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Occupational Dermatoses Related to Personal Protective Equipment Used During the COVID-19 Pandemic

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KEYWORDS
• COVID-19 • Personal protective equipment • Allergic contact dermatitis • Irritant contact dermatitis
• Seborrheic dermatitis • Rosacea • Acne • Mask dermatitis

KEY POINTS
• There has been a significant increase in prevalence of reported occupational dermatoses due to the enhanced infection prevention measures adopted by both health care workers and the general public in response to the COVID-19 pandemic.
• Irritant contact dermatitis is the most common occupational dermatitis reported and most often due to excessive hand washing and wearing of facial personal protective equipment such as masks and respirators.
• Gentle skin care, adequate moisturizing, and strategies to alleviate pressure are important preventative strategies for occupational dermatoses related to personal protective equipment.

INTRODUCTION
The outbreak of Coronavirus disease of 2019 (COVID-19) began in December 2019 in Wuhan, China1 due to the severe acute respiratory syndrome coronavirus 2 (SARS-CoV2).2,3 The first confirmed case in the United States (US) was reported on January 20th, 2020,2 and on March 11th, 2020 the World Health Organization declared COVID-19 as a global pandemic.4 By the end of 2020, there were 2 million reported cases and 345,000 deaths in the US due to COVID-19.5

SARS-CoV2 spread quickly due to its multiple modes of transmission: contact, droplet, and airborne transmission.6 The Centers for Disease Control (CDC) released guidelines emphasizing the importance of wearing a facemask, handwashing, and disinfecting surfaces,7 which led consumers and hospitals to stock facemasks, gloves, disinfectants, detergents, soaps, and hand sanitizers. In addition, the CDC guidelines for proper use of personal protective equipment (PPE) to protect health care workers (HCWs) recommended the routine use of N95 respirators, surgical masks, isolation gowns, eye protection (goggles or face shields), and gloves.8

Prolonged wearing of PPE, frequent handwashing, and disinfecting of surfaces have resulted in an increased number of skin complaints in both HCWs and non-HCWs. One study surveyed 542 HCWs and 97% reported skin damage caused by enhanced infection-prevention during the COVID-19 outbreak.9 The associated dermatoses include allergic contact dermatitis (ACD), irritant contact dermatitis (ICD), seborrheic dermatitis (SD), acne, and rosacea. In this review, the incidence and diagnosis of PPE-associated occupational dermatoses in both HCWs and non-HCWs as well as recommendations for the prevention and treatment of these dermatoses are also discussed.

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COMMON TYPES OF OCCUPATIONAL DERMATITIS

ACD and ICD are the 2 most common causes of occupational dermatitis. According to the American Academy of Dermatology, contact dermatitis (including both ACD and ICD) was the fifth most common diagnosis in the dermatology clinic and costs more than 1.54 billion health care dollars in 2016.10 ACD accounts for 20% of occupational contact dermatitis cases.11 ACD is a biphasic type IV delayed type hypersensitivity reaction that develops in response to contact allergens such as preservatives (formaldehyde), dyes (disperse blue), and metals (nickel).12 Acute episodes of ACD can present with edema, erythema, and vesiculation.11 Chronic ACD can lead to lichenification and fissuring of the skin.11 Epicutaneous patch testing is the gold standard for the diagnosis of ACD.11 During the COVID-19 pandemic, ACD has been reported due to PPE and personal care products (soaps, moisturizers, etc.) for the hands, trunk, and face (Table 1).13

ICD is responsible for 80% of all cases of occupational contact dermatitis.11 ICD occurs from direct cytotoxic injury to the skin induced by a physical or chemical irritant.12 ICD may include ulcerations and fissuring at the affected site,12 with symptoms of pruritis and burning sensation occurring immediately after exposure.11 ICD has been reported as a result of prolonged wearing of PPE and rigorous and frequent hand washing in the setting of COVID-19 (Table 2). Common body areas affected by ICD include the hands and convex surfaces of the face including the nose, ears, and cheeks from facemasks, goggles, and face shields.19 SD is a chronic inflammatory skin condition that presents as erythematous patches with greasy, yellow scales most commonly in areas densely populated with sebaceous glands such as the face (nasolabial folds, ears, eyebrows, and central forehead), scalp, chest, back, axilla, and groin.26 SD is likely due to an overgrowth of the Malassezia yeast and subsequent inflammatory reaction elicited by the yeast. It is thought that increased wear of facial PPE provides the ideal temperature and moist environment for Malassezia to grow and increases the risk to developing SD (Table 3).27 Acne vulgaris and rosacea (maskne) are the 2 types of papulopustular eruptions that have been associated with the prolonged use of facial PPE during the COVID-19 pandemic (see Table 3).21,28,34 Acne has 4 pathogenetic factors: the production of excess sebum, follicular epithelial hyperproliferation and plugging, follicular colonization by Propionibacterium acnes, and the presence of inflammation.35 The use of face masks allows for a warm, humid, and occlusive microclimate on the skin, which contributes to the development of acne.34,36 Rosacea has been seen to a lesser degree in the recent COVID-19 pandemic, although this may be due to underreporting.

Table 1
Reported cases of allergic contact dermatitis due to personal protective equipment and hand hygiene during COVID-19

| Authors (Alphabetical), Year Published | Country of Origin | HCWs or Non-HCWs | Number of Patients | Location of Dermatitis | Causative Agent |
|----------------------------------------|-------------------|------------------|--------------------|------------------------|----------------|
| Aerts et al,14 2020                    | Belgium           | Hcw              | 1                  | Nose Cheeks            | Formaldehyde and 2-bromo-2-nitropropane-1,3-diol (bronopol) |
| Bothra et al,15 2020                   | India             | Both             | 4                  | Periauricular          | No patch testing—suspected thermoplastic elastomer, rubber, latex |
| Ferguson et al,16 2020                 | United Kingdom    | Hcw              | 13                 | Face                  | Unknown |
|                                        |                   |                  |                    | 30 Hands               | Limited patch testing—“rubber accelerators” |
| Singh et al,17 2020                    | India             | Hcw              | 3                  | Face                  | Unknown |
| Xie et al,18 2020                      | China             | Non-Hcw          | 1                  | Nasal Bridge Cheeks    | Toluene-2,4-diisocyanate, dianinodiphenylmethane, and hexamethylene diisocyanate |
| Authors (Alphabetical), Year Published | Country of Origin | HCWs or Non-HCWs | Number of Patients | Location of ICD | Cause of Irritant Contact Dermatitis |
|--------------------------------------|-------------------|------------------|--------------------|-----------------|-------------------------------------|
| Alluhayyan et al, 2020               | Saudi Arabia      | HCWs             | Not specifically reported | Nasal bridge | Pressure from goggles and facemasks |
|                                      |                   |                  | 200                | Cheeks         | Chemicals from hand cleansers, disinfectants, and natural rubber/latex gloves |
|                                      |                   |                  |                    | Hands          |                                     |
|                                      |                   |                  |                    | Wrist          |                                     |
|                                      |                   |                  |                    | Forearms       |                                     |
| Bothra et al, 2020                   | India             | Both             | 5                  | Retroauricular | Mask straps (thermoelastic polymer, latex) Dyes and disinfectant use on masks |
| Chaiyabutr et al, 2020               | Thailand          | Non-HCW          | Not specifically reported | Face          | Multilayer surgical masks leading to occlusion; N95 mask borders leading to abrasion |
| Ferguson et al, 2020                 | United Kingdom    | HCWs             | 69                 | Face           | Pressure from fitted mask and length of mask worn Chemicals from Clinell wipes (GAMA Healthcare, Watford, UK), benzalkonium chloride |
|                                      |                   |                  | 110                | Hands          |                                     |
| Hu et al, 2020                       | China             | HCWs             | 58                 | Face           | Pressure from N95 respirators Latex gloves Disposable gowns worn 10 h daily for 3.5 mo |
|                                      |                   |                  | 54                 | Nasal bridge   |                                     |
|                                      |                   |                  | 37                 | Ears           |                                     |
|                                      |                   |                  |                    | Hands          |                                     |
|                                      |                   |                  |                    | Body           |                                     |
| Kiely et al, 2020                    | Ireland           | HCWs             | 26.28%             | Forehead       | Length of use of facial PPE Excessive handwashing |
|                                      |                   |                  |                    | Nose           |                                     |
|                                      |                   |                  |                    | Cheeks         |                                     |
|                                      |                   |                  |                    | Hands          |                                     |
|                                      |                   |                  |                    | Body           |                                     |
| Metin et al, 2020                    | Turkey            | HCWs             | 76.43%             | Face           | Excessive face washing Excessive hand hygiene Excessive glove use Excessive daily showering |
|                                      |                   |                  | *223 total        | Hands          |                                     |
|                                      |                   |                  |                   | HCW—some       |                                     |
|                                      |                   |                  |                   | complained of  |                                     |
|                                      |                   |                  |                   | facial and hand dermatitis |                                     |
|                                      |                   |                  | 194                | Face           |                                     |
|                                      |                   |                  | 782                | Hands          |                                     |
|                                      |                   |                  | 200                | Body           |                                     |

(continued on next page)
Rosacea can be clinically characterized as transient erythema, telangiectasias, and inflammatory papules/pustules. Acne can be distinguished from rosacea due to the presence of comedones.

**FACIAL PERSONAL PROTECTIVE EQUIPMENTS**

Facial PPE are one of the most important methods to prevent the spread of COVID-19 in the hospitals and the community. Various forms of facial PPE are used, including respirators (eg, N-95), cloth masks, surgical/medical masks, goggles, and face shields that are used by both HCWs and non-HCWs. Previous studies have shown that increased wearing of facial PPE leads to an increased prevalence of ACD, ICD, pressure-related skin injury, and worsening of underlying dermatoses such as acne and rosacea. Since March 2020, there has been an increase in reported cases of occupational dermatoses related to facial PPE. The type of mask, composition of mask, duration of wear, and underlying skin conditions are all potential factors in the development of occupational dermatoses to facial PPE.

The composition of the facial PPE materials are important to consider in potential cases of occupational dermatitis. ACD to facial PPE has been reported to textile dyes, elastic bands, metal wiring for nosepiece, and formaldehyde that may remain from the manufacturing process of the polypropylene shell. Wearing facial PPE for extended periods of time also increases risk of ICD, pressure-induced dermatitis, and worsening of preexisting skin conditions such as acne and rosacea. In one survey of HCWs, 61.7% experienced worsening of their preexisting skin condition due to wearing facial PPE, and 90.5% of HCWs had reported developing new skin problems related to PPE use. One study showed that cloth facemasks resulted in less adverse skin reactions compared with surgical masks and N95 respirators.

In addition to masks and respirators, goggles and face shields are other common forms of facial PPE used. Reported adverse skin reactions with the use of goggles and face shields include pressure injury, ICD, ACD, xerosis, and worsening of preexisting facial dermatoses such as acne and rosacea. In one survey, 28% of HCWs complained of eczema and xerosis from the use of masks, goggles, and face shields, most frequently involving the nasal bridge, ears, and periorcular region. In another study, the use of surgical masks and goggles for 8 hours or more had led to skin erosions on the forehead, nasal bridge, and zygoma. Skin damage over the nasal bridge was also seen in 87.9% of HCWs who wore goggles for more than 6 hours. Goggles led to 51.92% of facial occupational dermatoses in one study, followed by N95 respirators (30.77%) and face shields (17.31%).

**Table 2**

| Authors (Alphabetical), Year Published | Country of Origin | HCWs or Non-HCWs | Number of Patients | Location of ICD | Cause of Irritant Contact Dermatitis |
|---------------------------------------|-------------------|------------------|--------------------|-----------------|-------------------------------------|
| Singh et al, 2020                     | India             | HCWs             | 28                 | Forehead        | Duration of wear and fitting of goggles, N95 respirators, and face shields |
| Singh et al, 2020                     | Thailand          | Both             | 454                | Ears            | Physical/frictional from ear straps and pressure from face masks |

**Allergic Contact Dermatitis to Facial Personal Protective Equipment**

Cases of ACD to facial PPE reported during the current COVID-19 pandemic are summarized in Table 1. The most common causes of ACD due to facial PPE are additives and materials used in the manufacturing of respirators, surgical masks, face shields, and goggles. ACD has been reported to rubber accelerators such as thiurams, carbamates, dialkyl thioureas, and N-isopropyl-N-phenyl-p-phenylenediamine in elastic bands used to secure the facial PPE on the face. Facial PPE also contain potentially allergenic metals such as nickel and cobalt in the nose piece.
| Authors (Alphabetical), Year Published | Country of Origin | HCWs or Non-HCWs | Number of Patients | Type of Dermatitis | Location of Dermatitis | Treatment/Outcome |
|----------------------------------------|-------------------|------------------|-------------------|--------------------|------------------------|-----------------|
| Chaiyabutr et al, 2020 | Thailand | Non-HCWs | 248 | Acne | Face | - |
| Chiriac et al, 2020 | Romania | HCWs | 1 | Papulopustular rosacea | Face | Slight improvement after 2 wk of metronidazole, 1 g/d, twice a day and pimecrolimus 1% 1 h after removal of facemask |
| Daye et al, 2020 | Turkey | HCWs | 44 | Acne | Face | - |
| Giacalone et al, 2020 | Italy | Non-HCWs | 1 | Seborrheic Dermatitis | Nose Cheeks Beard | Low-potency steroid for 5 d and pimecrolimus 1% daily for 10 d Adapalene gel 0.1% and benzoyl peroxide gel 2.5% for 8 wk, zinc gluconate, 175 mg, and nicotinamide, 27 mg, daily for 3 mo Doxycycline, 40 mg, for 12 wk Treatments provided clinical benefit |
| Han et al, 2020 | China | Non-HCWs | 5 | Acne | Cheeks and nose | Good response to Adapalene gel 0.1%, +/- face peel with 20% α-hydroxy acid |
| Hu et al, 2020 | China | HCWs | 1 | Acne | Face | - |
| Ferguson et al, 2020 | United Kingdom | HCWs | 16 | Seborrheic Dermatitis Acne Rosacea | Face | - |
| Metin et al, 2020 | Turkey | HCWs | 82 | Seborrheic dermatitis Acne/folliculitis | Face and scalp Face | - |
| Singh et al, 2020 | India | HCWs | 5 | Acne | Face | - |
| Techasatian et al, 2020 | Thailand | Both | 333 | Acne | Face | - |
| Trepanowski et al, 2020 | USA | HCWs | 11 | Seborrheic dermatitis Acne Rosacea | Face | - |
| Veraldi and Angileri, 2020 | Italy | Both | 20 | Seborrheic dermatitis | Face | - |
| Zuo et al, 2020 | China | HCWs | 9 | Seborrheic dermatitis Acne Rosacea | Face | - |

Abbreviation: HCW, healthcare workers
to mold the mask to the wearers’ face. Textile dyes in surgical or cloth masks have also been reported to lead to ACD. Furthermore, formaldehyde used in the manufacturing of surgical masks and N95 respirators may still remain in the final product and have been reported to cause ACD. Other preservatives with potential to induce ACD due to facial PPE include methyl dibromoglutaronitrile, 2-bromo-2-nitropropane-1,3-diol, tolune-2,4-diisocyanate, diaminodiphenylmethane, and hexamethylene diisocyanate. The only way to prevent and treat ACD is to avoid the causative allergen, which can be identified via epicutaneous patch testing. Persistent exposure to the allergen can lead to worsening ACD resulting in inappropriate wear or fit of PPE, thereby increasing risk for contracting COVID-19. If avoidance is not possible or the relevant allergen is not identified, effort should be made to treat the cutaneous symptoms until a suitable alternative is found.

Irritant Contact Dermatitis to Facial Personal Protective Equipment

ICD is common with widespread use of facial PPE in both HCWs and non-HCWs. Reported cases of ICD due to facial PPE during the current COVID-19 pandemic is summarized in Table 2. One survey compared non-HCWs who wore cloth masks with those who wore surgical masks or N95 respirators. Pruritis was the number one complaint among all facial PPE. There were also more ICD in those who wore facial PPE for more than 8 hours daily. The study revealed that surgical masks had a greater number of adverse skin reactions when compared with cloth masks. A study in China surveyed HCWs who wore N95 respirators for an average of 12 hours a day for 3.5 months; 95.1% reported adverse skin reactions to N95s, including nasal bridge scarring (68.9%) due to pressure from the metal nose piece, facial itching (27.9%), skin damage (26.2%), dry skin (24.6%), and rash (16.4%). These findings were also similar to a study conducted during the 2003 SARS outbreak in Singapore where 307 HCWs were surveyed and 35.5% of those wearing N95 respirators complained of adverse skin reactions, most commonly acne (59.6%), facial itch (51.4%), and rash (35.8%). One group in India noticed an increase of cases in retroauricular dermatitis caused by wearing of cloth or surgical masks and N95 respirators with ear loops (composed of latex or thermoplastic polymer). In 1 month, 14 patients complained of skin pruritis, scaling, and erythema. Prevention of ICD relies on strategies to alleviate friction and pressure and are outlined in Table 4. Hydrocolloid dressings and barrier products made of acrylate, silicon, or dimethicone may be used on areas that are frequently irritated, such as the bridge of the nose, cheeks, and ears. Application of a thin dressing (such as DuoDERM Extra Thin, ConvaTec, Deeside, UK) between the facial PPE and the skin can offer some barrier protection. However, the effect on the seal of N95 is unknown. One recent small study analyzed the effect of 5 barrier protectants on the fit of 3M 1860 N95 respirator (St. Paul, MN). They found fit-testing pass rates ranged from 56% to 88% depending on the skin protectant used; only 36% of their cohort passed with all 5 protectants. Therefore, it is imperative to make sure that these dressings or barrier products do not interfere with the fit and safety of the facial PPE, and refit testing is necessary especially with N95 respirators to ensure a tight seal. To avoid retroauricular pressure-related irritant dermatitis, surgical masks with ear loops can be alternated with masks that tie to the back of the head to limit possible ICD to the tight elastic bands.

Treatment of Facial Personal Protective Equipment–Induced Allergic Contact Dermatitis and Irritant Contact Dermatitis

For all cases of potential ACD or ICD due to facial PPE, avoidance of possible allergen or irritant is preferred. Gentle skin care management such as washing with a fragrance-free, hypoallergenic nonsoap cleanser and applying daily moisturizer are key foundations to prevent xerosis that may increase susceptibility to ACD and ICD. Treatment of facial ACD and ICD include low-potency topical steroids for short periods of time, as prolonged use of topical steroids can increase the risk of periorificial dermatitis, cutaneous atrophy, and striae formation. Nonsteroidal alternatives suitable for long-term use on the face include topical calcineurin inhibitors such as tacrolimus 0.03% or 0.1% ointment, pimecrolimus 1% cream, and clobetasol 0.05% ointment. Discontinuation of current PPE and switching to a suitable alternative may be necessary in recalcitrant cases.
### Table 4
Clinical features and recommendations for the prevention and treatment of dermatoses associated with PPE wear and hand hygiene

| **Allergic Contact Dermatitis** | **Irritant Contact Dermatitis** | **Seborrheic Dermatitis** | **Acne** | **Rosacea** |
|---------------------------------|---------------------------------|---------------------------|----------|------------|
| **Prevention**                  | Use of 100% cotton or less occlusive facemasks alone or under surgical masks (if not in health care setting) Schedule 15-min breaks every 2 h for HCWs wearing facial PPE<sup>51</sup> Use of hydrocolloid dressings, silicon or dimethicone barrier creams, acrylate film at pressure or irritated areas<sup>19,47</sup> Use of daily gentle skin cleansers and moisturizer throughout the day If recurrent, can use ketoconazole 2% as shampoo or face wash empirically 2-3x/wk as prevention | Use of daily gentle skin cleansers and moisturizer throughout the day If recurrent, can use ketoconazole 2% as shampoo or face wash empirically 2-3x/wk as prevention | Daily gentle cleansing with salicylic acid or benzoyl peroxide Use of noncomedogenic facial products Use of clothless occlusive facemasks for the general public<sup>25</sup> Schedule 15-min breaks every 2 h for HCWs wearing facial PPE<sup>51</sup> | Use of daily gentle skin cleansers and moisturizer throughout the day Avoid triggers: extreme temperature, sunlight, spicy food, alcohol, strenuous exercise, acute psychological stressors<sup>52</sup> |
| **Clinical Diagnostic Features** | Well-demarcated, intensely pruritic eczematous eruptions; vesicular (acute) or lichenified (chronic) Acute ICD presents as painful, pruritic, erythematous, edematous lesions with vesicles and bullae<sup>11</sup> Chronic ICD presents as lichenified and hyperkeratotic lesions<sup>11</sup> | Acute ICD presents as painful, pruritic, erythematous, edematous lesions with vesicles and bullae<sup>11</sup> Chronic ICD presents as lichenified and hyperkeratotic lesions<sup>11</sup> | Pink patches with greasy white/yellow scale in areas with high concentration of sebaceous glands (nasolabial folds, ears, eyebrows, scalp)<sup>26</sup> Presence of open and/or closed comedones. Inflammatory lesions such as papules, pustules, nodules, or cysts may also be present<sup>53</sup> | Involvement of the nose, malar, and perioral areas. Involvement of at least one primary and secondary feature. Central facial erythema, flushing, telangiectasia, inflammatory papules/pustules, rhinophyma<sup>54</sup> |

(continued on next page)
|                                | Allergic Contact Dermatitis | Irritant Contact Dermatitis | Seborrheic Dermatitis | Acne | Rosacea |
|--------------------------------|----------------------------|-----------------------------|-----------------------|------|---------|
| **Diagnostic Tests**           | Patch testing is the gold standard | Skin biopsy if clinical diagnosis is not possible | Skin biopsy if clinical diagnosis is not possible | Skin biopsy if clinical diagnosis is not possible | Skin biopsy if clinical diagnosis is not possible |
|                                | Skin biopsy can be helpful to differentiate from other dermatoses |                               |                       |      | Presence of *Demodex* mites in follicles\(^{55}\) |
| **Treatment**                  | Avoid known allergen        | Avoid known irritant        | Ketoconazole 2%       | Mild | Mild    |
|                                | Localized: topical steroids or calcineurin inhibitors | Topical steroids or calcineurin inhibitors appropriate for body region | shampoo/body wash or antifungal cream as needed | Wash daily with benzoyl peroxide or salicylic acid wash | -Azelaic acid 15%, topical ivermectin 1%, topical metronidazole 0.75% cream or 1% gel, sodium sulfacetamide wash |
|                                | Widespread: systemic corticosteroids or other immunosuppressive therapies | Low-potency topical corticosteroid or topical calcineurin inhibitors for itching and erythema | | -Topical retinoid (tretinoin, adapalene, tazarotene) | Moderate/severe |
|                                |                            |                            | | -Topical antibiotics such as clindamycin 1% lotion daily | -Follow all recommendations for mild rosacea and add in oral antibiotics (eg, doxycycline) |
|                                |                            |                            | | Moderate | -Consider isotretinoin for severe cases |
|                                |                            |                            | | -Follow all recommendations for mild acne and add in oral antibiotics (eg, doxycycline) | For erythema |
|                                |                            |                            | | -For women, combined oral contraceptives and/or oral spironolactone are also appropriate | -Topical brimonidine 0.33% gel |
|                                |                            |                            | | Severe | -Topical oxymetazoline 1% cream |
|                                |                            |                            | | -Consider oral isotretinoin | |
**Seborrheic Dermatitis**

Long-term use of facial PPE may increase the skin permeability and temperature, which causes a change in the microbiota allowing *Malassezia* to proliferate and thrive in these conditions leading to worsening SD. During the COVID-19 pandemic, there have been several cases of SD exacerbated by facial PPE (see Table 3). A survey identified 37.5% of HCWs whose underlying SD had worsened due to facial PPE.33 Another study showed 34 new cases of SD in HCWs after the first month of the pandemic and worsening of SD in 47% of HCWs.24 Wearing facemasks for 6 to 10 hours per day exacerbated SD in 46.5% of patients in one series.27 Of these patients with worsening symptoms, 75% were men and 35% of them worked in health care settings.27

The best method to prevent exacerbation of SD is to cleanse the face with gentle facial cleansers before and after prolonged mask wearing and limit the time of continuous contact with facial PPE if possible.33 Treatment of underlying SD is also important with antifungal shampoos and creams such as ketoconazole 2% and low-potency topical steroids or calcineurin inhibitors.

**Papulopustular Eruption (Acne and Rosacea)**

New onset and exacerbation of acne and rosacea on the face occurs frequently due to facial PPE (see Table 3). Among HCWs and non-HCWs, acne flares were the biggest complaint with facial PPE (39.9%).25 The use of facial PPE for extended periods leads to a warm and humid environment under the PPE that can increase the sebum secretion rate and occlude pores, leading to comedone formation predisposing to acne flare-ups.31 During the 2003 SARS pandemic, 59.6% of HCWs complained of facial acne as one of the most difficult adverse skin reactions to wearing N95 respirators for many hours.34 The pressure from the close-fitting facial PPE also leads to pilosebaceous duct occlusion, resulting in acne mechanica.34,36 A survey of 390 HCWs reported that 61.7% had worsening of their skin since the start of COVID-19 pandemic with acne being the most frequently reported.32 HCWs had more symptoms compared with non-HCWs due to the increased duration of facial PPE worn and the use of N95 respirators.25 Another study in non-HCWs showed cloth masks led to fewer acne flares compared with surgical masks.21 It was recommended to decrease the flare ups, non-HCWs should use cloth masks instead of surgical masks.25 Because of the shortage of surgical masks, many HCWs and non-HCWs would reuse their disposable surgical masks. Compared with those who did not reuse their surgical masks, reusing surgical masks contributed to 1.5× increased risk of adverse skin reactions including acne.29

Practicing proper facial skin care is important to help prevent and treat acne and rosacea. Washing with gentle cleansers and, if tolerated, salicylic acid or benzoyl peroxide cleansers is an effective first step in treatment of acne and rosacea.51 Limiting cosmetics and make up products on the days of extended mask wearing can also be helpful. Application of retinoids such as retinol, adapalene, and tretinoin nightly can aid in follicular turnover preventing acne formation. Moderate-to-severe cases can be treated with systemic antibiotics if necessary.18,42 Prolong wearing of masks can aggravate existing acne vulgaris,34,36,44 and taking breaks from the mask 15 minutes every 2 hours can be helpful, if it is safe to do so.51

**GOWNS**

Gowns in the hospital setting provide an additional barrier to protect HCWs from risk of contracting COVID-19 from patients. There are limited reports of occupational dermatoses associated with prolonged wearing of gowns.45 Gowns that tightly adhere to the skin result in increased friction, moisture, and warmth which can increase the risk of developing ICD especially in intertriginous areas such as the axilla, under the breasts, and in the skin folds.45 In addition, chemicals and dyes used in the manufacturing of gowns including formaldehyde resins and textile dyes can contribute to the development of ICD and ACD.45 During the SARS pandemic in Singapore, repeated wearing of disposable gowns led to increased complaints of pruritus and dermatitis at the wrists of HCWs.34 One study found that protective clothing and gowns were the top nonglove PPE responsible for ICD.44 A study conducted during the COVID-19 pandemic surveyed 61 HCWs who regularly wore disposable protective clothing for 10 hours a day for 3.5 months.22 In that study, 60.7% of HCWs complained of adverse skin reactions such as dry skin (36.1%), pruritis (34.4%), rash (11.5%), and wheals (3.28%).22

**HANDS**

Because SARS-CoV2 can spread via contact and droplet transmission, proper hand hygiene is essential for decreasing viral transmission.6 The CDC recommends wearing gloves, washing hands, and the routine use of disinfectant wipes on all contact surfaces to decrease the spread of COVID-19.7 The US Environmental Protection Agency provides a database to search for effective surface
disinfectants for SARS-CoV2. Disinfectant wipes containing citric acid, ethyl alcohol, hydrogen peroxide, quaternary ammonium, or sodium hypochlorite as the active ingredients are said to have virucidal effects on surfaces. Because of these enhanced hygiene practices, there is an increasing prevalence of occupational hand dermatitis. Hands are affected in greater than 80% to 90% of occupational contact dermatitis. In HCWs, hand dermatitis is the most prevalent form of occupational dermatitis with greater than 30% of HCWs affected before the current pandemic. The most commonly reported hand symptoms in HCWs during the COVID-19 pandemic were dryness (92.9%), itchiness (50%), and redness (46.4%) mostly due to hand cleansers followed by the use of disinfectants and gloves. Cases of allergic hand dermatitis and irritant hand dermatitis are presented in Tables 1 and 2, respectively.

**Hand Hygiene**

Occupational dermatoses due to excessive hand washing are the most common complaint seen during the COVID-19 pandemic. The CDC recommends frequent handwashing with soap and warm water for 20 seconds. Repeated exposure to water with soaps, detergents, and antiseptic handwashes can affect the pH of the epidermis and negatively affect the skin’s structural integrity and protection against the environment. In addition, excessive handwashing can deplete the lipid barrier of the stratum corneum, leading to an increase in transepidermal water loss (TEWL). A damaged stratum corneum can allow irritants and allergens to penetrate the epidermis, ultimately leading to irritant and allergic hand dermatitis. One study showed that handwashing during the COVID-19 pandemic increased the risk of xerosis and eczema by 3.57 times. Another study showed that 74.5% of HCWs complained of skin symptoms, which included dryness, tenderness, itching, and burning due to excessive hand washing. Soaps, detergents, and antiseptic handwashes contain fragrances, surfactants, and preservatives that are potential contact allergens that can also cause ACD. The CDC recommends the use of hand sanitizers containing at least 60% ethanol or 70% isopropyl alcohol for use by HCWs. Alcohol-based hand sanitizers (ABHSs) are thought to be better in preventing ICD because they often contain emollients and moisturizers, thus resulting in less disruption to the lipid barrier on the skin than hot water, harsh soaps, and detergents. ABHSs with moisturizers are a better alternative to traditional soaps because they have the least sensitizing and irritancy potential with fewer allergens. However, ABHSs has also been implicated in causing skin dryness and subsequent ICD. ABHSs often contain ingredients (fragrances, tocopherol, propylene glycol, benzoates, and cetyl stearyl alcohol) that can also cause ACD.

**Gloves**

Rubber gloves provide an additional layer of protection for HCWs and non-HCWs in preventing viral transmission. Excessive glove use can be harmful to the skin, causing xerosis and hand dermatitis. One study showed that excessive use of gloves can lead to a 2.68 times increased risk of developing xerosis. Long-term use of gloves can also paradoxically lead to overhydration of the stratum corneum, which may lead to maceration and erosion of the skin. One study reported that 88.5% of HCWs wearing rubber latex gloves during the COVID-19 pandemic for an average of 10 hours a day for 3.5 months complained of skin reactions. The symptoms most commonly reported were dry skin (55.7%), itching (31.2%), rash (24%), and chapped skin (21.3%). Frequent moisturizing of the hands and using a cotton glove liner can also decrease the risk of developing irritant hand dermatitis.

Most rubber gloves contain rubber accelerators, such as thiurams, carbamates, diphenylguanidine, mixed dialkyl thioureas, and benzothiazoles, that accelerate the process to synthesize rubber consumer products from its raw material but are leading causes of glove-related ACD. The American Contact Dermatitis Society recommends the use of accelerator-free gloves for those with suspected or confirmed hand ACD. One study provided HCWs suffering from hand ACD a 1-month supply of rubber accelerator-free gloves, and both disease severity and patient quality of life improved dramatically.

**Surface Disinfectants**

Because of the indirect contact transmission of COVID-19, disinfecting surfaces multiple times throughout the day has become a habitual practice. Repeated cleaning and use of disinfectants may damage the skin surface and compromise the skin barrier leading to ICD. This exposes harsh chemicals such as N-alkyl dimethyl benzyl ammonium chloride on the skin. Exposure to fat soluble disinfectants such as 75% alcohol, chlorine-based disinfectants, and peroxycacetic acid can lead to ACD and can present with desquamation, rhagades, pruritis, and bleeding. Disinfectant wipes for surface cleaning should not be used directly on the skin. When cleaning
surfaces, proper skin protection such as the use of gloves when handling chemicals is recommended to protect the skin from any injury or direct chemical exposure. Rare cases of ACD have also been documented due to disinfectants. Cases of occupational airborne ACD have been seen from the use of a disinfectant spray containing linalyl acetate and cleaning detergent containing N-alkyl dimethylbenzylammonium chloride and n-alkyl dimethylethylbenzyl ammonium chloride.

If irritant hand dermatitis is suspected, the first step is to avoid the potential irritant whether it is in detergents, gloves, or harsh soaps. Switching to gentle cleansers and regularly moisturizing immediately after can alleviate most cases of hand dermatitis. Use of ABHSs with emollients can be helpful in select cases. Moisturizers that include petrolatum in the form of ointments can serve as a physical barrier and prevent further TEWL. Humectants such as urea and glycerin attract water and moisture to the epidermis. It is recommended that patients apply a thick petrolatum-based emollient nightly to the hands and cover with white cotton gloves before bed, leaving the gloves on until the next morning. Treatment of acute, itchy, irritant dermatitis with potent topical steroids can also help alleviate symptoms through judicious use of potent topical steroids, given the thickness of the stratum corneum on the hands.

Management of patients with allergic hand dermatitis includes identification of the allergen through patch testing and avoidance of the allergen. Potential allergens can be found in soaps, cleansers, gloves, and moisturizers. Avoidance of the allergen is curative in cases of ACD.

SUMMARY

In this review the authors discussed the common types of occupational dermatoses that have been reported due to increased use of PPE during the COVID-19 pandemic. They also discussed preventative, diagnostic, and treatment strategies for PPE-related occupational dermatoses. Until an effective vaccine and treatments become available worldwide, the authors will likely continue to see heightened prevalence of PPE-related dermatoses.

REFERENCES

1. Zhu N, Zhang D, Wang W, et al. A novel coronavirus from patients with pneumonia in China, 2019. N Engl J Med 2020;382(8):727–33.
2. Holshue ML, DeBolt C, Lindquist S, et al. First case of 2019 novel coronavirus in the United States. N Engl J Med 2020;382(10):929–36.
3. Gorbalenya AE, Baker SC, Baric RS, et al. The species severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2. Nat Microbiol 2020;5(4):536–44.
4. WHO Director-General’s opening remarks at the media briefing on COVID-19-11 March 2020. Available at: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19. [Accessed 14 December 2020].
5. CDC COVID Data Tracker. Available at: https://covid.cdc.gov/covid-data-tracker/#trends_totalandratedeaths. [Accessed 2 January 2021].
6. Health WHO, Programme E, Panel EA. Transmission of SARS-CoV-2 : implications for infection prevention precautions. 2020 (July):1–10. Available at: https://www.who.int/publications/i/item/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations. [Accessed 14 December 2020].
7. Protect yourself. Available at: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html. [Accessed 14 December 2020].
8. General optimization strategies. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/general-optimization-strategies.html. [Accessed 15 December 2020].
9. Lan J, Song Z, Miao X, et al. Skin damage among health care workers managing coronavirus disease-2019. J Am Acad Dermatol 2020;82(5):1215–6.
10. Lim HW, Collins SAB, Resneck JS, et al. The burden of skin disease in the United States. J Am Acad Dermatol 2017;76(5):958–72.
11. Sasseville D. Occupational contact dermatitis. Allergy Asthma Clin Immunol 2008;4(2):59–65.
12. Yu J, Chen JK, Mowad CM, et al. Occupational dermatitis to facial personal protective equipment in health care workers: a systematic review. J Am Acad Dermatol 2021;84(2):486–94.
13. Gheisari M, Araghi F, Moravvej H, et al. Skin reactions to non-glove personal protective equipment: an emerging issue in the COVID-19 pandemic. J Eur Acad Dermatol Venereol 2020;34(7):e297–8.
14. Aerts O, Dendooven E, Foubert K, et al. Surgical mask dermatitis caused by formaldehyde (releasers) during the COVID-19 pandemic. Contact Dermatitis 2020;83(2):172–3.
15. Bothra A, Das S, Singh M, et al. Retroauricular dermatitis with vehement use of ear loop face masks during COVID-19 pandemic. J Eur Acad Dermatol Venereol 2020;34(10):e549–52.
16. Ferguson FJ, Street G, Cunningham L, et al. Occupational dermatology in the time of the COVID-19 pandemic: a report of experience from London and Manchester, UK. Br J Dermatol 2020;2020–2.
17. Singh M, Pawar M, Bothra A, et al. Personal protective equipment induced facial dermatoses in healthcare workers managing coronavirus disease 2019. J Eur Acad Dermatol Venereol 2020;34(8):e378–80.
18. Xie Z, Yang YX, Zhang H. Mask-induced contact dermatitis in handling COVID-19 outbreak. Contact Dermatitis 2020;83(2):166–7.
19. Yu J, Goldminz A, Chisolm S, et al. Facial personal protective equipment: materials, resterilization methods, and management of occupation-related dermatoses. Dermatitis 2021;32(2):78–85.
20. Alluhayyan OB, Alshahri BK, Farhat AM, et al. Occupational-related contact dermatitis: prevalence and risk factors among healthcare workers in the AlQassim region, Saudi Arabia during the COVID-19 pandemic. Cureus 2020;12(10):e10975.
21. Chaiyabutr C, Sukakul T, Pruksaekakanan C, et al. Adverse skin reactions following different types of mask usage during the COVID-19 pandemic. J Eur Acad Dermatol Venereol 2020;95:1–3.
22. Hu K, Fan J, Li X, et al. The adverse skin reactions of health care workers using personal protective equipment for COVID-19. Medicine (Baltimore) 2020;99(24):e20603.
23. Kiely LF, Moloney E, O’Sullivan G, et al. Irritant contact dermatitis in healthcare workers as a result of the COVID-19 pandemic: a cross-sectional study. Clin Exp Dermatol 2020;46:142–4.
24. Metin N, Turan Ç, Utlu Z. Changes in dermatological complaints among healthcare workers during the COVID-19 outbreak in Turkey. Acta Dermato-Venereal Alp Pannonica Adriat 2020;29(3):115–22.
25. Techasatian L, Lebsing S, Uppala R, et al. The effects of the face mask on the skin underneath: a prospective survey during the COVID-19 pandemic. J Prim Care Community Health 2020;11:2150132720966167.
26. Clark GW, Pope SM, Jaboori KA. Diagnosis and treatment of seborrheic dermatitis. Am Fam Physician 2015;91(3):185–90.
27. Veraldi S, Angileri L, Barbareschi M. Seborrhoeic dermatitis and anti-COVID-19 masks. J Cosmet Dermatol 2020;19(10):2464–5.
28. Chiriac AE, Uwe W, Doina A. Flare-up of rosacea due to face mask in healthcare workers during COVID-19. Maedica 2020;15(16):416–7.
29. Daye M, Cihan FG, Durduryan Y. Evaluation of skin problems and dermatology life quality index in health care workers who use personal protection measures during COVID-19 pandemic. Dermatol Ther 2020;33:e14346.
30. Giacalone S, Minuti A, Spigariolo CB, et al. Facial dermatoses in the general population due to wearing of personal protective masks during the COVID-19 pandemic: first observations after lockdown. Clin Exp Dermatol 2021;46(2):368–9.
31. Han C, Shi J, Chen Y, et al. Increased flare of acne caused by long-time mask wearing during COVID-19 pandemic among general population. Dermatol Ther 2020;33(4):3–5.
32. Trepanowski N, Larson AR, Evers-Meltzer R. Occupational dermatoses among front-line health care workers during the COVID-19 pandemic: a cross-sectional survey. J Am Acad Dermatol 2021;84:223–5.
33. Zuo Y, Hua W, Luo Y, et al. Skin reactions of N95 masks and medial masks among health-care personnel: a self-report questionnaire survey in China. Contact Dermatitis 2020;83(2):145–7.
34. Foo CCI, Goon ATJ, Leow YH, et al. Adverse skin reactions to personal protective equipment against severe acute respiratory syndrome - a descriptive study in Singapore. Contact Dermatitis 2006;55(5):291–4.
35. Toyoda M, Morohashi M. Pathogenesis of acne. Med Electron Microsc 2001;34(7):29–40.
36. Tan KT, Greaves MW. N95 acne. Int J Dermatol 2004;43(7):522–3.
37. Wayne BB, Pelletier AL. Rosacea: a common, yet commonly overlooked, condition. Am Fam Physician 2002;66(3):435–40.
38. Lin P, Zhu S, Huang Y, et al. Adverse skin reactions among healthcare workers during the coronavirus disease 2019 outbreak: a survey in Wuhan and its surrounding regions. Br J Dermatol 2020;183(1):190–2.
39. Mawhirt SL, Frankel D, Diaz AM. Cutaneous manifestations in adult patients with COVID-19 and dermatologic conditions related to the COVID-19 pandemic in health care workers. Curr Allergy Asthma Rep 2020;20(12):75.
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40. Warshaw EM, Schlarbaum JP, Silverberg JI, et al. Safety equipment: when protection becomes a problem. Contact Dermatitis 2019;81(2):130–2.

41. Donovan J, Kudla I, Holness DL, et al. Skin reactions following use of N95 facial masks. J Child Neurol 2006;21(3):261–73.

42. Yan Y, Chen H, Chen L, et al. Consensus of Chinese experts on protection of skin and mucous membrane barrier for health-care workers fighting against coronavirus disease 2019. Dermatol Ther 2020;33(4):1–7.

43. Zhang B, Zhai R, Ma L. 2019 Novel coronavirus disease epidemic: skin protection for healthcare workers must not be ignored. J Eur Acad Dermatol Venereol 2020;34(9):e434–5.

44. Bhoyrul B, Lecamwasam K, Wilkinson M, et al. A review of non-glove personal protective equipment-related occupational dermatoses reported to epiderm between 1993 and 2013. Contact Dermatitis 2019;80(4):217–21.

45. Donovan J, Skotnicki-Grant S. Allergic contact dermatitis from formaldehyde textile resins in surgical and nonwoven textile masks. Dermatitis 2007;18(1):40–4.

46. Bui ATN, Yu Z, Lee K, et al. A pilot study of the impact of facial skin protectants on qualitative fit testing of N95 masks. J Am Acad Dermatol 2021;84(2):554–6.

47. Pacis M, Azor-Ocampo A, Burnett E, et al. Prophylactic dressings for maintaining skin integrity of healthcare workers when using N95 respirators while preventing contamination due to the novel coronavirus: a quality improvement project. J Wound Ostomy Continence Nurs 2020;47(6):551–7.

48. LeBlanc K, Heerschap C, Butt B, et al. Prevention and management of person protective equipment skin injury: update 2020. NSW OCC. Available at: www.nswocc.ca/ppe. [Accessed 16 January 2021].

49. Cuddigan J, Black J, Deppisch M, et al. NPIAP position statements on preventing injury with N95 masks. Available at: https://npiap.com/page/COVID-19Resources. [Accessed 10 January 2021].

50. Alves, P, Moura A, Ferreira A, et al: PRPPE Guide-lines of care for the management of acne vulgaris. J Am Acad Dermatol 2016;74(5):945–73.

51. Wilkin J, Dahl M, Detmar M, et al. Standard classification of rosacea: Report of the National Rosacea Society Expert Committee on the Classification and Staging of Rosacea. J Am Acad Dermatol 2002;46(4):584–7.

52. Two AM, Wu W, Gallo RL, et al. Rosacea: part I. Introduction, categorization, histology, pathogenesis, and risk factors. J Am Acad Dermatol 2015;72(5):749–58.
69. Long H, Zhao H, Chen A, et al. Protecting medical staff from skin injury/disease caused by personal protective equipment during epidemic period of COVID-19: experience from China. J Eur Acad Dermatol Venereol 2020;34(5):919–21.

70. Mauleón C, Mauleón P, Chavarría E, et al. Airborne contact dermatitis from n-alkyl dimethylbenzylammonium chloride and n-alkyl dimethylethylbenzylammonium chloride in a detergent. Contact Dermatitis 2006;55(5):311–2.

71. White JML, Goossens A. Occupational airborne allergic contact dermatitis to linalyl acetate in a disinfectant spray. Contact Dermatitis 2020;83(5):412–3.

72. Lodén M. Role of topical emollients and moisturizers in the treatment of dry skin barrier disorders. Am J Clin Dermatol 2003;4(11):771–88.