



DISCURSIVE PAPER

Best-practices for preventing skin injury beneath personal protective equipment during the COVID-19 pandemic: A position paper from the National Pressure Injury Advisory Panel

William V. Padula PhD, Assistant Professor^{1,2}  | Janet Cuddigan PhD, RN, FAAN, Professor^{2,3} | Lee Ruotsi MD, CWS-P, Wound & Burn Care Specialist^{2,4} | Joyce M. Black PhD, RN, FAAN, Professor^{2,3} | David Brienza PhD, Professor^{2,5} | Virginia Capasso PhD, RN, CWS, Clinical Nurse Specialist^{2,6} | Jill Cox PhD, RN APN-c, CWOCN, Clinical Associate Professor^{2,7} | Barbara Delmore PhD, RN, CWCN, Clinical Assistant Professor^{2,8}  | Sarah Holden-Mount PT, CWS, SVP Sales^{2,9} | Nancy Munoz DCN, MHA, RDN, FAND, Assistant Chief for Nutrition & Food Service^{2,10} | Ann Marie Nie MSN, APRN, CWOCN, Family Nurse Practitioner^{2,11} | Joyce Pittman PhD, RN, CWOCN, Associate Professor^{2,12} | Sharon E. Sonenblum PhD, Senior Research Scientist^{2,13} | Ann Tescher PhD, APRN, CNS, CCRN, CWCN, FCCM, Clinical Nurse Specialist^{2,14} | For the National Pressure Injury Advisory Panel (NPIAP)¹⁵

¹Leonard D. Schaeffer Center for Health Policy & Economics, Department of Pharmaceutical & Health Economics, School of Pharmacy, University of Southern California, Los Angeles, CA, USA

²Board of Directors, The National Pressure Injury Advisory Panel (NPIAP), Boston, MA, USA

³College of Nursing, University of Nebraska Medical Center, Omaha, NE, USA

⁴Saratoga Hospital Medical Group, Saratoga Springs, NY, USA

⁵School of Health and Rehabilitation Science, University of Pittsburgh, Pittsburgh, PA, USA

⁶Massachusetts General Hospital and Harvard Medical School, Boston, MA, USA

⁷School of Nursing, Rutgers University, Newark, NJ, USA

⁸NYU Langone Health, New York, NY, USA

⁹American Medical Technologies, Irvine, CA, USA

¹⁰Southern Nevada VA Health System, Las Vegas, NV, USA

¹¹Children's Hospitals and Clinics of Minnesota, Minneapolis, MN, USA

¹²College of Nursing, University of South Alabama, Mobile, AL, USA

¹³The George W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA, USA

¹⁴Mayo Clinic Hospital, Rochester, MN, USA

¹⁵NPIAP, Westford, MA, USA

Correspondence

William Padula, USC Schaeffer Center,
635 Downey Way (VPD), Los Angeles, CA
90089, USA.

Email: padula@healthpolicy.usc.edu

Abstract

COVID-19 has infected millions of patients and impacted healthcare workers worldwide. Personal Protective Equipment (PPE) is a key component of protecting frontline clinicians against infection. The benefits of PPE far outweigh the risks, nonetheless,

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many clinicians are exhibiting skin injury caused by PPE worn incorrectly. These skin injuries, ranging from lesions to open wounds are concerning because they increase the susceptibility of viral infection and transmission to other individuals. Early into the COVID-19 pandemic (April 2020), the U. S. National Pressure Injury Advisory Panel (NPIAP) developed a series of position statements to improve wear-ability of PPE and protect healthcare professionals and their patients as safe from harm as possible under the circumstances. The NPIAP positions, which were formed by conducting a systematic review of what was known at the time, include: (a) Prepare skin before and after wearing PPE with skin sealants, barrier creams and moisturisers; (b) Frequent PPE offloading to relieve pressure and shear applied to skin; (c) treat visible skin injuries immediately caused by PPE to minimise future infection; (d) non-porous dressings may provide additional skin protection, but lack evidence; (e) health systems should take care to educate clinicians about placement and personal hygiene related to handling PPE. Throughout all of these practices, handwashing remains a top priority to handle PPE. These NPIAP positions provided early guidance to reduce the risk of skin injury caused by PPE based on available research regarding PPE injuries, a cautious application of evidence-based recommendations on prevention of device-related pressure injuries in patients and the expert opinion of the NPIAP Board of Directors. Clinicians who adhere to these recommendations reduce the prospects of skin damage and long-term effects (e.g. scarring). These simple steps to minimise the risk of skin injury and reduce the risk of coronavirus infection from PPE can help.

1 | INTRODUCTION

The Coronavirus Disease 2019 (COVID-19) pandemic has infected millions of patients worldwide in nearly every country (World Health Organisation, Geneva, 2020). Healthcare professionals (e.g. nurses, physicians and therapists) are working tirelessly to manage patient needs in all clinical settings while remaining focused on preventing the further spread of Coronavirus Disease 2019 (COVID-19) infection. Particularly, in U. S. hospitals, emergency departments and critical care settings, healthcare professionals are contending with prolonged shifts to manage volume surges of COVID-19 positive patients and continuously wearing personal protective equipment (PPE). This has resulted in an alarming increase in skin injury to the faces of staff caused by PPE, particularly from tight masks covering the nose and mouth, and goggles or shields covering the eyes which extend from the face to the ears and back of the head (Gefen & Ousey, 2020a). A survey of 4,306 clinicians across 191 hospitals in China during the month of February 2020, alone, reported that 42.8% of clinicians experienced skin injuries related to PPE use (Jiang et al., 2020).

Skin injuries to the face, ears and scalp caused are particularly concerning consequences of wearing PPE. These areas of tissue damage, especially around mucous membranes can increase the susceptibility of infection (Li et al., 2020). Once skin tears, it is unable to serve as a natural barrier against infection in support of the immune system (Gefen, 2020; Rundle et al., 2020). Healthcare professionals

What does this paper contribute to the wider global clinical community?

- Personal Protective Equipment (PPE) is a key component of protecting healthcare professionals against becoming infected, and while the benefits of PPE far outweigh the risks, many healthcare professionals are exhibiting facial skin injury caused by PPE worn incorrectly.
- The U. S. National Pressure Injury Advisory Panel (NPIAP) has developed a series of position statements to improve wear-ability of PPE and protect healthcare professionals and their patients as safe from harm as possible under the circumstances.
- The NPIAP positions, which were based on available evidence, include: (a) Prepare the skin before and after wearing PPE with skin sealants, barrier creams and moisturisers; (b) Frequent PPE offloading to relieve pressure and shear applied to the skin; (c) treat visible skin injuries immediately caused by PPE to minimise future infection; (d) non-porous dressings may provide additional skin protection, but lack current evidence; (e) health systems should take care to educate frontline healthcare staff about placement and personal hygiene related to handling PPE.

with skin tears can become carriers, and therefore present the risk of transmittance of the virus between patients and other healthcare professionals; it is important for healthcare professionals to adhere to self-care of skin tears and open wounds, and good practices to minimise the spread of infection (e.g. handwashing, glove changing) (Rundle et al., 2020). These skin injuries cause pain and itching, prompting the clinician to touch their face, ears and scalp (Gefen & Ousey, 2020a). These injuries, ranging from small skin lesions (i.e. bruising and superficial wounds) to full-thickness wounds may place healthcare professionals at too great of an exposed risk to continue providing care, potentially limiting the number of available experienced providers thereby further straining the health care system (Gefen & Ousey, 2020b). Healthcare professionals with open facial wounds should be removed from beside clinical duties since there is a risk that the mask could be positioned incorrectly on the face in an attempt to decrease pain over the open wound site, thereby exposing the individual viral susceptibility. Despite good practices such as hand-washing hygiene, changes in practice such as touching the wound or trying to place the mask around the wound could increase exposure to COVID-19. Finally, some of these skin injuries can lead to facial scarring and disfigurement (Hu et al., 2020).

During the early phases of the COVID-19 pandemic, the U. S. National Pressure Injury Advisory Panel (NPIAP) reviewed available evidence on how to safely use the N95 respirator masks to prevent infection transmission while protecting the skin, releasing a position paper in April 2020 (Cuddigan et al., 2020) which has been used to guide subsequent work addressing this concern (Desai et al., 2020; Smart et al., 2020). The NPIAP also evaluated impact of surgical masks since the U. S. Centers for Disease Control and Prevention (CDC) has identified them as an acceptable alternative PPE to N95 masks during surgical procedures, or whenever healthcare professionals anticipate need for protection against splashes and sprays (U.S. Centers for Disease Control & Prevention, 2020). These NPIAP positions are available online (<https://npiap.com/page/COVID-19Resources>, National Pressure Injury Advisory Panel, Boston, MA; 2020). The same mechanical forces (i.e. pressure and shear) combined with the tolerance of skin and soft tissue for pressure, shear and friction that cause device-related pressure injuries in our patients are now causing pressure injuries in fellow healthcare providers wearing PPE including masks, face shields and goggles for long periods of time. N95 respirator masks have a particularly high risk for injury due to infection control requirements for a tight fit, especially if the mask is not properly fitted to an individual's face; skin injury can also occur as a result of moisture accumulation under the mask (Bischoff et al., 2018).

According to Darlenski and Tsankov, facial skin injury can make individuals more susceptible to spread of COVID-18 infection (Darlenski & Tsankov, 2020). Fortunately, these injuries to the face, ears and scalp that healthcare professionals are most susceptible to are also preventable if proper steps are taken. This NPIAP position paper reaffirms several important best-practices to improve the safety of healthcare professionals in hospitals and other healthcare facilities. These positions are comprehensive in terms of their

science, practicality to be carried out in an efficient cost-effective manner, and with resources available for healthcare facilities in the U. S. (Padula et al., 2011, 2019; Reddy et al., 2006). We have conducted a systematic review and analysis in order to establish national recommendations that support best-practices to minimise facial skin injury beneath PPE as an important component of containing the spread of COVID-19 and other infectious diseases.

2 | METHODS

In 2019 before the COVID-19 outbreak, the NPIAP formed a Guideline Governance Group (GGG) in partnership with the European Pressure Ulcer Advisory Panel and Pan-Pacific Pressure Injury Alliance in order to develop a clinical practice guidelines for the prevention and treatment of pressure injuries through a process of systematic review (Kottner et al., 2019). Released in November 2019, the international guidelines were informed by a review of 2,104 publications; information about the systematic review is available in the guideline report (European Pressure Ulcer Advisory Panel, National Pressure Ulcer Advisory Panel, & Pan-Pacific Pressure Injury Alliance, 2019). The guideline has been widely disseminated, resulting in 50,000 copies shared throughout the world to nearly every country and translated into 18 different languages.

In the context of this report, evidence was extracted from the systematic review conducted by the GGG regarding the aetiology of pressure injuries and prevention of device-related pressure injuries in patients and translated specifically for an understanding of skin injury to the face, ears and scalp caused by PPE in all healthcare personnel. Pressure injuries result in skin and underlying soft tissue damage caused by pressure and shear, usually over a bony prominence but may also be related to a medical device or other object (European Pressure Ulcer Advisory Panel et al., 2019). Thus, skin injury to the face, ears and scalp caused by PPE categorically falls under the domain of pressure injury since PPE applies pressure and shear to susceptible facial tissue. The work of the GGG was supplemented by systematic reviews of more recent literature on safe use of PPE and emerging reports of PPE related skin and soft tissue injuries in early international COVID-19 hotspots. These supplemental resources were reviewed by the position paper authors based on the methodology established by the GGG for the international guideline. Literature on pressure injury from medical devices, especially oxygen delivery devices, was reexamined to determine if the findings could guide practice when wearing PPE.

Positions presented in this paper were independently reviewed by the thirteen members of the board of directors for the NPIAP. For each position, the NPIAP translated the appropriate recommendation from the 2019 International Guidelines for Pressure Injury Prevention and Management (European Pressure Ulcer Advisory Panel et al., 2019). This position paper is unique in that it combines current evidence in both pressure injury prevention and PPE science as a basis for recommendations within the context of the COVID-19 crisis.

3 | POSITIONS AND RATIONALE

3.1 | Skin Preparation Before and After Wearing PPE

Before and after PPE wear, cleanse the face with a pH balanced cleanser to reduce bacterial/viral surface contamination. Skin moisturisers can be applied but must be allowed to dry before the mask is reapplied.

The skin can be prepped with a liquid skin sealant or protectant to reduce friction injury from the mask (Towfigh et al., 2008). These skin areas include all anticipated points of contact with the skin, such as the nose bridge, cheek bones, chin, behind the ears, and points on the forehead and scalp (Figure 1; Gefen & Ousey, 2020c). Areas such as behind the ears, where surgical masks with ear-loops are commonly used for many clinicians are important to prep to prevent retroauricular dermatitis since there is no subcutaneous tissue and even a relatively shallow pressure injury in these areas may be Stage 3 or 4 (Figure 2; Bothra et al., 2020).

Cyanoacrylates can also be used as skin prep – these skin protectants are used as a 'glue' to protect skin from tears or lacerations (Eaglstein & Sullivan, 2005). However, cyanoacrylates must be applied cautiously to avoid getting them into the eyes and mucous membranes (Yin et al., 2019). Skin protectants can also prevent overhydration and maceration of skin from moisture accumulation in the mask (Parnham et al., 2020). Skin protectants should be dry before applying the mask.

The use of petrolatum or mineral oil is not advised as a skin prep; these products can cause the mask to slip out of place and require frequent reapplication that involves touching the face (Gefen & Ousey, 2020c). Manufacturers of N-95 masks advise against petrolatum use under N-95 masks (Donovan et al., 2007).

3.2 | Frequent PPE Offloading

PPE should be frequently offloaded to allow skin and soft tissue across the face, behind the ears, and pressure points on the scalp

to recover and reperfuse (Gefen & Ousey, 2020c). Remove the mask from your face for 15 minutes every 2 hours outside of areas of patient contact. If this time frame is not practical, attempt to lift the mask by the sides for 5 minutes every 2 hours with clean hands. Any pressure relief will be provided to the skin and soft tissue will be beneficial (Visscher et al., 2015). However, we want to emphasise that offloading should be done with clean hands, and outside of areas of patient contact (Tomas et al., 2015). The seal between PPE and the staff member's skin should not be broken in an area present with infected patients (Gurses et al., 2019). If possible, switching to PPE with fewer direct contact points, such as face masks that can remain on place using a head band rather than ear loop, would be worthwhile.

3.3 | Treat visible skin injuries caused by PPE

If abrasions or pressure injury develops on the face, behind the ears or over the scalp from the mask, treat the visible injury or open wound with topical moisturisers, liquid skin sealants/protectants, cyanoacrylate or a protective non-porous dressing (Visscher et al., 2015). Areas that are hard to view (e.g. behind ears, areas of scalp covered by hair) will likely require extra attention. Advice of an occupational health practitioner should be sought with regard to the safety of returning to work with an open facial wound, as well as the availability of an alternative mask that may relieve pressure on the site of the open wound (Patel et al., 2017). Powered and supplied air respiratory protection (PAPR) masks may offer an alternative to N95 or surgical masks to relieve areas of injured skin while providing a substantial barrier of protection, although these devices are expensive and in short supply globally (Roberts, 2014). Persons with deep tissue injury or full-thickness pressure injury occurring on the face should be referred for professional wound care to minimise scarring or future exposure (Vincent et al., 2019). These wounds should be considered serious due to the risk of infection and scarring as they heal.

Note that nonvisible tissue damage under the skin, such as deep tissue pressure injury, is always a point of concern and should be

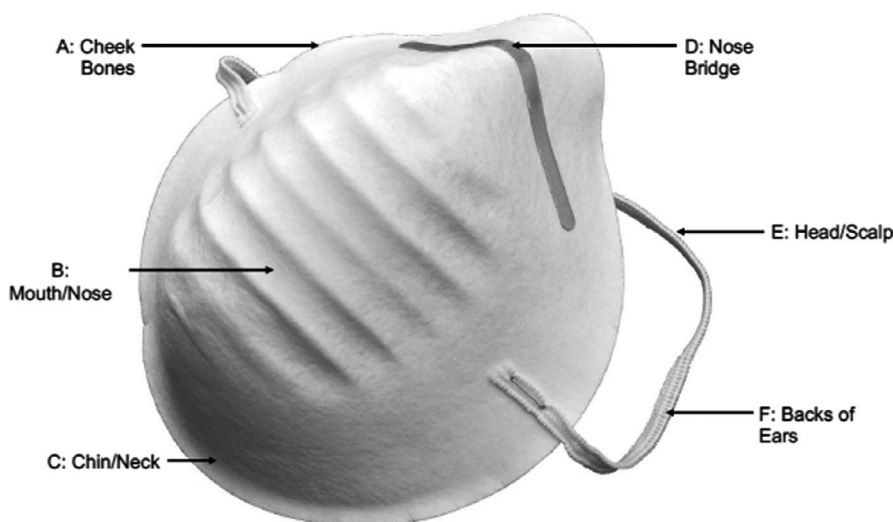


FIGURE 1 Force diagram of a common N95 mask with anticipated pressure points applied on skin (Note: many variations of N95 mask designs exist, so individual assessments of pressure points should be done as needed)

monitored (Edsberg et al., 2016). Also, bruising and erythema on the surface of skin for individuals with darker skin tones is more difficult to detect (Lyder et al., 1998). As a result, individuals doing self-assessment should closely monitor all signs or symptoms of pressure injury, including pain (Gefen & Ousey, 2020a).

3.4 | Uncertainty of dressings under PPE

After reviewing the evidence on both pressure injury prevention and effective use of PPE, the NPIAP believes that there are critical uncertainties regarding the safe use of thin prophylactic dressings under N95 masks (Gefen & Ousey, 2020c). NPIAP cannot make a recommendation regarding this proposed strategy (pro or con) at this time.

While the 2019 International Guideline for Pressure Injury Prevention and Management provides important evidence-based recommendations for prevention of pressure injuries from oxygen delivery masks *in patients*, any application of those recommendations to providers during the current COVID-19 pandemic comes with an important caveat (Kottner et al., 2019). That is, the essential function of a PPE mask (i.e. to prevent COVID-19 transmission from patient to provider) cannot be compromised (Ippolito et al., 2020). There is evidence to show that thin prophylactic dressings placed under medical devices (e.g. facial oxygen masks) in patient populations reduces the risk of pressure injuries (Kottner et al., 2019). This provides indirect evidence for implementing this practice in clinicians wearing N95 respirator masks. However, there are no comparable studies in clinicians wearing N95 respirator masks that can ensure the wearer's safety from viral penetration when a dressing is placed under a respirator type mask, possibly altering the fit of the mask on the face. Dressings with a porous outer surface are particularly problematic; the dressing may allow the

transfer of fluids or microorganisms onto the skin. NPIAP is aware of some preliminary clinical reports of confirmation of the proper fit of an N95 mask to occupational health and safety specifications after the application of thin prophylactic foam dressings (Jones et al., 2013). There is also a report that there is less aerosolisation of microorganisms upon dressing removal when thin hydrocolloid dressings are used. These preliminary reports are not sufficient evidence to recommend routine use of thin prophylactic dressings at this time due to critical uncertainties regarding whether this practice will increase the risk of COVID-19 infection. NPIAP recognises that pressure from surgical masks, PAPRs and face shields can also lead to facial skin injury. These PPE items are not designed to fit as tightly and therefore pressure can be redistributed by applying thin foam or hydrocolloid dressings under these devices. Attention should be given to the forehead, nose, cheeks and backs of the ears where PPE comes into the most direct contact (Desai et al., 2020).

For hospitals and clinicians who do wear prophylactic dressings under the N95 respirator mask, strips of non-porous dressings such as thin hydrocolloid should be applied to areas of pressure from the mask, which is usually the nasal bridge and cheek bones (Cai et al., 2019). Dressings should not be stacked one atop the other, as multiple dressings will increase the pressure applied to the skin. After applying dressings, confirm the fit of the N95 mask should always be confirmed with a seal check by blowing out and checking for leaks before patient contact.

To reduce the risk of transmission, follow infection control practices at the healthcare facility. When it is time to remove the dressings, assume dressings are contaminated and exercise caution with removal (Lenski & Scherer, 2016). NPIAP recommends that you close your eyes and hold your breath in exhalation during dressing removal to avoid potential transmission of aerosolised COVID-19.

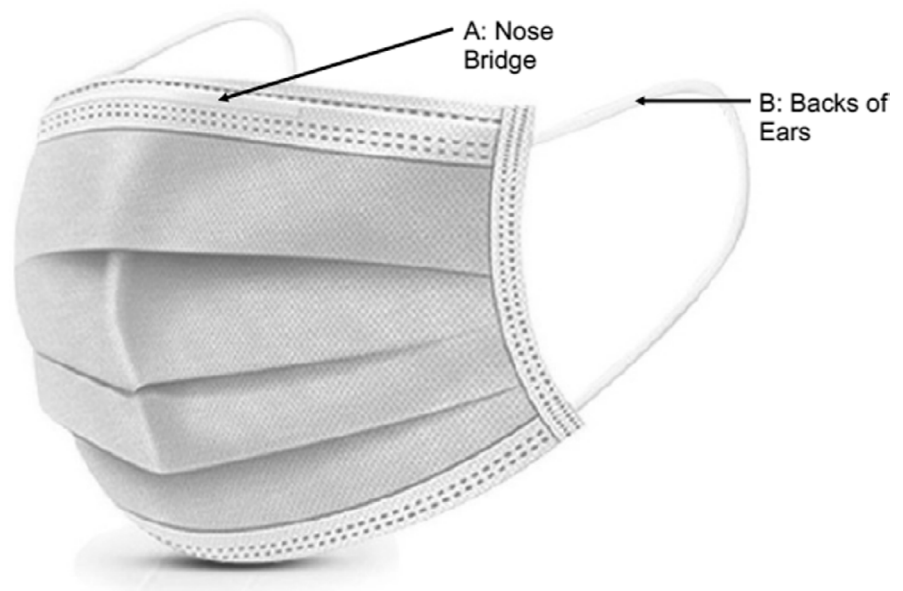


FIGURE 2 Force diagram of surgical mask with anticipated pressure points applied on skin

3.5 | Educating healthcare professionals about PPE placement and personal hygiene

Healthcare facilities should establish clear policies for educating healthcare professionals on these steps to maintain personal hygiene in order to protect themselves from COVID-19 as well as the health of vulnerable, non-infected patients in addition to those presenting with COVID-19. PPE items, including masks, goggles and shields should be fitted to the shape and size of the individual user's features; in fact, N95 masks come in multiple sizes (Desai et al., 2020). Concerns such as wear-time between refreshing PPE, properly donning PPE or refreshing PPE should be directed to follow manufacturer specifications since items such as N95 mask usage can vary between manufacturers. Incorrect fit of PPE on an individual can increase the risk of skin injury to the face, ears and scalp and exposure to COVID-19 (Gefen & Ousey, 2020c). Facilities should invest in training healthcare professionals on proper practices for donning and offing procedures related to PPE.

Handwashing or hand-sanitising before and after handling PPE remains an important step in these recommendations as well; however, this task should be done in tandem with needs to wash hands for other purposes to avoid over-washing (Beiu et al., 2020).

National shortages of PPE have led to facilities reusing certain products after sterilising them, such as N95 masks (Dai et al., 2021; Rowan & Laffey, 2020). This sterilisation process can impact the integrity and fit of the product (Jinadatha et al., 2015). When items such as N95 masks are reapplied, the clinician should also check the fit and seal of the mask.

3.6 | Recommendations for Future Research

As the field of PPE development and manufacturing advances in parallel with the ongoing effort to manage and prevent the spread of COVID-19, we have several recommendations for future research to improve our understanding of safe PPE wearing as well as PPE enhancements. First, the use of dressings under masks is not recommended by the NPIAP, although Gefen and Ousey have indicated that research on the biomechanical features of some dressings support this use (Gefen & Ousey, 2020b). More real-world evidence about dressings in combination with PPE would be helpful to create barriers between the PPE and the skin. Second, more research into enhancements in PPE designs, such as alternatives to ear-loops on surgical masks, or foam resurfacing over sharp edges of goggles and shields could provide us with knowledge to better guide clinicians towards proper use (Parush et al., 2020). Third, customisable PPE, with the use of 3D-printing or other rapid prototyping mechanisms to fit individuals' faces more appropriately offers a promising area of development (Manero et al., 2020). Fourth, the field would benefit from additional research to collect data on the incidence, prevalence, and permanence of skin injury caused by PPE across the many countries dealing with COVID-19 surges (Jiang et al., 2020). Fifth, the field would also benefit from additional research into changes in

the microclimate of skin and soft tissue around PPE since elements including moisture, pressure and shear vary considerably (Gefen et al., 2019). Sixth, the development of new PPE technology has advanced rapidly between 2019–2020 with the onset of the COVID-19 pandemic, such that investigations into proper donning of new PPE compared to existing offerings should be undertaken with respect to skin injury.

4 | CONCLUSIONS

Healthcare facilities need to be prepared for volume surges due to COVID-19 in many ways, as well as caring for non-COVID-19 patients who may become cross-exposed to infection as a result of multiple patient–clinician interactions. Facilities are being tested in terms of bed capacity, clinician preparedness, and the availability of masks, gloves and other PPE measures to establish barriers between patients and healthcare professionals. As facilities place orders and stockpile these essential products, they also need to consider stocking up on some of the products that reduce the risk of skin injury, such as skin protectants and prophylactic dressings.

This NPIAP position paper reaffirms these important best-practices to improve the safety of healthcare professionals in hospitals and other healthcare facilities dealing directly with COVID-19 patients or other types of individuals. The NPIAP provides interprofessional leadership to improve patient outcomes in pressure injury prevention and management through education, public policy and research. Our positions are supported by available evidence aggregated by a multi-disciplinary group of academic researchers, physicians, nurses, therapists and engineers on our board of directors in addition to panel membership across collaborating organisations, provider organisations and commercial industry. All positions in this position paper were independently reviewed by the thirteen members of the board of directors for the NPIAP (The National Pressure Injury Advisory Panel (NPIAP), 2020).

These NPIAP positions, developed early in the COVID-19 pandemic, represent a combination of tactics and products that can prove resourceful to reduce the risk of facial skin injury caused by PPE. These positions are not sanctioned as medical advice for healthcare professionals to abide by, but should be weighed with the tasks at hand to serve each patient at present, as well as continue to confidently serve the next patient while minimising risk of spreading infection. Healthcare professionals who adhere to these recommendations improve the prospects of less skin damage and long-term effects such as scarring. These recommendations also promote good hygiene and best practice to protect healthcare professionals from exposure to infection from COVID-19 or transmittance between multiple patients. These simple steps to minimise the risk of facial skin injury from PPE can help. The NPIAP encourages further research on the prevention of PPE related injuries without increasing the risk of infection for health care providers.

Finally, clinicians in hospitals, outpatient facilities and nursing homes will continue to cope with unexpected emerging challenges related to COVID-19 that are difficult to control for with respect to PPE wear. These recommendations represent best-practices, but we also advise that clinicians use their best judgement to achieve safe PPE wear without compromising care to the COVID-19 patient or other patients in a facility. With time, additional variables that impact the threshold between COVID-19 and PPE will hopefully be quantified to better inform practical implementation of these recommendations.

CONFLICTS OF INTEREST

None.

AUTHOR CONTRIBUTION

Authors contributed equally in accordance with ICMJE Guidelines.

ORCID

William V. Padula  <https://orcid.org/0000-0003-1161-6954>

Barbara Delmore  <https://orcid.org/0000-0002-6930-4569>

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