

Facial Personal Protective Equipment: Materials, Resterilization Methods, and Management of Occupation-Related Dermatoses

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Background: The coronavirus infectious disease 2019 pandemic has resulted in health care workers donning personal protective equipment (PPE) for extended periods.

Objectives: The aims of the study were to review facial PPE (surgical masks and N95 respirators) ingredients, to identify facial PPE resterilization techniques, and to recommend strategies for prevention and management of facial PPE-related dermatoses.

Methods: Twenty-one facial PPE (11 N95 respirators, 10 surgical masks) were reviewed. Resterilization techniques were identified. Personal protective equipment-induced occupational dermatoses and management strategies were explored.

Results: Polypropylene is the most common chemical identified in facial PPE. Most masks contain aluminum at the nose-piece. Two surgical masks released nickel. Facial PPE dermatoses include irritant contact dermatitis, allergic contact dermatitis, acne, and contact urticaria. Strategies for prevention and management of facial PPE occupational dermatoses are discussed.

Conclusions: There are increasing reports of occupational dermatoses associated with facial PPE. This review discusses the components of facial PPE, mask resterilization methods, and strategies for prevention and management of facial PPE dermatoses.

The coronavirus infectious disease 2019 (COVID-19) caused by severe acute respiratory disease coronavirus is spread via respiratory droplets. To prevent infection, health care workers (HCWs)

are required to don facial personal protective equipment (PPE), such as surgical/procedural masks and N95 respirators. Surgical masks and N95 respirators differ in their fit and ability to filter airborne particles. Surgical masks are designed to block large-particle sprays, splatter, droplets, and splashes. N95 respirators block at least 95% of 0.3- μ m test particles.

The need for facial PPE has resulted in an increase of facial PPE-associated occupational dermatoses, such as irritant contact dermatitis (ICD), allergic contact dermatitis (ACD), contact urticaria, and acne.¹ In Wuhan, China, 74.5% of HCWs caring for COVID-19 patients reported adverse skin reactions related to PPE, with the cheeks and nasal bridge being affected in 75.4% and 71.8%, respectively.² In addition, in an effort to maximize the availability of PPE, the US Food and Drug Administration has issued several Emergency Use Authorizations allowing for decontamination and resterilization strategies, which in some cases include the application of chemicals to PPE. Finally, there is a paucity of literature describing a recommended approach to the prevention and management of facial PPE-induced occupational dermatoses.

The objectives of this study were to review ingredients of facial PPE (surgical masks and N95 respirators), to identify methods of facial PPE resterilization, and to recommend strategies for prevention and management of facial PPE-related dermatoses. These strategies

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are based on recommendations from expert members of the American Contact Dermatitis Society.

METHODS

This study was determined exempt by the Duke Health Institutional Review Board. Thirty-one mask manufacturers approved by the National Institute for Occupational Safety and Health Research and the Food and Drug Administration were contacted by 2 authors (A.G., S.C.) between April 14, 2020, and April 21, 2020.³ Product information for 11 distinct N95 respirators (6 manufacturers) and 10 distinct surgical masks (3 manufacturers) was received from US and Canadian manufacturers. The remaining companies either did not respond, sourced masks from other manufacturers, or were not able to release information.

The metal nose pieces of 5 facial PPE (4 surgical masks, 1 N95 respirator) were tested for nickel release using dimethylglyoxime (DMG); pink color signifies nickel release.⁴ The Reveal & Conceal Nickel Spot Test (SmartPractice, Phoenix, AZ) was used to test 4 surgical masks. The Nickel Alert detect test kit (Athena Allergy, Inc, Huntersville, NC) was used for the N95 respirator (3M Product Number 8210).

Current mask resterilization techniques were analyzed, with attention given to reports of associated occupational dermatoses. In addition, the authors described recommended skin care practices for facial PPE-induced occupational dermatoses.

RESULTS

Components of N95 Respirators and Surgical Masks

The components of 11 N95 respirators and 10 surgical masks were reviewed (Tables 1, 2). The most common outer shell component of N95 respirators was polypropylene (7/11). The most common inner filter of N95 respirators was polyethylene (10/11). The straps of N95 respirators were made from elastic material, with some specifying polyisoprene (4/11).

Polypropylene was the primary material for 8 of the 10 surgical masks. All 5 surgical masks with face shields used polyethylene terephthalate. Ear loops were mostly elastic.

Of the 5 facial PPE evaluated with DMG, 2 surgical masks released nickel, 2 surgical masks were negative, and the N95 respirator was negative (Fig. 1).

N95 Respirator Resterilization

The COVID-19 pandemic has resulted in a high demand for PPE and fear of insufficient supply.⁵ According to the Centers for Disease Control and Prevention, the most effective N95 respirator decontamination methods are hydrogen peroxide (H_2O_2) vapor decontamination, UV germicidal irradiation, and moist heat.⁶

Hydrogen peroxide vapor decontamination^{7,8} requires uniform distribution of H_2O_2 vapor across N95 respirators with a subsequent aeration phase to lower the concentration of residual H_2O_2 on

masks to safe standards (<1 ppm).^{7,8} This method has an antimicrobial efficacy of greater than 99.999%.⁶

UV germicidal irradiation uses 0.5 to 1.8 J/cm² of UV-C and has antimicrobial efficacy of 99.9% for all tested viruses.⁶ Its main limitations include the potential for shadows, which can block UV light and inhibit efficacy.⁹ No chemicals are applied.

Warm moist heat sterilization exposes N95 respirators to water heated to 65°C for 30 minutes.¹⁰ No viable influenza A subtype H1N1 viruses remain on the surface of the mask after sterilization.¹⁰ There was also no visible deterioration or deformation to the mask after sterilization.

Steam decontamination has been used for surgical masks and N95 respirators.¹¹ Masks and respirators are exposed to steam from boiling water; they retained virus-blocking efficacy even after 2 hours of treatment. After 5 minutes of exposure to boiling water, the avian coronavirus (a mimic of severe acute respiratory disease coronavirus) was inactivated.

DISCUSSION

This study focused on the identification of chemical components in facial PPE and the examination of methods of N95 respirator resterilization, as well as the prevention and management strategies for individuals with facial PPE-induced occupational dermatoses.

Mask Materials

The individual components of facial PPE are not well described. Material information was received for 21 facial PPE (11 N95 respirators, 10 surgical masks).

Polypropylene, a rare allergen,¹² was the most frequently identified component of the outer shell and filter of N95 respirators and body of surgical masks. Polypropylene is melted during the synthesis of nonwoven textiles leading to formaldehyde byproducts that may be incompletely removed leading to ACD.¹³ Allergic contact dermatitis to formaldehyde from the degradation of polypropylene during the routine use of face masks has also been described.¹⁴ Health care workers with mask-related facial dermatitis and known formaldehyde allergy should avoid polypropylene masks.

Polyester is another material used in facial PPE. Despite its prevalent use in clothing, allergy to polyester resin is rare. Irritant reactions to polybasic acids, polybasic alcohols, fiberglass, and/or acetone components of polyester are possible.¹⁵ In the occupational setting, patients are more often allergic to the cobalt accelerator used in the processing of polyester.^{16,17}

Ethylene-vinyl acetate (EVA) was identified in the outer shell and nose foam of N95 respirators. Ethylene-vinyl acetate itself is not a cause of contact allergy, but acetophenone azine, a newly described allergen used in foam materials such as shin pads and other sports equipment, has been identified in EVA-based materials.¹⁸ Authors theorized that acetophenone azine might be a catalyst in the polymerization of EVA. Therefore, similar to the case of polypropylene,

TABLE 1. Materials of 11 N95 Respirators

N95 Respirators					
Product (Product Number)	Manufacturer	Mask Shell	Filter	Head Strap	Other Materials
VFlex Health Care Particulate Respirator and Surgical Mask (1804 and 1804S)	3M	Polypropylene	Polypropylene	Polyisoprene bound by steel staples (no natural rubber latex)	Aluminum nose clip, adhesive, black ink
VFlex Health Care Particulate Respirator and Surgical Mask (1805 and 1805S)	3M	Polypropylene	Polypropylene	Polyisoprene bound by steel staples (no natural rubber latex)	Aluminum nose clip, adhesive, black ink
Health Care Particulate Respirator and Surgical Mask (1860)	3M	Polypropylene	Polypropylene/polyester	Braided polyisoprene bound by steel staples	Aluminum nose clip, polyurethane foam nose cushion, ethylene/acrylic acid copolymer, and isooctyl acrylate/acrylic acid copolymer
Aura Health Care Particulate Respiratory and Surgical Mask (1870 and 1870+)	3M	Polypropylene	Polypropylene	Polyisoprene bound by steel staples (no natural rubber latex)	Aluminum nose clip, adhesive
PFL Particulate Respirator	Alpha Pro Tech	Polycellulose	Polypropylene	Synthetic elastic (no natural rubber latex), band heat-sealed to mask	Aluminum nose/chin bands, polypropylene strips for "Magic Arch"
Respirator, Cone Style	Cardinal Health	Polyester	Polypropylene	Knitted elastic strap	Aluminum nose clip, EVA nose foam
Respirator, Flat-Fold Style	Cardinal Health	Polyester	Melt blown (material not specified)		
1500 Series (1510, 1511, 1512, 1513, 1517)	Moldex	EVA/polyethylene/polypropylene	Polypropylene	Thermoplastic elastomer bound by tin plated steel wire staples	Polyethylene nose cushion
2200G Series (2210G, 2211G, 2212G, 2217G)	Moldex	EVA/polyethylene/polypropylene	Polypropylene	Thermoplastic elastomer bound by tin plated steel wire staples	Polyethylene nose cushion
Particulate Respirator, Cone Style (NON24506A)	Medline	Polypropylene (inner), polyester (outer)	Polypropylene	Latex-free elastic	
Surgical Respirator (65-3395 and 65-3395S)	Precept	Polyester	Polypropylene	Latex-free elastic	Aluminum nose clip

In some instances, when detailed information was not available, specific use of individual materials in the N95 respirators was inferred based on material description. EVA, ethylene-vinyl acetate.

acetophenone azine-allergic patients could theoretically be at risk of ACD to masks containing EVA.

Polyurethane, present in many plastics and used as part of the foam nose cushion of masks, has been reported to cause ACD. However, reactions are frequently attributed to isocyanate resins, which are highly irritating and sometimes sensitizing accelerators.¹⁹

Polyethylene terephthalate was identified in face shields associated with surgical masks. This is a rare allergen, with 1 reported case of ACD to polyethylene terephthalate mesh in a cochlear implant.²⁰

Adhesives (such as acrylates) were noted in several N95 respirators and surgical masks. Acrylate ACD has been reported from nail products, pressure sensitive adhesives, and insulin pumps.^{21,22} In 1 series, 6% of patch-tested patients were allergic to acrylates.²³

Aluminum is present in the nose piece and/or chin of N95 respirators and surgical masks. Allergic contact dermatitis to aluminum is uncommon. Several case reports of contact allergy to aluminum-based Finn Chambers have been described.^{24–27} Steel is occasionally used in the nose piece and staples of facial PPE.

TABLE 2. Materials of 10 Surgical/Procedural Masks

Surgical/Procedural Masks						
Product (Product Number)	Manufacturer	Face Shield	"Body" of Mask	Ear Loops or Ties	Nose Piece	Other Materials
Ear Loop Fluid-Resistant Face Mask (1817, 1820, 1820FS, 1826)	3M		Polypropylene	Elastic (natural rubber latex free)	Polyethylene-coated steel wire	
High Fluid-Resistant Surgical Mask (1835 and 1835FS)	3M	Poly(ethylene terephthalate) with antifog and antireflection	Polypropylene fiber	Poly(ethylene terephthalate) or polypropylene	Polyethylene-coated steel nose wire	
High Fluid-Resistant Procedure Mask (1840 and 1840FS)	3M	Poly(ethylene terephthalate) with antifog and antireflection	Polypropylene fabric	Poly(ethylene terephthalate)/polyurethane/nylon	Polyethylene-coated steel nose wire	Poly(ethylene terephthalate) side tape
600 Hygiene Mask	3M		Polyester and braided polyester		Aluminum	Cadmium-free steel
High-Performance Surgical Mask (1838R and 1838 FSG)	3M	Poly(ethylene terephthalate)	Polypropylene	Nonwoven fabric		Mask coating
Critical Cover CoolOne Face Mask	Alpha Pro Tech		Polypropylene, polycellulose	Soft knit ultrasonically welded to the mask	Aluminum strip	
Cone Style Mask (NON27381)	Medline		100% polyester (inner facing), 100% polyester (outer facing), and 100% polyester (filter media)	Polyester-coated rubber		
Fluid-Resistant Surgical Face Mask (NON27410EL)	Medline	Poly(ethylene terephthalate) with hydrophilic antifog coating	Thermalbond polypropylene (inner facing), spunbond polypropylene (outer facing), and melt-blown polypropylene (filter media)	Tubular latex-free elastic		Foam strip (antifog)
Max X Fluid-Resistant Procedural Face Mask (NON27710EL)	Medline	Poly(ethylene terephthalate) with hydrophilic antifog coating	Soft cellulose (inner facing), cellulose, pattern (outer facing), melt-blown polypropylene (filter media), and high-density polyethylene nonwoven fabric (fourth layer)	Tubular latex-free elastic		Foam strip (antifog)
Max-X Fluid Protection Surgical Face Mask (NON27712)	Medline		Soft cellulose, white (inner facing), cellulose, pattern (outer facing), 1 ply melt-blown polypropylene, white (filter media), and 1 ply of 19-g high-density polyethylene nonwoven fabric (filter media)	Spunbond		Foam strip (antifog)

Specific use of individual materials in the surgical masks was inferred based on material description because this information was generally not available.

Although steel components can vary, it often includes nickel, a common allergen with a positivity rate of 17.5%.²³ In our sample, 2 of the 4 surgical mask nose pieces were positive for nickel release.

Elastic straps used in facial PPE have been linked to contact allergy.^{28,29} Elastic straps contain rubber accelerators, which are used in the processing of raw rubber and are known allergens in

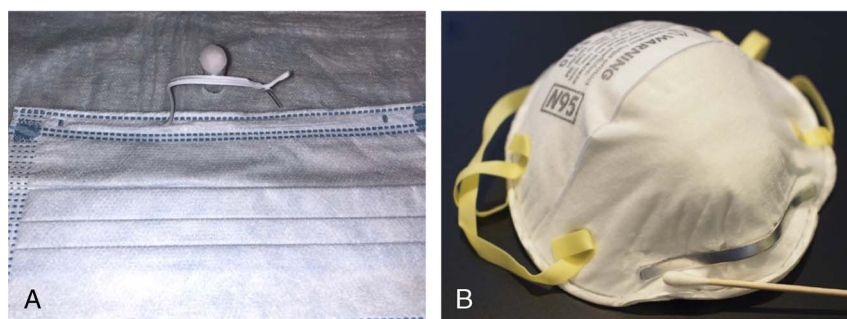


Figure 1. A, Positive DMG test (pink discoloration) on surgical mask. B, Negative DMG test on N95 respirator. DMG, dimethylglyoxime.

occupational and nonoccupational settings.^{30,31} Polyisoprene, another component of head straps, has been associated with ACD.³²

In this study, with exception of “black ink,” mask manufacturers did not disclose the use of dye in facial PPE, although many masks have color. One case report documented yellow pigment in an N95 respirator.¹⁴ Additional information on dyes present in medical masks is necessary.

Respirator Reuse and Decontamination

Because of the sudden increased need for PPE for HCWs, several methods of mask and respirator decontamination are being used. Hydrogen peroxide vapor decontamination, UV germicidal irradiation, and moist heat are currently advertised by the Centers for Disease Control and Prevention as the most promising methods.⁶

The main theoretical cutaneous risk with sterilized N95 respirators is ICD. Irritant contact dermatitis from N95 respirators exists at baseline as has been described in several studies. However, the authors are not aware of reports of ICD specifically attributed to sterilized N95 respirators.^{2,33}

Allergic contact dermatitis and ICD to H_2O_2 are quite rare, with only a few known case reports.³⁴ In addition, protocols dictate appropriate aeration of H_2O_2 during decontamination. For this reason, the authors believe that cutaneous reactions directly attributable to H_2O_2 in the setting of N95 respirator decontamination would be rare. Surveillance is needed to determine whether reusing masks after decontamination increases exposure to mask components including allergens and irritants.

Facial PPE Occupational Dermatoses

Common cutaneous reactions to surgical masks and N95 respirators include ACD, ICD, acne, and contact urticaria.^{2,33,35,36} There are a number of consensus statements and guidelines already published on the subject, including strategies for management and avoidance.^{37–40} This section includes recommendations for cutaneous management, incorporates components of these published guidelines, and introduces additional strategies specific to dermatology practice.

Skin Care

General skin care management is recommended for all individuals using facial PPE. Individuals should wash their face with a gentle skin cleanser and apply daily moisturizer. The labels “hypoallergenic” and “gentle” are not regulated, making the selection of optimal products difficult.^{41,42} Other publications have covered the topic of recommended moisturizers,⁴² and allergen-specific databases can be used for identification of allergen-free products.⁴³

The British National Health Service (NHS) recommends that topicals be applied at least 30 minutes before PPE use,³⁷ whereas a Portuguese group recommends 60 minutes,⁴⁰ and the Wound, Ostomy, and Continence Nurses Society (WOCNS) recommends 1 to 2 hours.⁴⁴ Our recommendation is that the chosen time interval between product application and donning of PPE needs to be sufficient to create a nonmoist, nontacky, nonmacerated cutaneous surface.

Anatomy-Specific Management Strategies

Ears

Long-term use of face masks can lead to irritation behind the ears from elastic straps. Health care workers can consider alternating between surgical masks with ear loops and surgical masks with tie straps to decrease pressure. Thin dressings can be applied to contact areas around or behind the ears to relieve pressure from elastic straps. Some vendors have developed devices that allow users to attach straps behind the head to remove tension⁴⁵; examples include headbands affixed with buttons and plastic 3D-printed straps. The WOCNS states that this type of device modification is acceptable for surgical masks but cautions that they could alter the fit and performance of N95 respirators⁴⁶; guidance from local hospital policy should be obtained before using these devices with N95 respirators.

Nose and Cheeks

N95 respirators require a tight fit to achieve adequate seal and protection. The nasal bridge, nasal tip, and malar cheeks are common contact points.

Survey studies on the recent COVID-19 pandemic have identified prolonged mask use for more than 6 hours as a risk factor for adverse cutaneous reactions.^{2,33} Shorter use times, or longer breaks between shifts, could be considered. An expert panel from the

Nurses Specialized in Wound, Ostomy and Continence Canada and a Portuguese group both recommend that PPE be removed and pressure be relieved every 4 hours,^{39,40} whereas the National Pressure Injury Advisory Panel (NPIAP) recommends that if pressure relief is needed, users remove the mask for 15 minutes every 2 hours.³⁸ Alternatively, the NPIAP recommends that pressure can be relieved by lifting the mask away from the face for 5 minutes every 2 hours. The NHS also recommends breaks every 2 hours.³⁷

Skin-protective topicals can be considered as long as they do not interfere with fit and safety. Options include silicone or dimethicone barrier creams, acrylate-based products, and other topical skin protectants. Suggested products are listed in Table 3. The NPIAP recommends against the use of petrolatum jelly, mineral oil, or other greasy topicals under N95 respirators.³⁸

The use of prophylactic dressings with N95 respirators is controversial; they should not be used unless approved by local hospital policy. Dressing options are reviewed in Table 3. The NPIAP stops short of endorsing occlusive dressings with N95 masks but provides guidance that if thin dressings are used, they can be cut into strips for the cheeks, nasal bridge, and behind the ears. Repeat fit testing should be performed with the dressing in place to ensure an appropriate seal.³⁸ They also state that dressings should be considered contaminated and recommend that users close their eyes and hold their breath in exhalation during removal. The Portuguese group, NHS, and Nurses Specialized in Wound, Ostomy and Continence Canada have similar recommendations,^{37,39,40} and 2 provide photographs of anatomy-fitting shapes into which dressings can be cut.^{39,40}

In contrast, the WOCNS recommends against use of dressings under N95 masks because they may interfere with fit.⁴⁴

Disease-Specific Management Strategies

Irritant Contact Dermatitis

Irritant contact dermatitis is likely the most common manifestation of cutaneous mask adverse reaction. Strategies should focus on preventing friction and pressure while also maintaining proper device performance. Cleaning the skin daily to remove excess oil and mask residue is important. Gentle skin care, including regular application of moisturizers and/or barrier creams along with targeted therapy for dermatitis, is appropriate. A change of mask brand or style can be considered. Even after the skin has healed, barrier protection should continue.

Allergic Contact Dermatitis

The goal of management for ACD from facial PPE is allergen avoidance. Comprehensive patch testing and repeat open application testing of potential culprit products may be necessary to identify causative agents. Patch testing of facial PPE can be completed by deconstructing the PPE to isolate individual components (layers of mask, nosepiece, ear piece, etc) and then direct application to the skin with a drop of saline and application of tape, followed by standard patch test protocols. If patch testing is not possible, avoidance of potential allergens, gentle skin care, and targeted dermatitis therapy are the best practices. In addition, a change of the brand, style, and/or mask color can be considered. If there is concern for

TABLE 3. Proposed Products for Management of Face Mask Dermatitis

Product Category	Manufacturer	Product Name
Dressing	ConvaTec	Duoderm Extra Thin
	Spenco	2nd Skin Moist Burn Pad
	DermaRite	DermaViewII Transparent Film Dressing
	Johnson & Johnson	BAND-AID HYDRO SEAL
Acrylate barrier products	DermaRite	DermaPrep Liquid Barrier Skin Prep
	Cardinal Health	Kendall Barrier Wipes
	Medline Industries	Marathon No Sting Cyanoacrylate Skin Protectant
Silicone barrier products	Essity	Cutimed PROTECT
	Molnlycke	Mepitac tape
	ConvaTec	Sensi-Care Sting Free Skin Barrier
	DermaRite Industries	StingFree Alcohol Free Liquid Skin Prep & Shield
Acrylate and silicone barrier products	Medline Industries	SurePrep Rapid Dry
	3M Health Care	3M Cavilon Advanced Skin Protectant
	3M Health Care	3M Cavilon No Sting Barrier Film
Dimethicone barrier products	Smith+Nephew	No-Sting Skin Prep Protective Dressing
	Safe n' Simple	Safe n' Simple No-Sting Skin Barrier Film Spray**
	Safe n' Simple	Safe n' Simple No-Sting Skin Barrier Film Wipes**
	Smith+Nephew	Skin-Prep Protective Dressing Wipes*
	Gloves in a Bottle	Gloves in a Bottle Shielding Lotion
	La Roche-Posay	Cicaplast Baume B5
Other barrier products	Neutrogena	Mineral sheers (mica/bismuth powders)
Powders		

*Contains diazolidinyl urea.

**Contains propylene glycol.

polypropylene (or formaldehyde) allergy, consider a polyester or polycellulose-based mask.

Acne

Facial cleansing should occur at the end of each shift. Sensitive skin types may need to reduce the use of cleansers containing salicylic acid, benzoyl peroxide, and other irritants. Oily skin types may need to wash the face before and after wearing the mask. Gentle skin care and standard targeted therapy for acne are appropriate. A report of N95 respirator-related acne in HCWs identified topical retinoids and systemic antibiotics as useful in 2 patients.³⁵

Contact Urticaria

Nonsedating antihistamine therapy should be considered to prevent urticaria. Management may require decreased exposure time to tight-fitting masks or job reassignment if therapeutic measures are unsuccessful.

Limitations

There are many facial PPE manufacturers in the United States. Although we attempted to reach a representative sample of the US market, the availability of comprehensive manufacturing information and the willingness of manufacturers to provide information limited our analysis. This study did not evaluate face masks made in Asia, which is currently the largest manufacturer of facial PPE in the world; how widely they are used in the United States is unknown.⁴⁷

CONCLUSIONS

The COVID-19 pandemic has resulted in the increased use of facial PPE by HCWs triggering a rise in occupational dermatoses, with ICD likely most common. Elastic bands, metal nose rims, and undeclared formaldehyde may cause ACD. We reviewed common mask reesterilization strategies and made recommendations on the prevention and management of facial PPE-related occupational dermatoses.

REFERENCES

1. 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):291–294.
2. 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):190–192.
3. CDC. Approved N95 respirators. Available at: https://www.cdc.gov/niosh/nppt/topics/respirators/disp_part/respsource3surgicaln95.html. Published 2020. Accessed April 16, 2020.
4. Thyssen JP, Skare L, Lundgren L, et al. Sensitivity and specificity of the nickel spot (dimethylglyoxime) test. *Contact Dermatitis* 2010;62(5):279–288.
5. Artenstein AW. In pursuit of PPE. *N Engl J Med* 2020;382(18):e46.
6. CDC. Decontamination and reuse of filtering facepiece respirators. Coronavirus disease 2019. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/decontamination-reuse-respirators.html>. Published 2020. Accessed April 22, 2020.
7. Battelle. *Final Report for the Bioquell Hydrogen Peroxide Vapor (HPV) Decontamination for Reuse of N95 Respirators*. Columbus, OH; 2016. Available at: <https://www.fda.gov/media/136386/download>. Accessed July 5, 2020.
8. Duke. Webinar: N95 decontamination using H2O2. Occupational & Environmental Safety Office. Available at: <https://www.safety.duke.edu/news-events/webinar-n95-decontamination-using-h2o2>. Published 2020. Accessed April 22, 2020.
9. Mills D, Harnish DA, Lawrence C, et al. Ultraviolet germicidal irradiation of influenza-contaminated N95 filtering facepiece respirators. *Am J Infect Control* 2018;46(7):e49–e55.
10. Heimbuch BK, Wallace WH, Kinney K, et al. A pandemic influenza preparedness study: use of energetic methods to decontaminate filtering facepiece respirators contaminated with H1N1 aerosols and droplets. *Am J Infect Control* 2011;39(1):e1–e9.
11. Ma QX, Shan H, Zhang CM, et al. Decontamination of face masks with steam for mask reuse in fighting the pandemic COVID-19: experimental supports. *J Med Virol* 2020. doi: 10.1002/jmv.25921. [Epub ahead of print].
12. Sánchez-Morillas L, Reaño Martos M, Rodríguez Mosquera M, et al. Delayed sensitivity to prolene. *Contact Dermatitis* 2003;48(6):338–339.
13. Malo JL, Cartier A, Pineault L, et al. Occupational asthma due to heated polypropylene. *Eur Respir J* 1994;7(2):415–417.
14. Donovan J, Skotnicki-Grant S. Allergic contact dermatitis from formaldehyde textile resins in surgical uniforms and nonwoven textile masks. *Dermatitis* 2007;18(1):40–44.
15. Fowler J, Zirwas M, eds. *Fisher's Contact Dermatitis*. 7th ed. Phoenix, AZ: Contact Dermatitis Institute; 2019.
16. Aalto-Korte K, Suuronen K. Occupational contact allergy to components of polyester resin systems. *Contact Dermatitis* 2016;75(1):14–19.
17. Cahill JL, Andersen KE. Occupational cobalt-allergic contact dermatitis resulting from polyester resin. *Contact Dermatitis* 2010;63(5):292–294.
18. Raison-Peyron N, Bergendorff O, Bourrain JL, et al. Acetophenone azine: a new allergen responsible for severe contact dermatitis from shin pads. *Contact Dermatitis* 2016;75(2):106–110.
19. Goossens A, Detienne T, Bruze M. Occupational allergic contact dermatitis caused by isocyanates. *Contact Dermatitis* 2002;47(5):304–308.
20. Lung H, Huang L, Lin H, et al. Allergic contact dermatitis to polyethylene terephthalate mesh. *J Invest Allergol Clin Immunol* 2009;19(2):161–162.
21. Mowitz M, Herman A, Baeck M, et al. N,N-dimethylacrylamide—a new sensitizer in the FreeStyle Libre glucose sensor. *Contact Dermatitis* 2019;81(1):27–31.
22. Raison-Peyron N, Mowitz M, Bonardel N, et al. Allergic contact dermatitis caused by isobornyl acrylate in OmniPod, an innovative tubeless insulin pump. *Contact Dermatitis* 2018;79(2):76–80.
23. DeKoven JG, Warshaw EM, Zug KA, et al. North American Contact Dermatitis Group patch test results: 2015–2016. *Dermatitis* 2018;29(6):297–309.
24. Siemund I, Mowitz M, Zimerson E, et al. Variation in aluminium patch test reactivity over time. *Contact Dermatitis* 2017;77(5):288–296.
25. Rystedt I. Factors influencing the occurrence of hand eczema in adults with a history of atopic dermatitis in childhood. *Contact Dermatitis* 1985;12(4):185–191.
26. Deleuran MG, Ahlström MG, Zachariae C, et al. Patch test reactivity to aluminium chambers. *Contact Dermatitis* 2019;81(4):318–319.
27. Ward J, Walsh R, Bellet J, et al. Allergic contact dermatitis to aluminum-based chambers during routine patch testing. In: Presented at the American Contact Dermatitis Society Annual Meeting; Denver, CO; 2020.
28. Kosann M, Brancaccio R, Cohen D. Occupational allergic contact dermatitis in an obstetrics and gynecology resident. *Am J Contact Dermat* 2003;14(4):217–218.

29. Hamann CP, Rodgers PA, Sullivan K. Allergic contact dermatitis in dental professionals: effective diagnosis and treatment. *J Am Dent Assoc* 2003;134(2):185–194.
30. Di Altobrando A, Gurioli C, Vincenzi C, et al. Allergic contact dermatitis caused by the elastic borders of diapers. *Contact Dermatitis* 2020;82(1):71–72.
31. Perez-Crespo M, Silvestre JF, Lucas A, et al. Contact dermatitis due to stockings. *Dermatitis* 2009;20(4):221–222.
32. Li BS, Cary JH, Maibach HI. Relapsing polyisoprene glove allergic contact dermatitis: another call for more complete glove package label declaration. *Contact Dermatitis* 2018;79(4):242–243.
33. 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):1215–1216.
34. Aguirre A, Zabala R, Sanz de Galdeano C, et al. Positive patch tests to hydrogen peroxide in 2 cases. *Contact Dermatitis* 1994;30(2):113.
35. Tan KT, Greaves MW. N95 acne. *Int J Dermatol* 2004;43(7):522–523.
36. Alanko K, Susitaival P, Jolanki R, et al. Occupational skin diseases among dental nurses. *Contact Dermatitis* 2004;50(2):77–82.
37. NHS England and NHS Improvement. Helping prevent facial skin damage beneath personal protective equipment. Available at: https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/04/C0129_Preventing-skin-damage-under-PPE_9-April.pdf. Published 2020. Accessed April 25, 2020.
38. Cuddigan J, Black J, Deppisch M, Pittman J, Sonenblum S, Tescher A. NPIAP position statements on preventing injury with N95 masks. Available at: https://cdn.ymaws.com/npiap.com/resource/resmgr/position_statements/Mask_Position_Paper_FINAL_fo.pdf. Published 2020. Accessed April 25, 2020.
39. LeBlanc K, Heerschap C, Butt B, Bresnai-Harris J, Wiesenfeld L. Prevention and management of personal protective equipment skin injury: update 2020. NSWOCC. Available at: www.nswoc.ca/ppe
40. Alves P, Moura A, Vaz A, et al. PRPPE I COVID 19. Prevention of skin lesions caused by personal protective equipment (face masks, respirators, visors and protection glasses). In: *Associação Portuguesa de Tratamento de Feridas*. Porto, Portugal: Largo Eng. Antonio de Almeida; 2020:8.
41. Zirwas MJ. Attempting to define “hypoallergenic”. *JAMA Dermatol* 2017;153(11):1093–1094.
42. Xu S, Kwa M, Lohman ME, et al. Consumer preferences, product characteristics, and potentially allergenic ingredients in best-selling moisturizers. *JAMA Dermatol* 2017;153(11):1099–1105.
43. American Contact Dermatitis Society. American Contact Dermatitis Society Contact Allergen Program. Available at: <https://www.contactderm.org/resources/acds-camp>. Published 2020. Accessed April 20, 2020.
44. Berke C, Bryant D, Kent D, Pontieri-Lewis V. Guidance for maintaining skin health when utilizing protective masks for prolonged time intervals. Available at: https://cdn.ymaws.com/www.wocn.org/resource/resmgr/docs/Guidance_for_Skin_Health_Upd.pdf. Published 2020. Accessed April 25, 2020.
45. Jiang W, Cao W, Liu Q. Wearing the N95 mask with a plastic handle reduces pressure injury. *J Am Acad Dermatol* 2020;82(6):e191–e192.
46. Stasko T, Brown MD, Carucci JA, et al. Guidelines for the management of squamous cell carcinoma in organ transplant recipients. *Dermatol Surg* 2004;30(4 Pt 2):642–650.
47. Bradsher K. China dominates medical supplies, in this outbreak and the next. *New York Times* 2020. Available at: <https://www.nytimes.com/2020/07/05/business/china-medical-supplies.html>. Accessed July 5, 2020.