

Rational use of PPE and preventing PPE related skin damage

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ABSTRACT

On 31st December, 2019, an outbreak of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was declared in Wuhan, China. On 24 March 2020, there was a nationwide lockdown for 21 days, followed by Janata curfew on 22nd March. As the pandemic has developed and spread across continents, everyone including policy makers have realized shortage of personal protective equipment (PPE) such as N95 respirators, coverall, and face shields. This is one of the major factors putting healthcare workers not only at risk of infection but also to various side effects of prolonged use of PPE. Based on international experiences, new ideas in procuring and mass manufacturing, rational use of PPE equipment is the need of hour, especially for developing nations which lack adequate resources and infrastructure for manufacturing PPEs.

Keywords: COVID, personal protective equipment, rational, side effects, skin

Introduction

After the outbreak of COVID-19, on 30th January 2020, the WHO declared it to be a public health emergency based on growing case notification rates at Chinese and international locations.

Personal protective equipment (PPE) is the most discussed topic currently among not only the frontline healthcare staff but also among the central and state health departments, local business community, general public, media, etc., The two main issues related to PPE are shortages and injudicious use of protective equipment. This review seeks to add some coherence on rational

use of PPE, what PPE is recommended, when and why and also briefly discuss on PPE related skin damage.

Mode of Transmission

The SARS-CoV-2 viruses predominantly spread by droplet and contact routes. Airborne transmission is not documented, however aerosol generating procedures can cause virus to stay in the air, over distances beyond 2 m.^[1]

Personal Protective Equipment (PPE)

Occupational Safety and Health Administration (OSHA) defines PPE as “specialized clothing or equipment worn by an employee for protection against an infectious material.”^[2] The various components to healthcare worker safety programs are training and administrative controls, engineering controls, work practice controls, and PPE. In COVID-19, PPE is the most essential armor for protection of healthcare workers against disease transmission.

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How to cite this article: Sureka B, Nag VL, Garg MK, Tak V, Banerjee M, Bishnoi A, et al. Rational use of PPE and preventing PPE related skin damage. J Family Med Prim Care 2021;10:1547-53.

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Received: 30-08-2020

Revised: 27-10-2020

Accepted: 30-10-2020

Published: 29-04-2021

Access this article online

Quick Response Code:



Website:
www.jfmpc.com

DOI:
10.4103/jfmpc.jfmpc_1772_20

Types and Components of PPE

Broadly, there are two types of PPE – (i) standard PPE and (ii) customized PPE.

Standard components of PPE are face shields, goggles, mask, gloves, coverall/gowns (with or without aprons), head cover/surgical cap, and shoe cover. Customized PPE is recommended by CDC when the healthcare systems become stressed and enters the contingency mode.^[3] This may be an alternative to what is known as *jugaad innovation*. During crisis, CDC even recommends use of disposable aprons, laboratory coats as an alternative to gowns and cloth face masks, and reusing medical masks as an alternative to single use masks.^[4] During crisis, alternate sources of manufacturing customized gowns using synthetic raw materials (e.g., polyester) should be explored. Fabrics can be engineered to achieve desired properties after chemical or physical treatments. Reusable gowns made of 100% polyester or polyester/cotton is a viable option when the demand is unpredictable and end not known.^[5]

Face shields and goggles

A face shield provides barrier protection to the eyes, nose, and lips. The face shield should be made of clear plastic and provide good visibility. It should have adjustable band to fit snugly against the forehead, preferably fog resistant. It should be made of reusable material which can be disinfected without losing its functionality.

Goggles should be made of transparent glasses and covered from all sides. It should have vent valves and be able to accommodate prescription glasses. It should be made of reusable material which can be disinfected without losing its functionality.

Mask

The type of mask to be used depends upon the risk profile and category of the personnel. The two categories of mask recommended for COVID 19 are triple layer surgical mask and N95 respirator mask depending upon the risk involved. N95 respirator should ensure quality compliance and preferably be NIOSH N95, EN 149FFP2, or equivalent.

Gloves

Nitrile gloves are preferred over latex gloves because they are chemical resistant. Non-powdered latex gloves are preferred to powdered gloves if nitrile gloves are not available.

Coverall/Gowns

Coverall provide 360° protection from top to bottom protecting the torso, back, lower legs, head, and sometimes feet of healthcare worker. Coveralls/gown should be made of fluid or blood impervious fabric.

Shoe cover

Shoe covers should be made of same water impervious fabric as of coverall and should preferably reach up to mid-calf.

Head cover

Head cover provides protection to the hair and scalp from possible exposure. Coveralls usually have head cover also known as hood. Those using gowns should use a separate head cover.

When to use which PPE?

When to use which PPE depends upon whether the PPE is being used as a standard precaution or as an expanded isolated precaution.

Standard precautions

It was previously known as universal precaution. Gloves, gowns, mask, and goggles or a face shield are used as standard precautions depending upon the level and body part being exposed.

Expanded isolation precautions

In some instances, healthcare personnel are required to wear PPE where contact, droplet, or airborne infection is anticipated. Contact precautions require gloves and gown for contact with the patient. Droplet precautions require the use of a surgical mask within 3 feet of patient and a respirator if less than 1 feet, and airborne infection isolation requires that only a respirator (N95 mask) be worn.

Levels of PPE

Level 1 PPE

For Standard Infection control precautions, it includes disposable gown, disposable gloves. If risk of spraying or splashing is anticipated, surgical mask and face shield/goggles is recommended.

Level 2 PPE

For direct/indirect contact precautions/droplet precautions/airborne precautions, it includes fluid-resistant disposable gown, disposable gloves. If risk of spraying or splashing is anticipated, surgical mask and face shield/goggles is recommended. Head cover and N95 respirator is to be considered in cases of airborne infection.

Level 3 PPE

Enhanced precautions for suspected or confirmed infectious diseases of high consequence which spread by direct/indirect contact or by airborne route, it includes fluid-resistant coverall with hood/long-sleeved gown with disposable fluid-resistant hood, N95 mask, face shield, 2 sets of gloves, shoe covers.

Recommendations for appropriate use of PPE

At AIIMS Jodhpur, we follow the recommendations defined by WHO and MOHFW for use of PPE in COVID and non COVID areas.^[6-8] We have designed our own customized coverall and gown. This customized PPE consists of full inner coverall with hood and additional outer gown (giving double-layer protection), shoe cover [Figure 1]. The customized PPE is made of water impervious Polyester fabric with coating on one side of fabric to make it water impervious. This fabric has also been approved for reuse by the Centres for Disease Control and Prevention, USA.^[9] This material is available in market and can be manufactured by any local textile manufacturer. At places where this customized

PPE is not available, water impervious quality checked coverall is to be used. The list of various components of PPE being used in AIIMS Jodhpur at various COVID and non-COVID areas are listed in Tables 1–3. PPEs are not alternative to basic preventive public health measures such as hand hygiene, respiratory etiquettes which must be followed at all times.

Cost-effectiveness analysis

Customized PPE which is being used at AIIMS Jodhpur costs Rs. 850/unit which includes coverall, gown, shoe cover, and a face shield. Imported PPEs cost Rs. 1,500/unit which includes



Figure 1: Customized PPE (made of water impervious polyester coated with polyacrylic) consisting of inner coverall, outer gown, face shield, shoe cover, gloves, N95 mask being used at AIIMS Jodhpur

coverall and a shoe cover. Face shield has to be purchased separately in imported PPE which cost around Rs 300/unit. So the total cost of imported PPE for end user is approximately Rs 1,800/unit. Figure 2 shows cost-effective analysis of imported and customized PPE. It is clearly seen that customized PPE is more cost-effective as compared to imported PPE.

Ethical considerations for rational use of PPE

During a pandemic like COVID-19, method of allocating PPEs should be collaborative, transparent, equitable, and accountable. The Centers for Disease Control and Prevention (CDC) issued statement regarding the distribution of vaccines and ventilators during the influenza pandemic in 2007 and 2011.^[10,11] Similar ethical considerations can be applied while allocating different types of PPE to the healthcare providers.

Considering the shortage of PPE, hospitals must implement policies that must be scientific and ethical while allocating these scarce resources.^[10-12]

Utilitarian approach

This approach considers protecting those clinicians who are best able to save the most number of patients. Hospitals should avoid elective surgeries and work in teams while operating and visiting wards so that minimum people from one Department is exposed at a given time.

Sickest first

This approach is routinely used to triage patients for

Table 1: Appropriate use of PPE in various COVID areas at our AIIMS Jodhpur

Setting	Target personnel	PPE	Patient*
COVID-19 SCREENING AREA IN EMERGENCY FOR SUSPECTED CASES			
Emergency Screening Area	Doctor/Nurse	Customised PPE** + Essentials ^{##}	Triple layer mask
	Date entry operator	Customised PPE + Essentials	
	Cleaner/Sweeper/HA	Customised PPE + Essentials	
Transport of suspected COVID-19 patients to SARI ward	HA	Customised PPE + Essentials	Triple layer mask
DESIGNATED COVID-19 AREA			
SARI-ICU	Doctor/Nurse	Coverall/Customized PPE + Essentials	Triple layer mask
	Cleaner/Sweeper/HA	Customised PPE+Essentials	
Ward (Suspects)	Doctor (if posted)	Customised PPE+Essentials	Triple layer mask
	Nurse	Customised PPE+Essentials	
	Cleaner/Sweeper/HA	Customised PPE+Essentials	
	Doctor/Nurse	Customised PPE+Essentials	
Ward (COVID-19 POSITIVE NON-VENTILATORY)	Cleaner/Sweeper/HA	Customised PPE+Essentials	Triple layer mask
Ward (COVID-19 POSITIVE VENTILATORY)	Doctor	Coverall/Customised PPE + Essentials	Triple layer mask
	Nurse	Coverall/Customised PPE + Essentials	
	Cleaner/Sweeper/HA	Customised PPE + Essentials	
Dead Body Packing	Cleaner/Sweeper/HA	Customised PPE + Essentials	Triple layer mask
	Radiology Technician	Customised PPE + Essentials	
TRANSPORT OF COVID-19 SUSPECT/CONFIRMED CASE IN HOSPITAL AMBULANCE			
Ambulance (HCW travelling with patient)	Doctor/Nurse	Customised PPE + Essentials	Triple layer mask
	Driver/Patient	Triple layer mask	

**Customized PPE - Special PPE designed by AIIMS Jodhpur having inner gown with outer coverall. ^{##}Essentials - N95, gloves, goggles, shoe cover, face shield. Quality assured coverall with hood - where Customized PPE not available. *Minimum distance of one meter needs to be maintained while transporting. Anywhere where there is aerosol generating procedure, Full PPE/Customized PPE to be used

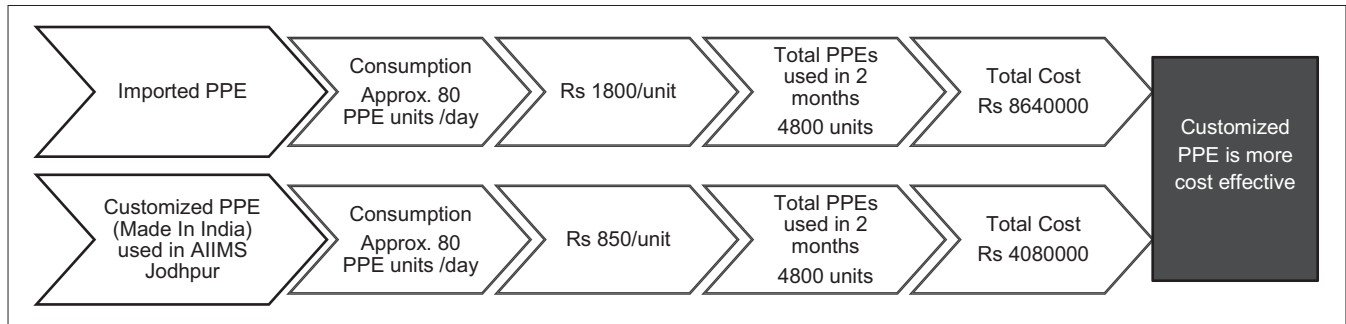


Figure 2: Cost-effectiveness analysis

Table 2: Appropriate use of PPE in non COVID non-aerosol areas in AIIMS Jodhpur			
Setting	Target personnel	PPE	Patient*
NON-COVID AREA IN HOSPITAL AND EMERGENCY			
Emergency (non-aerosol generating procedure)	Doctor	Standard routine precautions as taken in emergency	Standard precautions
	Nurse		
	Cleaner/Sweeper/HA		
General OPD	Doctor	Triple layer mask	
	Nurse	Triple layer mask	
	Cleaner/Sweeper/HA	Triple layer mask	
General Ward/Private Ward	Doctor	Triple layer mask	
	Nurse	Triple layer mask	
	Cleaner/Sweeper/HA	Triple layer mask	
ICUs (non-aerosol generating procedure)	Doctor	Standard routine precautions as taken in ICU	
	Nurse		
	Cleaner/Sweeper/HA		
Laboratory personnel (Handling COVID-19 respiratory samples)	Doctor	Coverall/Customised PPE** + Essentials##	
	Nurse	Coverall/Customized PPE+Essentials	
	Cleaner/Sweeper/HA	Customized PPE+Essentials	
	Fumigation	Customized PPE	
Laboratory personnel (Handling COVID-19 samples) - Pathology and Biochemistry	Doctor/Nurse	Triple layer mask, gloves	
	Technician	Triple layer mask, gloves	
	Cleaner/Sweeper/HA	Standard routine precautions	
Laboratory personnel (Handling non COVID-19 samples)	Doctor	Standard precautions as taken in Lab	
	Nurse		
	Cleaner/Sweeper/HA		
Mortuary	Dead body transport to mortuary	Triple layer mask, gloves	
	Dead body handling	Triple layer mask, Gloves plus	
	Autopsy	All standard precautions	
Laundry	Cleaner/Sweeper/HA	Coverall/Customized PPE+Essentials	
	Cleaner/Sweeper/HA	Customized PPE+Essentials	
Diagnostic Radiology (Non-COVID)	Doctor/Technician	Triple layer mask	
Administrative Offices	All Staff	Cloth mask/Triple layer mask	
COVID case/Suspect	Patient	Triple layer mask	

**Customized PPE - Special PPE designed by AIIMS Jodhpur having inner gown with outer coverall. ##Essentials - N95, gloves, goggles, shoe cover, face shield. Quality assured coverall with hood - where Customized PPE not available

emergency care. This approach for rationalizing PPE may be used in COVID critical care and high dependent areas.

Prioritize allocation of PPE to those healthcare workers who are treating patients *who are most likely to recover*.

Social worth

This principle is usually not accepted but in absolutely necessary limited circumstances, this can be invoked. Social worth principle refers to patient’s overall worth to society.

Multiplier effect

This principle also known as instrumental value refers to an individual’s ability to carry out function that is essential to prevent social disintegration. This principle prioritizes those healthcare workers who have the ability to save more lives which will achieve a multiplier effect in the society.

Principle of reciprocity

Giving priority to those who put themselves at risk during a severe pandemic.

Table 3: Appropriate use of PPE in various non COVID aerosol/body fluid generating areas

Setting	Target personnel	Additional PPE apart from routine standard precautions
Dental/ENT/Ophthalmology/Surgical Oncology	Doctor	N-95, goggles, face shield
PAC Clinic	Doctor	N-95, face shield
All ICUs/Critical Care	Doctor/Nurse	N-95, goggles, face shield
Labor room	Doctor/Nurse	Customised PPE**, Triple layer mask for all, face shield, N-95 mask*
Operation Theatre	Doctor/Nurse	Customised PPE**, triple layer mask for all, face shield, goggles, N-95 mask*
Emergency	Doctor/Nurse (performing aerosol generating procedure)	Customised PPE** + Essentials ^{###}
Routine laboratory	Respiratory samples	N-95 mask
Ambulance (HCW travelling with patient)	Doctor/Nurse (Managing SARI patient)	Customised PPE** + Essentials ^{###}
Intubation	Doctor/Nurse	Headgear + N95 + gloves
Intervention Cardiology	Doctor/Nurse	Customised OT PPE ^{***} + Disposable gown + Essentials ^{####}
Intervention Radiology	Doctor/Nurse	Customised OT PPE ^{***} + Disposable gown + Essentials ^{####}
Dialysis	Doctor/Nurse	All standard routine precautions + N95 + face shield

*N-95 mask - if patient is a resident of containment zone. **Customized PPE - Special PPE designed by AIIMS Jodhpur having inner gown with outer coverall. ^{###}Essentials - N95, gloves, goggles, shoe cover, face shield. ^{***}Customized OT PPE - Special PPE designed for OT by AIIMS Jodhpur. ^{####}Essentials - N95/triple layer mask, gloves, goggles, shoe cover, face shield. Quality assured coverall with hood - where Customized PPE not available

Allocating PPE based on principles like *first-come-first-served*, based on *seniority or position* is not acceptable during public health emergency.

Strategies for sourcing PPE during the pandemic

During COVID-19 pandemic, the healthcare systems have become stressed and entered the crisis mode. Institutions need to strategize their sourcing and procurement of PPE within the rules and regulations laid down by the Government. Few strategies of sourcing and conserving PPE during the COVID-19 pandemic are listed in Table 4. Standard operating procedures and mechanisms for reusing various components of PPE need to be laid down so as to prevent stock out. Recommendations of disinfection of various components of PPE are listed in Table 5.

PPE related skin damage

Contact dermatitis, skin hypersensitivity reactions, and issues of overheating are known side effects of PPE use. With regular hand washing and extended use of PPE, skin issues are emerging among healthcare workers. The various side effects and measures to prevent these side effects are highlighted in Table 6.

Important points for primary care physicians

The primary care physicians should be aware of all types and levels of PPE. Minimum basic level of PPE consisting of N95 mask and a face shield should be worn in the clinic while seeing patients. In a community healthcare center, if there is provision of admission of COVID-positive stable patients or those requiring minimal oxygen support, physicians at ground level should be aware of different levels of PPE and ensure availability. Adequate safe disposal of PPE is equally important. There may be shortage of supplies so measures for disinfection and reuse of all components of PPE should be in place.

Table 4: Strategies for sourcing PPE during the pandemic^[3]

1. Purchase from international suppliers
2. Reclaiming from non-healthcare sectors like farming, construction sites, salons, dentists, veterinarians
3. Charity donations
4. Reusing after cleaning and disinfecting
5. Repurpose - example cloth masks instead of medical mask to patients, 3D manufactured face shields, polyester coveralls and gowns, motorcycle helmets with visors, x-ray films as barriers, etc.
6. Cancel elective and ambulatory procedures
7. Utilize telemedicine, mobile and remote monitoring systems to reduce patient contact
8. Reduce training of students
9. Use robots and motorized system for delivery of food in wards, temperature monitoring
10. Use PPE only after risk stratification
11. Employ young immune workers and avoid exposure of vulnerable healthcare workers
12. Government solutions - like ease of doing business, rules relaxation
13. Create own customized solutions depending upon the local supply and available resources
14. Develop Jugaad innovations

Key points

- Standard and customized PPE are two types of PPE available in the market currently.
- Standard components of PPE are face shields, goggles, mask, gloves, and coverall/gowns.
- Level 1 PPE may be used in OPD and screening areas maintaining social distancing.
- Level 2 PPE is used when aerosol generation is not anticipated.
- Level 3 PPE is recommended whenever aerosol generation is anticipated.
- Customized PPE made from polyester fabric approved by SITRA/DRDO can be reused after proper disinfection.

Table 5: Disinfecting and reusing strategies for various components of PPEs^[6,13]

Component of PPE	Reuse contingency/crisis plan	Cleaning and Disinfection
Surgical mask	Not recommended	-
N95 respirator	Recommended	Hydrogen peroxide vapour UV radiation Ethylene oxide
Coveralls/Gowns	Recommended Not recommended for reuse after aerosol generating	Cleaning with warm water or Sodium hypochlorite 0.05%
Goggles	Recommended Not recommended for reuse after aerosol generating	Using sodium hypochlorite 0.1% followed by rinsing with clean water or cleaning with 70% alcohol wipes
Face shield	Recommended Not recommended for reuse after aerosol generating	Using sodium hypochlorite 0.1% followed by rinsing with clean water or cleaning with 70% alcohol wipes
Gloves	Not recommended	-

Table 6: Side effects of PPE use and various methods to prevent side effects^[14-16]

PPE	Side effects	Remedy
Face shields/goggles	Discomfort, fatigue Skin tissue damage Toxicity due to disinfecting chemical	Regular moisturizing Protective hydrocolloid bandages over pressure points
Mask (N95)	Facial dermatitis Respirator-induced acne Itching Rash Scar at nose bridge Wheals Pressure ulcer Respiratory fatigue Headache Hypoxia	Ensure proper fit and don't over-tighten the respirator Don't wear a mask over the respirator Regular moisturizing Protective hydrocolloid dressings over the nasal bridge Mucopolysaccharide cream
Gloves	Dry skin Itch Rash Allergic contact dermatitis Wheals	Regular moisturizing Topical steroid cream for dermatitis Antihistaminic for wheals
Coverall	Itch Rash Overheating Dehydration	Regular moisturizing Consider different fabric if allergy persists
Gown	Itch Rash	Regular moisturizing Consider different fabric if allergy persists
Shoe cover	Itch Rash Wheals	Regular moisturizing Consider different fabric if allergy persists
Head cover	Itch Rash Hair loss	Regular moisturizing Use cloth inside head cover

Conclusion

It is essential that healthcare workers understand the purpose of PPE, where and when to use what forms of PPE to reduce disease transmission. It is equally important that every healthcare worker use it appropriately to preserve what limited stocks may be to ensure there is sufficient supply during surge of cases in the community. Hospital administrators and government agencies have a crucial role to play in reaching out to the suppliers and develop a sustained supply chain system. Side effects of excessive use of PPE need to be kept in mind and adequate PPE free periods should be provided in the duty roster.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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