findings	Yes	Page 15
Other			
S20 Conflicts of interest	Potential sources of influence or perceived influence on study conduct and conclusions; how these were managed	Yes	Page 1
S21 Funding	Sources of funding and other	Yes	Page 2

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	support; role of funders in data collection, interpretation, and reporting		

[a]The rationale should briefly discuss the justification for choosing that theory, approach, method, or technique rather than other options available, the assumptions and limitations implicit in those choices, and how those choices influence study conclusions and transferability. As appropriate, the rationale for several items might be discussed together.

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