# Pressure Injuries Due to Personal Protective Equipment in COVID-19 Critical Care Units

By Stefano Bambi, PhD, MSN, CCRN, Gian Domenico Giusti, MSN, CCRN, Alessandro Galazzi, MSN, CCRN, Elisa Mattiussi, MSN, RN, Irene Comisso, MSN, CCRN, Matteo Manici, MSN, RN, Moris Rosati, BSN, RN, and Alberto Lucchini, RN

**Background** Caring for patients with COVID-19 requires wearing a full set of personal protective equipment (PPE) to avoid contamination. Personal discomfort has been associated with use of PPE, and anecdotal reports describe pressure injuries related to wearing PPE.
**Objectives** To investigate the occurrence of device-related pressure injuries due to wearing PPE among Italian nurses caring for patients with COVID-19 in critical care settings.
**Methods** This descriptive study used an online survey investigating both the demographic characteristics of respondents and complications related to wearing PPE, including the development of pressure injuries.
**Results** A total of 266 nurses throughout Italy completed the survey; 32% of respondents were men. Nurses' median age was 36 years (range 22-59 years), and the median time spent working in their current clinical setting (an intensive care or high-dependency unit) was 3 years (range 0-32 years). Personal protective equipment was worn for a median duration of 5 hours (range 2-12 hours). While wearing PPE, 92.8% of nurses experienced pain and 77.1% developed device-related pressure injuries, mainly on the nose and forehead. Pain was more frequent among nurses with such injuries. Transparent dressings, emollient cream, and no dressing were associated with development of device-related pressure injury.
**Conclusions** Pressure injuries related to PPE represent an important adverse effect for nurses caring for patients with COVID-19. This topic deserves study to determine adequate solutions for preventing and treating such injuries and their potential influence on nurses' work tolerance.
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A specific aspect that characterizes health care during the COVID-19 pandemic is personnel approaching patients while wearing a full set of personal protective equipment (PPE).[1,2] In addition to head covers and impermeable gowns or protective suits, health care workers wear an N95 or KN95 particulate-filtering facepiece respirator (or the European equivalent, an FFP2 or FFP3 respirator) and goggles or a face shield—all of which can be sources of discomfort,[3] especially for intensive care unit (ICU) nurses, who spend most of their time at patients' bedsides.

The importance of PPE for staff cannot be emphasized enough.[4] The discomfort associated with the devices, however, can interfere with providers' professional tasks. Thus the perceived usability (in terms of ergonomics) of the filtering facepiece respirator, for example, is as important as the configuration of the mask.[5]

Early anecdotal reports and photographs posted online show that nurses employed in COVID-19 ICUs had pressure injuries (PIs) develop after wearing masks and other protective equipment for the face.[6] Many international scientific associations such as the National Pressure Injury Advisory Panel (NPIAP) and the Nurses Specialized in Wound, Ostomy and Continence Canada soon recognized the importance of this problem.[7,8]

The discomfort associated with PPE can interfere with providers' professional tasks.


**About the Authors**

**Stefano Bambi** is a staff nurse in the medical and surgical intensive care unit, Careggi University Hospital, Florence, Italy. **Gian Domenico Giusti** is a staff nurse in the intensive care unit, Perugia University Hospital, Perugia, Italy, and a nurse educator in the Department of Experimental Medicine, School of Nursing, University of Perugia, Perugia, Italy. **Alessandro Galazzi** is a clinical nurse educator in the Healthcare Professions Department, Foundation IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy. **Elisa Mattiussi** is a nurse educator in the Department of Medical Sciences, School of Nursing, University of Udine, Udine, Italy; and a staff nurse in the Department of Anaesthesia and Intensive Care, Azienda Sanitaria Universitaria Friuli Centrale, University Hospital of Udine, Udine, Italy. **Irene Comisso** is a staff nurse in the Clinica di Anestesia e Rianimazione, Azienda Sanitaria Universitaria Friuli Centrale, Udine, Italy. **Matteo Manici** is a staff nurse in the postsurgical intensive care unit, University Hospital of Parma, Parma, Italy. **Moris Rosati** is a staff nurse in the Anestesia e Rianimazione DEA e dei Trapianti, Azienda ospedaliero-universitaria Senese, Siena, Italy. **Alberto Lucchini** is a nurse coordinator in the general intensive care unit, ASST Monza, San Gerardo Hospital, University of Milano-Bicocca, Monza, Italy.

**Corresponding author:** Gian Domenico Giusti, MSN, CCRN, Dipartimento di Medicina Sperimentale, Polo Didattico Sant'Andrea delle Fratte - Piazzale Gambuli, 06132 Perugia, Italy (email: giandomenico.giusti@unipg.it).


These types of PIs can be included in the category of device-related PIs (DRPIs) because of their similar characteristics.[9,10] Device-related PIs are usually related to medical devices such as cervical collars, noninvasive ventilation interfaces, electrocardiography wires, tracheal tubes, nasogastric tubes, and urinary catheters. The main causal mechanisms and risk factors for these PIs are the tightness of the device; the forces of friction, pressure, and shear; skin moisture; and use at anatomical areas with limited fat tissue.[11-13] Similarities exist between DRPIs that occur in patients and those that occur in health care professionals; however, evidence-based recommendations based on studies of patients have not been carefully examined for application to health care providers. Caution should be exercised in generalizing patient-related findings to health care providers.[13]

The development of PIs related to wearing PPE has recently drawn the attention of the scientific community. Lin et al[14] reported PPE-related adverse skin events (eg, scales, erythema, and injuries) on the cheeks (75.4%) and the nasal bridge (71.8%) among health care workers during the SARS-CoV-2 outbreak in China. Two of the main risk factors for adverse skin events were female sex (odds ratio [OR], 1.87 [95% CI, 1.04-3.39]; $P = .04$) and wearing PPE more than 6 h/d (OR, 4.26 [95% CI, 1.99-9.12]; $P < .001$).[14]

Lan et al[15] pointed to a high rate of skin damage among 542 health care workers caring for patients with COVID-19; 97% (n = 526) of these workers experienced damage, and the nasal bridge was the most affected site (83.1%). Wearing an N95 mask (OR, 2.02 [95% CI, 1.35-3.01]; $P < .01$) and goggles (OR ,2.32 [95% CI, 1.41-3.83]; $P < .01$) for more than 6 hours increased the risk of skin damage.[15] Lan et al also found that the amount of time wearing a face shield was not associated with skin damage. Almost three-fourths (70.3%) of health care workers wearing N95 masks, goggles, and face shields reported skin dryness and tightness.[15]

Data regarding the COVID-19 outbreak in Singapore showed that health care workers wore N95

masks for a mean of 5.9 h/d.[16] Similarly, in a recent large survey, Jiang et al[17] reported that 85.3% of the health care workers caring for patients with COVID-19 wore PPE for more than 4 hours; in general, respondents reported mean daily wear of 7.6 hours (SD 2.92 hours). The prevalence of PPE-related PIs was 30% among those respondents. The use of maximal PPE with an N95 or KN95 mask was a significant risk factor for a DRPI developing (OR, 1.44 [95% CI, 1.14-1.83]; $P = .002$).[17]

Interestingly, Foo et al,[18] who surveyed 109 health care workers during the severe acute respiratory syndrome outbreak in Singapore in 2003, found only 1 case (0.9%) of nose bridge redness with the use of an N95 mask. In that study, the most common adverse events were acne (59.6%), facial itch (51.4%), and rash (35.8%). The mean time spent wearing an N95 mask was 8 h/d.[18]

Because the recent widespread incidence of COVID-19 in Italy has given rise to an enormous effort to provide care and treatment to critically ill patients, in this study we examined the occurrence of DRPIs among nurses using facial PPE including N95 (or equivalent) masks, goggles, and face shields in critical care settings.

## Methods

### Design

We performed a descriptive study using a short survey designed for the study. The survey was conducted through an online questionnaire in Google Forms and aimed to gather data about the occurrence of DRPIs among nurses during their care of patients with COVID-19.

### Sample

We enrolled a convenience sample of nurses working in COVID-19 ICUs and high-dependency units in 9 regions throughout Italy. The inclusion criteria were employment caring directly for patients with COVID-19 and working in a high-dependency unit or an ICU. Other than the clinical setting, we applied no exclusion criteria. We recruited nurses via email through our professional networks and our social networks. Participation in the survey was voluntary.

### Instrument

The questionnaire consisted of 2 main sections. The first section recorded anonymized demographic data. The second section included 13 (8 closed- and 5 open-ended) items investigating the main complications related to wearing PPE (Table 1). We designed the questionnaire to be completed easily and quickly, because it was to be disseminated during the COVID-19 emergency period in Italy. Because we developed the questionnaire for use in this study, we did not evaluate its psychometrics.

**Table 1**
**Questionnaire about pressure injuries related to PPE**

| Item | Answer type |
|---|---|
| Region of provenance | Open answer |
| Age (years) | Number |
| Sex | Male<br>Female |
| Clinical setting | ICU<br>HDU |
| Overall length of service (years) | Number |
| Duration of service in the current clinical setting (years) | Number |
| Types of PPE worn in addition to N95 (or equivalent) mask | Face shield<br>Goggles<br>Face shield and goggles<br>None<br>Other (open answer) |
| Mean consecutive hours of wearing PPE during a single work shift (hours) | Number |
| Pain due to PPE | Yes/no |
| Mean score of pain due to PPE on numerical rating scale (1-10) | Number |
| Use of protective dressing to prevent DRPI | Yes/no |
| If yes, type of protective dressing to prevent DRPI | Open answer |
| Presence of PPE-related DRPI | Yes/no |
| Time of occurrence of the first DRPI (hours/days) | Open answer |
| Anatomical site of DRPIs (all the sites) | Open answer |
| Anatomical site of the most severe DRPI | Open answer |
| EPUAP/NPIAP/PPPIA stage/category of the most severe DRPI | Stage 1 pressure injury<br>Stage 2 pressure injury<br>Stage 3 pressure injury<br>Stage 4 pressure injury<br>Unstageable pressure injury<br>Deep-tissue pressure injury |
| Type of wound dressing used to treat the most severe DRPI | Transparent dressing<br>Thin hydrocolloid<br>Thick hydrocolloid<br>Polyurethane foam dressing<br>Other (open answer) |
| Discomfort and problems related to wearing PPE (excluding DRPI) | Open answer |

Abbreviations: DRPI, device-related pressure injury; EPUAP, European Pressure Ulcer Advisory Panel; HDU, high-dependency unit; ICU, intensive care unit; NPIAP, National Pressure Injury Advisory Panel; PPE, personal protective equipment; PPPIA, Pan Pacific Pressure Injury Alliance.

**Table 2**
**Demographic characteristics of the 266 respondents**

| Characteristic | Value[a] |
|---|---|
| Region | |
| Abruzzo | 8 (3.0) |
| Emilia-Romagna | 17 (6.4) |
| Friuli-Venezia-Giulia | 12 (4.5) |
| Lazio | 6 (2.3) |
| Lombardia | 46 (17.3) |
| Marche | 17 (6.4) |
| Toscana | 116 (43.6) |
| Umbria | 42 (15.8) |
| Veneto | 2 (0.8) |
| Clinical setting | |
| Intensive care unit | 231 (86.8) |
| High-dependency unit | 35 (13.2) |
| Sex | |
| Male | 85 (32.0) |
| Female | 181 (68.0) |
| Age, y | |
| Median (IQR) | 36 (30-45) |
| Range | 22-59 |
| Overall duration of service, y | |
| Median (IQR) | 12 (5-20) |
| Range | 0.5-37 |
| Duration of service in current clinical setting, y | |
| Median (IQR) | 3 (0.5-12) |
| Range | 0-32 |

Abbreviation: IQR, interquartile range.

[a] Values are number (percentage) of respondents, unless otherwise indicated in the first column.

**Table 3**
**Anatomical sites of pressure injuries related to wearing personal protective equipment (N=205 respondents)**

| Site | No. (%) |
|---|---|
| Nose | 179 (87.3) |
| Ears | 78 (38.0) |
| Forehead | 68 (33.2) |
| Cheeks | 25 (12.2) |
| Cheekbones | 19 (9.3) |
| Occiput | 7 (3.4) |
| Chin | 5 (2.4) |
| Other: eyes, lips, hands | 13 (6.3) |

### Statistical Analysis

We recorded data in Microsoft Excel (Microsoft Corp) and performed statistical descriptive and exploratory analyses through IBM SPSS Statistics for Windows version 20.0 (IBM Corp). We conducted the descriptive analysis according to the nonnormal distribution of the variables and used median, interquartile range (IQR), and range. In particular, the respondents' subjective reports of the mean duration of PPE wear and their scores on the numerical rating scale for pain were not normally distributed. We performed an exploratory analysis using the $\chi^2$ test or Fisher exact test (where appropriate) to assess differences between proportions for various demographic and outcome groups.

### Ethical Issues

The questionnaire was introduced through an informed consent form, which participants were to read before completing the questionnaire. This form declared that the data gathered would remain anonymous, in accordance with national privacy regulations. Completion of the form constituted informed consent. We did not consult with our local ethics committee because surveys that do not involve patients do not need authorization from an ethical review board.

## Results

### Descriptive Analysis

A total of 266 nurses completed the online questionnaire. However, not all nurses responded to every question, so the total number of respondents varied within the analyses. The demographic characteristics of the sample are shown in Table 2.

Among 261 respondents, in addition to N95 or KN95 masks and head covers, 44 (16.9%) used only goggles and 85 (32.6%) used only face shields. A large proportion of nurses (49.8%, n = 130) wore a face shield and goggles. Only two respondents wore powered air-purifying respirators.

Nurses wore PPE continuously for a median of 5 hours (IQR, 4-6 hours; range, 2-12 hours). Among 265 nurses, 246 (92.8%) stated that PPE caused them pain, with a median intensity of 5 (IQR, 3-6; range, 1-10) on the numerical rating scale. Protective wound dressings on painful sites were adopted by 191 of 266 respondents (71.8%). Respondents (N = 263) mainly used hydrocolloid dressings (n = 141, 53.6%), foam dressings (n = 33, 12.5%); soothing/emollient cream (hydrating cream; n = 24, 9.1%), and transparent dressings (n = 4, 1.5%) to prevent the occurrence of DRPIs.

Among all 266 nurses who responded, 205 (77.1%) stated that they had at least 1 DRPI develop during their shifts caring for patients with COVID-19. The first PI occurred after a median of 3 hours (IQR, 2-7 hours; range, 1-30 hours) of PPE wear. The anatomical sites of DRPIs are reported in Table 3. The most severe DRPIs reported by the

respondents occurred on the nose and ears. Table 4 summarizes all the most severe PIs according to the European Pressure Ulcer Advisory Panel/NPIAP/Pan Pacific Pressure Injury Alliance stage or category. Only 14 of 203 DRPIs (6.9%) were higher than stage 2. The types of wound dressings or treatment used by nurses to promote healing of their most severe DRPIs are shown in Table 5. Last, other kinds of discomfort caused by wearing PPE are presented in Table 6.

### Exploratory Analysis

We found no statistically significant differences in DRPI occurrence between nurses who were working in the different regions of Italy ($\chi^2 = 15.2$; $P = .06$), between those working in an ICU or a high-dependency unit (76.2% vs 82.9%, respectively; $\chi^2 = 0.8$; $P = .38$), or between men and women (77.6% vs 76.8%, respectively; $\chi^2 = 0.0$; $P = .88$). We did, however, identify a slight difference in DRPI occurrence with various combinations of PPE: goggles, 70.5%; face shield, 76.5%; goggles with face shield, 81.5% ($\chi^2 = 9.4$; $P = .05$). This difference was not statistically significant.

Pain related to wearing PPE was present in both nurses who had DRPI develop (96.1%) and those who did not (82.0%; $\chi^2 = 14.0$; $P < .001$). Conversely, we identified no differences in the presence of pain related to wearing the various types of PPE: goggles, 93%; face shield, 90.6%; goggles and face shield 95.4% ($\chi^2 = 0.8$; $P = .36$).

Among nurses using preventive wound dressings, a DRPI developed in 85.3%, whereas only 56% of nurses who did not use any kind of preventive measure had a DRPI develop ($\chi^2 = 26.2$; $P < .001$). Various preventive wound dressings or products were associated with the development of DRPIs: DRPIs developed in 100% (4 of 4) of those who used transparent dressings, in 91.7% (22 of 24) who used soothing/emollient (hydrating) cream, 83.7% (118 of 141) who used hydrocolloid dressings, 79% (26 of 33) who used foam dressings, and 50% (25 of 50) who used no dressing or product ($\chi^2 = 31.6$; $P < .001$).

**Table 4**
**Site of the most severe device-related pressure injuries and EPUAP/NPIAP/PPPIA stage/category**

| Anatomical site | No. of pressure injuries | | | |
|---|---|---|---|---|
| | Stage 1 | Stage 1 | Stage 3 | Unstageable |
| Nose | 70 | 65 | 11 | 2 |
| Ears | 14 | 14 | 1 | |
| Forehead | 3 | 8 | | |
| Hands | 2 | 3 | | |
| Cheekbones | 2 | 1 | | |
| Mesophryon | 1 | 1 | | |
| Mouth | 1 | | | |
| Cheeks | 1 | | | |
| Eyes | 1 | | | |
| Occiput | 1 | | | |
| Head | 1 | | | |
| Total | 97 | 92 | 12 | 2 |

Abbreviations: EPUAP, European Pressure Ulcer Advisory Panel; NPIAP, National Pressure Injury Advisory Panel; PPPIA, Pan Pacific Pressure Injury Alliance.

**Table 5**
**Wound treatment used by nurses to promote the healing of their most severe pressure injuries related to wearing personal protective equipment (N=200)**

| Dressing or product | No. (%) |
|---|---|
| Thin hydrocolloid dressing | 96 (48.0) |
| Thick hydrocolloid dressing | 33 (16.5) |
| Polyurethane foam dressing | 25 (12.5) |
| Transparent dressing | 21 (10.5) |
| Soothing/emollient cream (hydrating cream) | 12 (6.0) |
| Hyaluronic acid | 1 (0.5) |
| Zinc oxide | 1 (0.5) |
| None | 11 (5.5) |

## Discussion

This study showed that three-quarters of the nurses caring for critically ill patients with COVID-19 had injuries related to PPE develop. Clinical setting (ICU or high-dependency unit) was not associated with the difference in the percentage of nurses who had a DRPI develop. The main anatomical sites where injuries occurred were the nose, ears, and forehead. Furthermore, 75% of nurses stated that they wore PPE continuously for more than 4 hours, and the first PI developed after 2 hours of wear.

Our study also revealed that headache was the most common adverse effect of wearing PPE (excluding development of a DRPI) and occurred in 27.8% of respondents. This percentage is far lower than the 81% among the health care workers who responded to a survey administered by Ong et al[16] during the COVID-19 pandemic in Singapore. The independent risk factors for the occurrence of headache were preexisting diagnosis of primary headache disorder (OR, 4.20 [95% CI, 1.48-15.40]) and more than 4 h/d of PPE (N95 mask and goggles) wear (OR, 3.91 [95% CI,

**Table 6**
**Symptoms of discomfort and other issues reported by nurses as due to wearing personal protective equipment (N=266)**

| Symptom/issue | No. (%) |
|---|---|
| Headache/migraine | 74 (27.8) |
| Itch | 42 (15.8) |
| Erythema | 26 (9.8) |
| Sweat/heat | 20 (7.5) |
| Difficulty breathing | 18 (6.8) |
| Fatigue | 17 (6.4) |
| Oral or nasal dryness | 16 (6.0) |
| Dermatitis | 12 (4.5) |
| Burning eyes/eye dryness | 8 (3.0) |
| Limited view | 7 (2.6) |
| Claustrophobia | 2 (0.8) |
| Other issues | 11 (4.1) |

1.35-11.31]; $P=.01$).[16] Respondents thought that their headache had been caused by N95 masks (53.1%), goggles (51.6%), or both (52.3%).[16]

In our study, 85.3% of nurses using a preventive wound dressing had a DRPI develop, whereas a DRPI occurred in only 56% of those who did not use any preventive measure; this difference was statistically significant. Moreover, the amount of time spent wearing PPE was the same in the group with DRPIs and in the group without (median, 5 hours; IQR, 4-6 hours). This result could be affected by 3 issues: (1) We do not know whether some nurses began to use wound dressings before or after their first DRPI occurred. (2) Evidence is lacking about the effectiveness of preventive wound dressings for PPE-related injuries. (3) Models of available masks, goggles, and face shields with diverse designs could have exerted some influence on the development of DRPIs. Furthermore, in the study by Jiang et al,[17] some people thought that the use of a preventive dressing might affect the airtightness of N95 respirators and goggles and diminish their protective effect.[17] The NPIAP also expresses this main concern in their recent statement on the prevention of DRPIs due to N95 masks.[7]

The efficacy of wound dressings in preventing DRPIs due to PPE and the effects of wound dressings on how well the masks fit should be tested.

Currently, adequate preventive measures are lacking for DRPIs related to PPE wear. As some authors have suggested, the use of powered air-purifying respirators could be a solution, but one that could have significant costs.[19] Potentially, several types of wound dressing could be applied to pressure points at the interface of skin and mask or goggles, with the aim of preventing PPE-related PIs and avoiding discomfort.

According to recent guidelines from the European Pressure Ulcer Advisory Panel, NPIAP, and Pan Pacific Pressure Injury Alliance, some direct evidence exists for the use of dressings to prevent DRPIs in patients.[13] The types of dressings studied were based on hydrocolloid, foam, silicone gel, and transparent films. Nevertheless, no preventive skin dressing or product has been studied in personnel wearing PPE.[13] Some experts have suggested applying a barrier on the skin under the face mask, such as a thick layer of petroleum jelly, every 30 minutes,[20] although NPIAP counsels against the use of petroleum jelly and any other products that could increase slippage of a face mask and affect its function.[7] Furthermore, NPIAP does not recommend the use of thin preventive dressings under N95 masks because of the lack of evidence of safety in terms of the risk of COVID-19 infection, as the virus could gain access between the mask and the dressing.[7]

Conversely, the Italian Society of Wound Care (Associazione Infermieristica per lo Studio delle Lesioni Cutanee [AISLeC]) recommends the use of protective dressings for PPE-related injuries and states that hydrocolloid dressings are slightly more effective than transparent dressings when applied on the nasal bridge.[21] Moreover, the AISLeC states that silicone-based wound dressings are more easily removed and have a higher efficacy in mitigating friction than other kinds of dressings.[21] The AISLeC, however, counsels against the use of multilayered wound dressings because they can exert higher pressure on tissue at the interface with the device.[21] Nonetheless, the efficacy of wound dressings to relieve the pressure of PPE on tissue should be tested, and adequate tightness of N95/KN95 respirator masks with the use of wound dressings also must be evaluated.[19]

Last, this study also reported the treatments (dressings and other products) nurses chose to promote the healing of their most severe PPE-related PIs. However, the effectiveness of wound dressings on these kinds of PIs still has to be studied in depth; at the moment, no research on this topic has been published.

## Limitations

Despite this study's large sample of 266 respondents, the results may not be generalizable because

the sample is not completely representative of the entire population of nurses working with critically ill patients with COVID-19. Moreover, the differences in the proportions of respondents from the various regions of Italy could have affected the results, given possible differences in the organizational and clinical aspects of their work. The differences in the type, brand, and availability of PPE used by respondents in the various regions may have affected the external validity of this study. Also, we cannot exclude the possibility of self-selection bias and bias due to the respondents' self-determination of the stage of their DRPIs.

## Conclusions

Pressure injuries related to PPE are a new kind of DRPI that has emerged as a main adverse effect for nurses caring for critically ill patients with COVID-19. The potential effects of PPE-related pressure ulcers include pain nurses experience during work shifts and, in our opinion, a reduction of their physical resistance in the workplace.

The results of this study show that this problem can occur early and at a high rate. The presence of pain seems to be a warning sign for the development of a DRPI. Moreover, our findings suggest that wearing the combination of goggles and a face shield could promote the occurrence of a DRPI, but these results need to be studied in a larger sample in order to achieve statistical confirmation. The role of preventive wound dressings should be more fully investigated because they have been associated with the occurrence of DRPIs. Adequate solutions to prevent and treat such DRPIs should be urgently addressed through well-designed research studies.

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None reported.

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