

# Is it a challenging task to work with personal protective equipment in a COVID-19 ICU: Findings from a hospital-based cross-sectional study from north India

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## ABSTRACT

**Introduction:** Amidst the coronavirus disease 2019 (COVID-19) pandemic, the use of personal protective equipment (PPE) is mandatory for healthcare workers to remain protected against infection. The present study was undertaken to evaluate challenges faced by the healthcare workers while using level 3 PPE. **Methods:** This hospital-based study was conducted among resident doctors selected by convenience sampling method using a pretested, semi-structured, self-administered questionnaire after getting informed consent from the participants to collect data on the somatic, psychological, and technical problems faced while working in PPE. Bivariate and multivariable logistic regression was done between outcome variables and other independent variables to check for the association. **Results:** Of the total, 252 resident doctors completed the survey, their age ranged from 22 to 36 years with 140 (55.6%) males and 112 (44.4%) females. One-twenty-nine (51.2%) residents were trained to work in ICU, 73 (29%) participants used PPE ≤10 times and the rest 179 (71%) used PPE more than 10 times. The difficulties faced were as follows: visual impairment ( $n = 244$ , 96.8%), headache ( $n = 226$ , 89.6%), breathing difficulty ( $n = 216$ , 85.7%), hearing impairment ( $n = 201$ , 79.8%), sweating ( $n = 242$ , 96%), and fear of being infected ( $n = 156$ , 61.9%). Two-thirty-six (93.6%) participants felt that overall work quality reduced due to PPE. Headache, hunger, urge to micturate, anxiety, sleep disturbances, and need to change the timing of medication or diet were higher with increased duration of work with PPE. **Conclusion:** A longer duration of work is associated with headache, hunger, anxiety, and sleep disturbances. More research has to be done to improve the PPE to reduce problems like visual impairment, skin irritation, sweating, and breathing difficulty.

**Keywords:** COVID-19 ICU, headache, healthcare worker, PPE, visual impairment

## Introduction

Since the emergence of the novel Coronavirus in Wuhan, Hubei province (China) in December 2019, it started spreading

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CTRI registration no.: CTRI/2020/06/025560

Received: 27-09-2021

Revised: 07-12-2021

Accepted: 11-12-2021

Published: 14-05-2022

rapidly all over the world.<sup>[1]</sup> On March 11, 2020, the World Health Organization (WHO) declared “coronavirus disease 2019” (COVID-19) a global pandemic.<sup>[2]</sup> Globally, there were approximately 102.4 million people infected with coronavirus and around 2.2 million deaths as of February 01, 2021.<sup>[3]</sup> The coronavirus spreads through direct contact from the respiratory aerosol generated by an infected person or by indirect contact such as contact with contaminated surfaces.<sup>[4,5]</sup> To remain

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**How to cite this article:** Mahalingam K, Surbhi, Balaji A, Ganesh R, Daniel RA, Aggarwal R, *et al.* Is it a challenging task to work with personal protective equipment in a COVID-19 ICU: Findings from a hospital-based cross-sectional study from north India. *J Family Med Prim Care* 2022;11:1935-42.

### Access this article online

#### Quick Response Code:



Website:  
www.jfmpc.com

DOI:  
10.4103/jfmpc.jfmpc\_1937\_21

protected against infection, the healthcare workers must have a barrier between infectious material (blood, body fluids, aerosol, and respiratory secretions) and themselves. Personal protective equipment (PPE) acts as a barrier and is commonly used in health care settings. PPE refers to protective clothing, shoes, gloves, face shields, goggles, facemasks, and/or respirators designed to protect the wearer.

There are three levels of PPE recommended in different situations. Level 1 is recommended for standard infection control precautions (SICPs) when no suspected or known infectious agent is present; Level 2 is recommended in case of dealing with suspected or confirmed infectious agents that spread by contact, droplet, or airborne route and are not highly contagious; and Level 3 enhanced precautions are recommended for suspected or confirmed infectious disease of the high possibility of contagious spread due to direct/indirect contact or airborne route.<sup>[6]</sup> Level 3 PPE consists of a fluid-resistant long-sleeved gown, disposable fluid-resistant hood, full-length plastic apron, disposable full-face visor, FFP3 respirator, 2 sets of long cuffed gloves, surgical boots/shoes, and disposable boot covers. The same is also recommended while dealing with confirmed COVID-19 patients in an intensive care unit (ICU).<sup>[7]</sup> Use of a PPE does not eliminate the source of infection; hence, the wearer is at risk of being exposed to the hazard if the equipment fails. PPE creates a barrier between the user and the working environment, which can put extra strain on the wearer and impair their ability to carry out work comfortably. Any of these reasons can discourage wearers from using PPE correctly, therefore placing them at risk of getting infected. Better ergonomically designed PPE may help to minimize these issues and can, therefore, help to ensure safe practices. Even after all the measures, the use of level 3 PPE for long hours continuously can be exhausting and extremely uncomfortable with an increasing magnitude over time.<sup>[8]</sup> Few studies evaluated the PPE associated headache, skin rashes, and discomfort in breathing while using facepiece respirators.<sup>[8-18]</sup>

During the pandemic, doctors across various streams including primary care physicians were called up for managing COVID-19 patients both in ward and ICU. In this study, we aimed to evaluate both the somatic and psychological issues faced while using level 3 PPE among the resident doctors of a tertiary care hospital in north India. This study would give a better idea to the primary care physicians about the comfort level while working with PPE and also aid the health care administrators/policymakers to formulate tailored preventive strategies to make the use of PPE more acceptable and environment friendly.

## Materials and Methods

### Study setting and population

This hospital-based cross-sectional study was performed at a tertiary care center in north India after obtaining ethical committee clearance IEC-428/22.05.2020, RP-19/2020. Voluntary participation from doctors posted in COVID-19 ICU who had completed at least two duties was sought for the study.

### Study tool

After obtaining consent, a pretested, semi-structured, self-administered questionnaire was given to the participants and their responses were documented [Figure 1]. The questionnaire had the following domains: demographic data; data regarding the number of times PPE used and its duration; difficulty in breathing, hearing, or carrying usual work; ability to control thirst, hunger, or micturition; other physical and psychological affections while using PPE. The average time taken by the participant to complete the questionnaire was 15 minutes.

Only those participants who had completed the questionnaire were included in the analysis.

### Statistical analysis

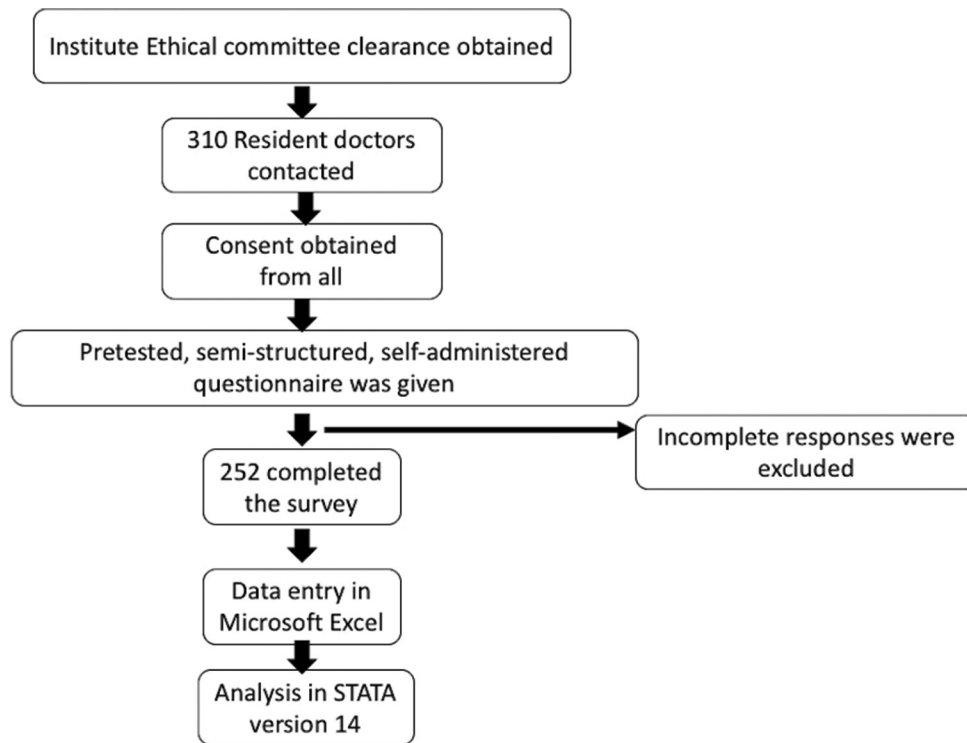
Data entry was done in Microsoft Excel and imported to STATA version 14 for analysis. Continuous variables were reported with their mean  $\pm$  SD. The normality of the data was checked statistically by the Shapiro–Wilk test. Spearman's Rank Correlation Coefficient was used to assess the correlation between the quantitative variables. Bivariable and multivariable logistic regression analysis was conducted between outcome variables (headache, visual impairment, and breathing difficulty) and other independent variables to check for the association. Both crude and adjusted odds ratios with their 95% confidence intervals (CI) were computed. Those variables with a *P* value  $< 0.1$  were added to the multivariable model, excluding collinear variables and the strength of the association was reported by crude and adjusted odds ratio. A *P* value of  $< 0.05$  was considered significant.

## Results

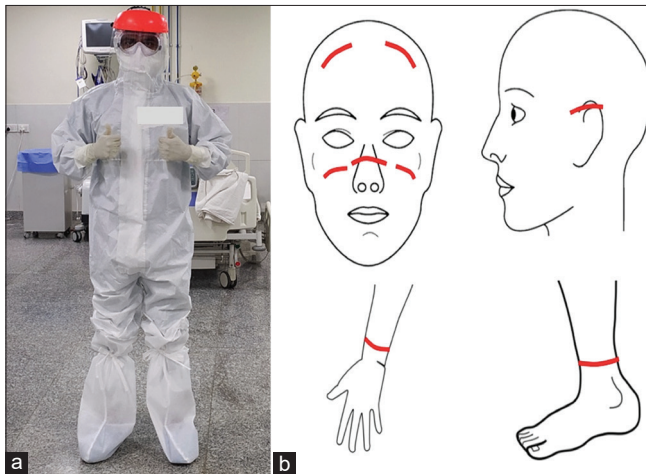
Out of 310 residents contacted, 252 residents completed the questionnaire (response rate 81.3%) and were included in the analysis. The PPE suits and masks were for single use. Goggles, face shields, and shoes were reused after disinfection with a 1% sodium hypochlorite solution. Figure 2a shows a participant after donning level 3 PPE. The age of the participants ranged from 22 to 36 years. The demographic details of the participants are mentioned in Table 1. The challenges faced by the participants while working with the PPE is mentioned in Table 2. The various challenges faced were compared with the duration of work and the significant parameters are mentioned in Table 3.

Logistic regression of various parameters associated with headache is mentioned in Table 4. Participants who worked more than 5 hours had 2.89 times higher odds of developing a headache and participants who felt face shield heavy had 5.08 times higher odds of developing a headache. Participants with difficulty in breathing and sweating had 6.48- and 24.45-times higher odds of developing a headache.

Logistic regression of various parameters associated with difficulty in breathing is mentioned in Table 5. Participants who



**Figure 1:** Schematic representation of study implementation



**Figure 2:** (a) Participant wearing level 3 PPE. (b) Schematic diagram showing sites prone to impression or bruise due to PPE

experienced headache and irritation due to masks had 3.87 times and 2.57 times higher odds of having difficulty in breathing. Logistic regression of various parameters associated with visual impairment is mentioned in Table 6.

## Discussion

The use of PPEs by healthcare workers plays a vital role in protecting them from infections acquired during patient care through droplet or airborne transmission.<sup>[19]</sup> They are more important while dealing with the infectious disease of high consequence infectious potential like COVID-19. As per the best

of our knowledge, our study is the first one to have evaluated the challenges faced [Table 2] by the resident doctors after donning level 3 PPE while working in the intensive care unit. In our survey, only 81.3% answered the given questionnaire. The reason for other residents not answering could be a lack of interest in the survey, hectic duty shifts, etc., This explains the need for one-to-one interviews to get 100% compliance. Because of the pandemic, non-ICU residents were posted along with ICU residents to support them in their work. Residents from every department participated in the survey.

In our study, the problems that majority of participants experienced were headache, visual impairment, hearing impairment, difficulty in breathing, impression/bruise or pain in the PPE contact points, sweating, and reduction in overall work quality due to PPE. Headache was seen in 89.6% of the participants in our study. It was almost similar to the study by Ong *et al.*<sup>[9]</sup> where 82% had de novo headaches and 91.3% had exaggeration of preexisting headache. In the study by Hajjij *et al.*<sup>[14]</sup> on the use of PPE during the COVID-19 pandemic, 62% had headache due to PPE (32.9%-de novo and 29%-aggravation of preexisting headache). The factors postulated to contribute to head associated with PPE use are sustained compression of the pericranial soft tissue due to donning of PPE, difficulty in breathing, hypoxia, hypercarbia due to tightly fitting masks, stress, age, sleep deprivation, etc.<sup>[9, 12-15, 20]</sup> In our study, working for more than 5 hours, feeling faceshield heavy, difficulty in breathing, and sweating were associated with headache. Ong *et al.*<sup>[9]</sup> stated that combined usage of N95 mask and protective eyewear for more than 4 hours was associated with a higher chance of de novo PPE-associated headaches. Hajjij *et al.*<sup>[14]</sup> stated that

**Table 1: Characteristics of the study participants**

Characteristics	Participants n=252 (percentage)
Gender	
Male	140 (55.6%)
Female	112 (44.4%)
Age (in years)	
22-30	190 (75.4%)
30-40	62 (24.6%)
Department:	
Anesthesia	78 (31%)
Ophthalmology	72 (28.6%)
Medicine	51 (20.2%)
Surgery	29 (11.5%)
Others	22 (8.7%)
Past medical illness:	
Asthma	16 (6.4%)
Tuberculosis	5 (2%)
Hypertension	5 (2%)
Hypothyroidism	3 (1.2%)
Diabetes	2 (0.8%)
Others	3 (1.2%)
(Two people had both asthma and hypertension)	
PPE usage time in hours	
<3	11 (4.4%)
≥3 and ≤5	34 (13.5%)
>5 and ≤7	191 (75.8%)
>7	16 (6.3%)
Number of times PPE used	
≤5	31 (12.3%)
>5 and <10	42 (16.7%)
>10	179 (71%)
Types of mask used	
N95 with an expiratory valve	128 (50.8%)
N95 without an expiratory valve	73 (29%)
Both (on different duties)	51 (20.2%)
Participants who used Level 3 PPE before COVID-19 pandemic	15 (6%)
Participants using refractive glasses	142 (56.3%)
Type of goggles used	
With adjustable headband	220 (87.3%)
With vent	163 (64.7%)

COVID-19: Coronavirus disease 2019

a work shift of more than 8 hours was associated with de-novo headache. Bharatendu *et al.*<sup>[17]</sup> stated that the use of N95 facemask causes cerebral hemodynamic alterations, which could contribute to headache and the use of additional powdered air-purifying respirator could mitigate these problems.

In our study, 85.7% of the participants had trouble in breathing. We have not used a scale to grade the difficulty in breathing. Khoo *et al.*<sup>[21]</sup> reported that the use of a 3 M Powered Air-Purifying Respirator caused breathing discomfort in 74.4% of the individuals (Minimal work of breathing-60.5%, moderate work of breathing- 7%, uncomforTable 4.6%, and suffocating-2.3%). Lee *et al.*<sup>[18]</sup> assessed the increase in breathing resistance after using the N95 mask and reported that there is a mean increment of 126% in inspiratory flow resistance and 122% in expiratory flow resistance. Verbeek *et al.*<sup>[22]</sup> conducted an interventional review about PPE and prevention of infectious disease and

**Table 2: Challenges faced by the resident doctors while working with level 3 PPE**

Characteristics	Participants n=252 (%)
Difficulty in mobility	149 (66.2%)
Soiling of scrubs	66 (29.3%)
Inadequate covering by PPE	21 (8.3%)
Impressions and bruise on arms, legs, and face [Figures 1b, 2e, f].	226 (89.7%)
Fogging of	
Goggles [Figure 2d]	248 (98.4%)
Face shield	104 (41.3%)
Visual impairment	244 (96.8%)
Pain over the nasal bridge or cheeks or ears due to goggles	238 (94.4%)
Contact or sweat induced dermatitis [Figure 2 a, b, c]	76 (30.2%)
Faceshield interfering mobility of the head	161 (63.9%)
Headache	226 (89.6%)
Difficulty in breathing	216 (85.7%)
Mask	
Pain over the nose or ear	244 (96.8%)
Irritation	193 (76.6%)
Tearing of gloves while working or removing	100 (39.6%)
Recurrent rolling of the outer glove sleeve	124 (49.2%)
Difficulty in hearing	201 (79.8%)
Fear of being infected during work	156 (61.9%)
Apthous ulcers	42 (16.7%)
Nausea	115 (45.6%)
Sweating	242 (96%)
Itching	107 (42.5%)
Not able to control thirst	50 (20%)
Hungry during duty	171 (67.8%)
Fainted during duty	34 (13.5%)
Gastritis	85 (33.7%)
Urge to micturate during duty	129 (51.2%)
Burning micturition or urinary tract infection	43 (17%)
Females:	n=112
Long hair causing a problem	75 (67%)
Menstruation interfering duty	
None of the times	21 (18.8%)
Sometimes	62 (55.4%)
Most of the times	29 (25.9%)
Not satisfied with the quality of PPE	76 (30%)
If given a choice, not willing to work in duty with PPE again	171 (67.9%)
Overall work quality reduced due to PPE	236 (93.6%)

PPE: Personal Protective Equipment

concluded that PPE made of more breathable material had greater user satisfaction but there was only low-quality evidence that it may not lead to more contamination. Thus, it is necessary to make a more breathable respirator that does not increase the risk of contamination. Li *et al.*<sup>[23]</sup> reported that the face mask can influence the heart rate and can cause the subjective perception of discomfort. They suggested that it could be due to a significant difference in temperature and humidity after wearing the facemasks. Locatelli *et al.*<sup>[10]</sup> recommended that the comfort and tolerability of healthcare workers need to be assessed while fit testing. Arora *et al.*<sup>[24]</sup> stated that the adequate mask fit could not be achieved by untrained individuals. In our study, one-fourth of the participants did not get a face mask that fits them; thus,

**Table 3: Significant factors associated with the increased duration of work**

Parameters associated with increased duration of work	Spearman's Rank Correlation Coefficient (r)	P
Pain over ears/nose	0.29	<0.001
Headache	0.18	0.004
Anxiety	0.20	0.002
Sleep disturbances	0.23	<0.001
Hunger	0.15	0.02
Need to make changes in diet content or timing	0.27	<0.001
Gastritis	0.16	0.01
Urge to micturate	0.23	<0.001

**Table 4: Bivariable and multivariable logistic regression for various factors associated with headache**

Parameters	Crude Odds ratio (95% CI)	P	Adjusted Odds ratio (95% CI)	P
Age				
≤30 years	1	0.25		
>30 years	1.89 (0.62-5.74)			
Gender				
Male	1	0.51		
Female	1.31 (0.57-3.02)			
Training in ICU				
Non-ICU trained residents	1	0.34		
ICU trained residents	0.67 (0.30-1.52)			
Number of duties completed				
≤10	1	0.26		
>10	1.61 (0.69-3.75)			
Duration of each duty				
≤5 h	1	0.006	2.89 (1.02-8.19)	0.04
>5 h	3.47 (1.43-8.12)			
Use of refractive glass	1.88 (0.82-4.27)	0.13		
Use of vented goggles	2.34 (1.03-5.32)	0.04	2.46 (0.9-6.73)	0.08
Use of goggles with adjustable headband	3.74 (1.46-9.52)	0.006	3.01 (0.9-9.99)	0.07
Fogging	9.33 (1.25-69.29)	0.03	6.13 (0.71-52.13)	0.09
Pain due to goggles	2.54 (0.66-9.8)	0.17		
Visual impairment	3.05 (0.58-15.98)	0.18		
Face shield heavy	3.87 (1.65-9.11)	0.002	5.08 (1.76-14.61)	0.003
Difficulty in breathing	4.8 (1.98-11.7)	0.001	6.48 (2.2-19.03)	0.001
Sweating	6.67 (1.74-25.4)	0.005	24.45 (4.5-56.12)	<0.001
Pain due to mask	5.76 (1.29-25.7)	0.02	2.16 (0.31-14.91)	0.79
Impaired hearing	2.82 (1.19-6.66)	0.02	2.42 (0.79-7.42)	0.12
Hunger	1.63 (0.71-3.73)	0.25		
Presence of long hair	1.47 (0.47-4.6)	0.5		

it is necessary to provide face masks in different sizes according to the individual.

Fogging [Figure 3d] affected the visual acuity and it interfered with routine works like securing intravenous line, withdrawing blood sample, and intubation making these jobs difficult. Khoo *et al.*<sup>[21]</sup> reported that use of powdered air-purifying respirators caused visual impairment in around 75% of the participants. In a study by Meyer *et al.*<sup>[25]</sup> on respiratory protective devices, they observed that the visual discomfort correlated with the limitation in the field of vision. But in our study, visual impairment was mainly due to fogging. Visual impairment due to fogging can also predispose to falls.<sup>[26]</sup>

In our study, more than 89.7% of the participants had impressions or bruise or pain over certain pressure points where

PPE/goggles/masks come in contact with the skin [nasal bridge, forehead, above the ear, cheeks, wrists, and ankles; Figure 2b]. The use of PPE made with softer material may reduce this problem further.

Most of the PPE kits we are using are made up of nonporous material and are airtight so that the virus does not pass through, because of which all the humidity and heat generated by the body is trapped inside it.<sup>[8]</sup> Ninety-six percent of our participants too reported sweating as a major problem. Loibner *et al.*<sup>[16]</sup> reported that working at cooler temperature may be beneficial in dealing with heat stress and fluid loss. In our study, around one-third of participants had adverse skin reactions [Figure 3a-c]. It was comparable to a study by Foo *et al.*<sup>[11]</sup> where 35% of participants had adverse skin reactions. As it was a questionnaire-based study,

**Table 5: Bivariable and multivariable logistic regression for various factors associated with difficulty in breathing**

Parameters	Crude Odds ratio (95% CI)	P	Adjusted Odds ratio (95% CI)	P
Age				
≤30 years	1	0.11		
>30 years	2.22 (0.82-5.99)			
Gender				
Male	1	0.47		
Female	1.3 (0.63-2.68)			
Training in ICU				
Non-ICU trained residents	1	0.35		
ICU trained residents	1.4 (0.68-2.84)			
Number of duties completed				
≤10	1	0.57		
>10	0.79 (0.36-1.77)			
Presence of systemic illness				
No	0.68 (0.26-1.80)	0.44		
Yes				
Duration of each duty				
≤5 h	1	0.46		
>5 h	1.38 (0.58-3.27)			
Use of refractive glass	1.88 (0.82-4.27)	0.13		
Headache	4.8 (1.97-11.7)	0.001	3.87 (1.42-10.54)	0.008
Use of mask with valve	0.61 (0.27-1.3)	0.23		
Correct fit of mask	0.54 (0.21-1.37)	0.19		
Irritation due to mask	2.79 (1.33-5.85)	0.007	2.57 (1.12-5.92)	0.03
Pain due to mask	6.65 (1.57-27.8)	0.01	4.01 (0.73-21.6)	0.11
Sweating	0.65 (0.08-5.34)	0.7		
Anxiety	2.17 (1.04-4.5)	0.04	0.98 (0.41-2.31)	0.97
Palpitation	4.42 (1.3-14.72)	0.02	2.69 (0.65-11.12)	0.17
Nausea	2.46 (1.13-5.35)	0.02	1.28 (0.47-3.48)	0.61
Giddiness	2.83 (1.27-6.31)	0.01	1.75 (0.60-5.12)	0.31

**Table 6: Bivariable and multivariable logistic regression for various factors associated with visual impairment**

Parameters	Crude Odds ratio (95% CI)	P	Adjusted Odds ratio (95% CI)	P
Age				
≤30 years	1	0.98		
>30 years	0.98 (0.19-4.97)			
Gender				
Male	1	0.10		
Female	5.84 (0.7-48.2)			
Training in ICU				
Non-ICU trained residents	1	0.15		
ICU trained residents	0.3 (0.06-1.55)			
Number of duties completed				
≤10	1	0.006	42.48 (1.31-1369.63)	0.03
>10	18.87 (2.27-156.3)			
Duration of each duty				
≤5 hours	1	0.03	0.87 (0.10-7.15)	0.87
>5 hours	4.95 (1.19-20.6)			
Use of refractive glass	2.20 (0.51-9.43)	0.29		
Use of goggles with vent	1.10 (0.25-4.72)	0.89		
Goggles with adjustable headband	2.38 (0.45-12.32)	0.30		
Fogging	145.8 (12.83-1656.51)	<0.001	57.54 (1.79-1840)	0.02
Pain due to goggles	43.51 (8.97-210.9)	<0.001	32.85 (3.26-330.29)	0.003
Headache	3.05 (0.58-15.93)	0.19		

we could not exactly examine and diagnose the type of dermatitis in the participants. Pressure due to the tight fit of the mask or goggles along with hot and humid conditions created by the entire PPE could have led to these adverse skin reactions.

During their duty, 20% of participants were unable to control their thirst. One-third of the participants developed gastritis at some point, which may be due to either long fasting hours or it may be stress-induced.<sup>[27,28]</sup>



**Figure 3:** Clinical picture showing adverse skin reaction (a-c), fogging of goggles (d), an impression (e), or bruise (f) due to PPE

Around two-thirds of participants reported fear of being infected during duty and nearly half of them were anxious during the duty. Studies suggest that the use of a respirator can cause psychological affections and psychomotor alterations making routine work more challenging.<sup>[29-31]</sup> Morgan<sup>[29]</sup> observed that some users of industrial respirators had anxiety or claustrophobia. In our study, psychological symptoms reduced in about three-fourths of them on subsequent duties or by reassurance from their colleagues. Anxiety, hunger, sleep disturbances, and pain or heaviness with goggles were higher in participants working for a longer duration. Most of the participants felt that their work quality was reduced because of PPE and if given a choice two-thirds of them never liked to work where using a PPE is mandated.

Although there are various challenges with PPE use, the primary care physicians and all other healthcare workers must always use appropriate PPE while dealing with COVID-19 patients/suspects as none of the vaccines can provide 100% protection and a newer variant of the SARS-CoV-2 is emerging every time.<sup>[32-37]</sup> Though wearing PPE is challenging, it can be made more acceptable and comfortable experience by overcoming the above-mentioned challenges through intersectoral coordination and appropriate interventions by the policymakers.

### Strengths and limitations

Our study is the first hospital-based study conducted in north India, to assess the somatic and psychological issues faced by doctors working with level 3 PPE. We approached all the residents who had done a minimum of two duties with PPE to get an accurate estimate of the challenges faced wearing PPE. A high response rate and adequate sample size ensured minimum selection bias. A limitation of our study was a measurement bias of a few variables where the assessment was not done based on an objective scale to assess the discomfort of the participants. Being a monocentric study, one should be cautious while interpreting the results when compared with international literature.

### Conclusion

These frontline workers glorified as COVID-19 warriors need to be comfortable while working. Pain caused by goggles, headache, anxiety, hunger, sleep disturbances, and the need to change the timing of medication or diet were higher with increased duration of work with PPE. We suggest that the reduction of duty hours may reduce the impact of problems. Ensuring the availability of PPE suits and respirators in different sizes is a must. More ergonomically designed PPEs are needed to improve and prolong the efficiency of the doctors working with level 3 PPE in ICU setup to mitigate visual impairment, skin irritation, sweating, and breathing difficulty.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

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