

Health Problems and Skin Damages Caused by Personal Protective Equipment: Experience of Frontline Nurses Caring for Critical COVID-19 Patients in Intensive Care Units

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ABSTRACT

Background: In the event of coronavirus disease-2019 (COVID-19) spread worldwide, frontline healthcare workers play a key role in the containment of this devastating pandemic, and to prevent the cross-transmission and gain confidence in battle with the pandemic, they are wearing personal protective equipment (PPE).

Aim and objective: To explore the adverse health problems and skin reactions caused by the use of PPEs among the frontline nurses in the ICUs of COVID hospital.

Materials and methods: A cross-sectional study was conducted using an online-based questionnaire assessing the physical problems, and adverse skin reactions of PPEs were sent among the 150 frontline nurses in ICUs of COVID hospital. The collected data were analyzed using descriptive statistics.

Results: We got 137 valid responses from frontline nurses, and the most common adverse health effects expressed by them were headache (73.4%), extreme sweating (59.6%), and difficulty in breathing (36.7%); 91.7% complained about the fogging of the goggle. Majority of frontline nurses expressed nasal bridge scarring (76.64%) and indentation and pain on the back of the ears (66.42%) as the adverse skin reactions after wearing N95 masks. The common skin problems identified due to double gloving of latex gloves were excessive skin soakage with sweat (70.07%) and skin chapping (19%). The protective clothing caused minimal adverse reactions, and excessive sweating (71.53%) was the most reported.

Conclusion: The healthcare workers wearing PPE for a prolonged period show significant adverse effects, so appropriate strategies should be taken to prevent the adverse effects by designing effective PPEs and education of preventive measures among healthcare workers.

Keywords: Adverse skin reactions, Coronavirus, COVID-19, Frontline nurses, Health problems, Personal protective equipment, PPE-related dermatitis.

Indian Journal of Critical Care Medicine (2021); 10.5005/jp-journals-10071-23713

INTRODUCTION

Personal protective equipment (PPE) refers to the personal protective equipment used to avoid or reduce the accidental injuries and occupational hazards at work, and they are meant to protect against the physical, chemical, and biological factors encountered in the work environment. With the emergence of highly infectious epidemics, such as Ebola virus diseases and SARS, healthcare workers are at much greater risk of infection than the general population, due to the exposure to the highly infectious bodily fluids and droplet nuclei in the immediate patient environment. So, treating and caring for such patients need the contact precautions by means of personal protective equipment to reduce the transmission risk.¹

The use of these protective equipment has got attention among the healthcare workers during the global public health emergency due to the coronavirus disease-2019 (COVID-19) appeared in December 2019. Nurses in the front line are highly at risk of contracting COVID-19 while caring for the patients, as they have prolonged duration of exposure performing many care interventions including aerosol generating procedures. Of the frontline nurses working in the emergency department of a tertiary center, 44% perceived that their workplace is not safe against COVID-19 infection spread and 86% feared infecting family members.²

Based on the precautionary protocols adopted by various agencies in controlling the infection, adequate use of personal protective equipment is reasonable based on the evidences,

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How to cite this article: Jose S, Cyriac MC, Dhandapani M. Health Problems and Skin Damages Caused by Personal Protective Equipment: Experience of Frontline Nurses Caring for Critical COVID-19 Patients in Intensive Care Units. *Health Problems and Skin Damages Caused by Personal Protective Equipment: Experience of Frontline Nurses Caring for Critical COVID-19 Patients in Intensive Care Units*. *Indian J Crit Care Med* 2021;25(2):134–139.

Source of support: Nil

Conflict of interest: None

especially when aerosol-generating medical procedures are being performed. The studies conducted during SARS infection 2003 show that the healthcare workers who used mask, gown, and hand washing less likely developed infection than who did not use them.^{3,4}

Since the mode of transmission of the disease is established to be respiratory droplet and indirect contact with fomites,⁵⁻⁷ the use of the PPEs is essential to prevent the cross-transmission of the infection. The PPEs comprises the equipment that protect the mouth, nose, eyes, ears, bare skin, and vulnerable parts, such as head and hands from the deadliest infectious secretions from the patients.

In order to prevent the transmission, the healthcare workers are using the personal protective equipment for prolonged duration while caring for the COVID-19 patients; however, PPE may causes serious skin problems due to long-term sealing, friction and pressure, physical strain (dehydration, heat, and exhaustion), and emotional problems, such as physical isolation, fear about infections. Hence, constant vigilance regarding infection control and follow up rehabilitative measures are essential to enhance the moral and productivity of the healthcare workers.^{2,8,9} These physical and skin adverse effects of PPE among the healthcare workers resulted in reduced morale for overloaded work and made them anxious. So, an appropriate monitoring of these adverse effects should be done and effective preventive measures should be adopted. So, in this study, we have explored the characteristics of the skin damage and other health problems caused due to the personal protective equipment and corresponding care and preventive measures required among the frontline nurses caring for critical COVID-19 patients.

MATERIALS AND METHODS

Research Design and Participants

In order to explore the incidence of adverse effects of wearing PPE on frontline nurses caring for critical COVID-19 patients for prolonged period, a quantitative descriptive design was employed. The survey target population was all frontline nurses who were directly involved in the management and care of COVID-19 patients in a critical care setting of COVID hospital in a tertiary care center in North India. These nurses were wearing various PPEs, such as N95 mask, latex gloves, goggles, face shields, and protective clothing continuously for 6 hours per day for 7 days.

Instruments and Data Collection Procedure

An online survey was formulated using Google Forms with questions on demographics and a questionnaire regarding the usual practice and availability of PPE along with adverse effects of wearing PPE on the frontline nurses. The structured questionnaire was developed by the researchers by using the thorough literature review and discussion with health professionals regarding the health problems experienced by them, and it consisted of general health problems and specific adverse skin reactions of using mask, goggle, face shields, and protective clothing. The respondents were asked to select the health problems experienced by the particular PPE. The experts from the field of nursing and medicine were invited to evaluate the content validity.

The study was started after getting permission from the concerned authority and Institutional Ethics Committee. The participants were informed about the purpose of the study, and informed consent was taken prior to the data collection. The content-validated survey tool developed by Google Forms was sent to 150 frontline nurses in the intensive care units of COVID-19 hospital in North India through various social media during the month of September 2020. The participation to the study was fully voluntary and non-commercial. We could get 91% response rate from the participants with reminders, and the mandatory items were highlighted in the tool.

RESULTS

Data were collected from 137 frontline nurses working in the intensive care units of COVID-19 hospitals and analyzed with SPSS version 22.0.

Demographic Characteristics

Valid responses were received from 137 of 150 frontline nurses who were selected for the study, mean age of the participants was 30.4 (SD: 3.3; range: 23–45) years, majority of the participants were females (53.3%) and married (67.9%), and majority of them had completed bachelor degree in nursing (85.45).

Table 1 depicts that more than half (51.10%) of the study participants were above 30 years old, and 75% had more than 5 years of experience in nursing profession with a mean of 8 (SD = 4.25) years, and 85.40% nurses had completed bachelors in nursing. More than 80% of participants were living with their family or in groups. 91.20% expressed confidence in self-protection against COVID-19 infection.

PPE Usage, Knowledge, and Training and Confidence in Self-protection

The frontline nurses working in the dedicated COVID hospital selected for the study were using N95 masks, surgical latex gloves, waterproof long-sleeve full-body gowns, face shields/visor, and goggles in the routine patient care. All the respondents in the study reported that they had formal training in the use of PPE before joining

Table 1: Sociodemographic characteristics of frontline nurses caring COVID-19 patients in intensive care units of COVID-19 hospital (*n* = 137)

| Variables | Mean ± SD or frequency (%) |
|--|----------------------------|
| Age (Years) | 30.36 ± 3.3 |
| 20–30 | 67 (48.90%) |
| 31–40 | 70 (51.10%) |
| Gender | |
| Female | 73 (53.3%) |
| Male | 64 (46.7%) |
| Marital status | |
| Unmarried | 43 (31.40%) |
| Married | 93 (67.9%) |
| Divorced/separated | 1 (0.70%) |
| Educational level | |
| Diploma in nursing | 17 (12.4%) |
| Basic/post-basic in nursing | 117 (85.4%) |
| Postgraduation in nursing | 3 (2.2%) |
| Having children | |
| Yes | 76 (55.5%) |
| No | 61 (44.5%) |
| Number of members in household | |
| Alone | 25 (18.2%) |
| 2–4 | 92 (67.2%) |
| >5 | 20 (14.6%) |
| Years of experience in nursing profession | 8 ± 4.25 |
| 1–5 | 32 (23.40%) |
| 6–10 | 71 (51.80%) |
| >11 | 34 (24.80%) |
| Confidence in self-protection | |
| Confident | 125 (91.20%) |
| Unconfident | 12 (8.8%) |

the duty in COVID unit. The healthcare workers should be trained well before posting in COVID-19 units, since there are possibilities of self-contamination and transmission of infections among the healthcare workers during the doffing.^{10,11} And the institution was following many innovative techniques to monitor the doffing of the frontline workers by instructing each step in the doffing procedure from the control units with the help of microphone and speakers; trained observers with checklists supervise them closely through CCTV camera installed in doffing areas and by providing prompt corrections.¹⁰ This helps the healthcare workers in completing the doffing without much errors and proper disposal of the PPEs in appropriate bins according to the biomedical waste disposal.

In the present study, 91.20% of the frontline nurses expressed a self-confidence in the protection against the COVID-19 infection. The reasonable supply of the PPEs and appropriate techniques followed in the doffing and training in the infection prevention made them confident in protection against the transmission of COVID-19.

Adverse Health Effects of PPE Use

The participating nurses were wearing the PPE kit for an average of 6 hours per day for 7 days continuously. Due to the contagious nature of the COVID-19 infection, the nurses were forced to continue using the protective gears.

Figure 1 shows that majority of the nurses experienced headache (73.4%), extreme sweating (59.6%), and difficulty in breathing (36.7%). Excessive sweating causes restlessness and various discomforts among the nurses, and fogging of goggle affected almost all the frontline nurses (91.7%), which resulted in restricted visibility. Some of the nurses experienced difficulty in walking (28.4%) due to jumpsuits, and 27.5% experienced excessive thirst and dry mouth. Many minor ailments like nausea, giddiness, weakness, and leg cramps were experienced by the nurses while using PPE and full suit clothing.

Adverse Skin Reactions Developed by Frontline Nurses Using PPE

Table 2 shows that of the 137 frontline nurses who expressed the skin lesions with continued use of personal protective gears during the battling against the COVID-19 infection, 105 (76.64%) expressed nasal bridge scar and 91 (66.42%) felt indentation and pain on back of the ears. Ninety six (70.07%) participants had skin

soaking with sweat, which led to skin chapping among 26 frontline nurses, inability to hold objects and hindered nurses from doing routine works and even holding pen. Ninety eight (71.53%) frontline nurses had complaint of excessive sweating/soaking due to the protective clothing.

Table 3 shows that 135 of 137 respondents expressed one or more skin lesions caused by PPE, and 53.3% of the participants expressed more than 4 skin problems. In the present study, a mean of 4 (SD 2) skin problems is shown per participants. So it is clearly evident that wearing PPE is really very uncomfortable and inconvenient for a prolonged period. In the study, the average number of skin problems is significantly higher among younger age-groups (20–30), females, and those who are unconfident in self-protection $p < 0.05$.

Table 2: Adverse skin reactions reported by frontline nurses while using personal protective equipment (PPE) in caring critical COVID-19 patients (n = 137)

| Adverse skin reactions of using PPE | Frequency (%) |
|---|---------------|
| Related to N95 mask and goggles/face shields | |
| Blistering of mouth | 11 (8.02) |
| Skin allergic dermatitis | 9 (6.5) |
| Nasal bridge scar | 105 (76.64) |
| Skin friction erosion | 40 (29.20) |
| Facial itching/rashes | 11 (8.02) |
| Indentation and pain on back of ears | 91 (66.42) |
| None | 3 (2.20) |
| Related to latex gloves | |
| Skin soaking in sweat | 96 (70.07) |
| Skin chapping | 26 (18.97) |
| Skin dermatosis | 6 (4.37) |
| Skin itching/rash | 19 (13.87) |
| Dry skin | 25 (18.25) |
| None | 13 (9.49) |
| Related to protective clothing | |
| Contact dermatitis | 8 (5.84) |
| Itching/rashes | 14 (10.22) |
| Dry skin | 13 (9.49) |
| Excessive sweating/soaking | 98 (71.53) |
| None | 22 (16.05) |

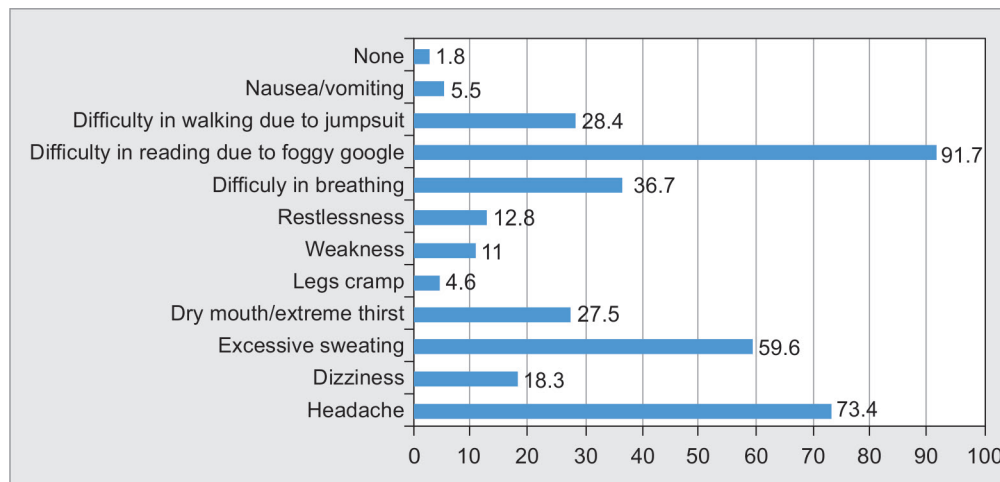


Fig. 1: Physical health problems experienced by frontline nurses while using PPE



Table 3: Number of skin problems among the frontline nurses caused by personal protective equipment and comparison of skin problems and demographic variables ($n = 137$)

| Variables | Mean \pm SD or frequency (%) | | |
|--------------------------------------|--------------------------------|---------|---------|
| Number of skin problems | 4 \pm 2 | | |
| No skin lesions | 2 (1.45%) | | |
| 1–3 skin problems | 62 (45.25%) | | |
| 4–8 skin problems | 66 (48.3%) | | |
| 9–11 skin problems | 7 (5%) | | |
| Sociodemographic variables | Mean \pm SD | t-value | p-value |
| Age (Years) | | | |
| 20–30 | 1.69 \pm 0.63 | 2.05 | 0.046* |
| 31–40 | 1.49 \pm 0.53 | | |
| Gender | | | |
| Female | 1.67 \pm 0.60 | 1.86 | 0.043* |
| Male | 1.48 \pm 0.56 | | |
| Years of experience | | | |
| 1–10 | 1.60 \pm 0.60 | 0.786 | 0.433 |
| 11–20 | 1.46 \pm 0.52 | | |
| Confidence in self-protection | | | |
| Confident | 1.55 \pm 0.60 | 2.31 | 0.03* |
| Unconfident | 1.92 \pm 0.50 | | |

*Significant at 0.05

DISCUSSION

In addition to other infection control measures, rational use of full-body PPE can diminish the risk of infection among frontline nurses. Availability of PPE helped in achieving a perception of self-protection and thereby raising a self-confidence, which made a constructive work environment among the frontline workers. But wearing those PPE caused many physical and skin problems among the frontline workers, so appropriate techniques should be developed to minimize and prevent these adverse effects, which will definitely help those who are still fighting COVID-19. The study showed that most common adverse skin reactions among frontline nurses using PPE included nasal bridge scar, facial itching, skin damage, dry skin rash, chapped skin, and wheals.

The major health problems expressed by the healthcare workers were mainly due to the inappropriate PPE size, jumpsuits that hinder the nurses in performing procedures, and difficulty in walking. Excess materials also cause the risk of contamination due to dragging it across surfaces. Heat and moisture generated inside the PPE after the prolonged period make the healthcare workers more dis-comfortable, with sweating profusely, restlessness, headache, weakness, and giddiness. Another major problem was the limited visibility due to the fogging of the goggles.

N95 masks were recommended by CDC and WHO for healthcare workers caring for COVID-19 patients, and these are specialized masks designed for the protection against the highly transmissible respiratory infections. The mask covers the mouth and nose and effectively filters out particles ≥ 300 nm in size, thereby preventing the transmission of COVID-19. In order to prevent the COVID-19 transmission, frontline nurses were wearing N95 masks for prolonged period, which resulted in the nasal bridge scar and friction erosion of the facial skin. Similar findings were echoed in a study conducted in Hubei Province in China.¹² Foo et al. noticed that most common adverse reactions were acne, facial itching and rash, pigmentation of nasal bridge, cheeks, and chin.¹³ In this study, acne

was one of the most prevalent skin reactions related to the use of N95 respirator masks. So, these skin reactions of N95 masks are due to the healthcare workers having to tie the mask tightly and squeeze the metal clip hard to ensure the tightness of the mask so as to ensure a complete protection against the infection. This in turn leads to the physical problems such as headache, giddiness, weakness, nausea, and vomiting among the nurses due to the hypoxemia and hypercapnia; similar finding was found in a study conducted by Lim et al.¹⁴

The compression of the metal strap at the fixed site for prolonged duration constantly results in the device-related pressure injuries. The excessive binding of the mask is such that edge of the mask is in close contact with the skin for a long period of time; this results in friction between the edge of mask and skin and leads to the formation of erythema, blisters, or ulcers; the moisture created inside the mask during the respiration facilitates the softening of the skin and augments the external injury due to the shear forces of edge of masks on nasal bridge. Another major problem experienced by the participants was "indentation and pain on the back of ears" due to the device-related pressure due to repeated friction caused by ear ropes of face masks.¹⁵

Since the mode of transmission of the COVID-19 is established for indirect contact and fomites, hand hygiene and full protection with double gloving are mandatory while caring for COVID patients. The most common adverse effects experienced by the present-study participants were skin soaking in sweat, skin chapping, dry skin, and skin itching or rash; the humid atmosphere and tight double gloves caused the excessive sweating and led to the skin chapping, but in another study conducted in China, majority of healthcare workers show dry skin, itching, and rash as the adverse reactions of using latex gloves. This was similar to the findings of the study conducted during SARS in 2006.¹³ These adverse reactions are mainly caused due to the hypersensitivity to latex and frequent hand washing with soap and water, without proper drying of the hands, resulting in the irritation and improper air circulation inside the gloves, which causes contact dermatitis and rashes. This can be prevented by appropriate drying of hands before putting on the gloves and wearing a plastic glove inside the latex gloves to prevent allergic dermatitis.^{15,16}

Frontline nurses were wearing protective clothing during the duty time to protect themselves from the aerosols and fomites. Excessive sweating was the commonly expressed problem among the study participants as the study was conducted during the summer season with humid condition. The adverse skin reactions caused by protective clothing are relatively less, and it included itching and dry skin. Another study conducted in China also showed that the findings are congruent with the present study.¹² The irritation from excessive sweating and the repeated friction of protective clothing during walking cause an allergic skin reaction. The physical discomfort and symptoms can lead to psychological burden and further affect their role performance at work and family.^{17,18} Along with safety, testing, and quarantine strategies, the healthcare workers must be provided with safe and comfortable PPE to stretch their service toward the successful handling of this pandemic.¹⁹ The failure to solve the issues related to PPE may result in absenteeism and refusal to work in COVID units.²⁰

This study put light on modification of the designs and need of more advanced techniques that can be safely worn and remain comfortable for prolonged duration with efficient protection against the cross-transmission. Headache and other PPE-related

health issues are associated with increased duration of wearing PPE.²¹ Measures must be taken to minimize the duration of healthcare workers continuously wearing the PPE by taking appropriate break off 15 minutes every 2 hours from the mask, and N95 masks straps should worn on the crown to prevent pressure on ears, apply alcohol-free film barriers in the areas of constant contact with the PPE, dry the hands well before donning the gloves, and apply petrolatum on the skin damage.^{22,23} Duration of the duty of our nurses was six hours, and the effect of reducing the duration of duty to 4 hours can be evaluated.

None of the study participants reported of any dermatologist consultation, but some had reported self-medications and application of emollients, oil, and other cosmetic lotions on the skin rashes minimized the irritations and dermatitis. A study conducted in Wuhan, China, at the beginning of the pandemic shows that there is a correlation between the mental outcomes and number of skin lesions caused by PPE.²⁴ Appropriate training on the prevention of skin lesions and quality of PPE materials should be made available to the healthcare workers to reduce the incident of these adverse effects, and thereby, we can enhance the mental health and morale of the frontline workers.^{25,26}

LIMITATIONS OF THE STUDY

Our study findings were solely based on the self-reported questionnaire, and the reported adverse reactions of the PPE could not be verified and documented by the investigators. We could not assess the severity, pattern, site, or exact cause of these adverse effects, and we only studied one site with a single exposure factor, but some of the skin reactions are due to more than one factor. In addition to these, the present study failed to evaluate the emotional effects of the PPE and problems experienced in communication with other healthcare workers and practical problems in providing nursing care and administration of medications. This study conducted only among one cadre of healthcare workers, so there is a need to consider other cadre of workers whose nature of responsibilities and knowledge entirely differ from the study participants.

CONCLUSION

The present study demonstrated that the incidence of physical health problems and skin damages due to PPE use of frontline nurses was very high. So, the exposure time of the frontline workers with PPE should be kept minimal and prophylactic dressings could be considered to alleviate the device-related pressure injuries. The threat of the COVID-19 is not yet contained worldwide, so the study findings are significant in the current scenario and the healthcare workers should keep in mind while using PPE to prevent these adverse reactions and in the management of new epidemics that may emerge in the future.

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