

Personal Protective Equipment (PPE) Infographic Technical Document

Executive Summary

During the current pandemic, many healthcare workers have become infected with SARS-CoV2 while caring for patients with COVID-19. Reasons for these nosocomial transmissions have been frequently attributed to inadequate and insufficient personal protective equipment (PPE). The shortage of PPE will likely be most acute in low- and middle-income countries (LMICs) where there are no stockpiles and limited supply chain and production options. The aims of this infographic are:

- 1) To educate frontline healthcare workers on appropriate use of PPE during COVID-19.
- 2) To empower healthcare workers to protect themselves using the best available resources.

This document reviews the sources upon which the recommendations portrayed in the infographic are based. Specifically, we discuss guidance on the appropriate use of gowns, gloves, masks, face protection, and hand washing while caring for patients with COVID-19. Recommendations are largely drawn from WHO and CDC strategies for crisis settings with supplementation from the primary literature. A references list for the infographic recommendations is also available through a url and QR code posted on the infographic.

Overview

In many LMICs, deficits in PPE are a routine challenge, apart from crisis contexts. This frequently leads to healthcare workers placing themselves at personal risk while caring for patients. This risk is amplified during outbreaks such as the current COVID-19 pandemic, where inadequate knowledge, access, and use of PPE, coupled with increased burden on healthcare systems, result in excess rates of healthcare worker infections.¹⁻³ Healthcare workers frequently resort to using ineffective PPE substitutes in an effort to protect themselves. Moreover, a lack of adequate training on PPE use obviates the effectiveness of whatever PPE is available.⁴ In previous coronavirus outbreaks, inappropriate PPE use was strongly correlated with healthcare worker infections.⁵ Training has important psychological benefits as well. Among Italian healthcare workers treating COVID-19 patients, adequate information about PPE use reduced risk perception, even though the majority reported PPE shortages.⁶

Apart from PPE, the infrastructure of healthcare systems in LMICs may not be sufficiently set up to promote adequate infection prevention and control (IPC) practices, including hand hygiene. In this resource-constrained situation where solutions are urgently needed, construction of missing IPC infrastructure is not feasible. Alternative, temporizing solutions should be considered and prioritized. A major risk factor for healthcare workers becoming infected with SARS-CoV2 is suboptimal hand hygiene.⁷ Thus, information about hand hygiene has been included in the infographic as another strategy for protecting healthcare workers.

General advice

Under general advice regarding PPE, we provide the following recommendations:

- Use the highest appropriate PPE protection available to you.
- Remove and discard PPE if soiled, damaged, or hard to breathe/see through.
- Don't touch outside of PPE. If adjustments are needed, immediately perform hand hygiene.
- Don't share masks, gowns, or gloves.

These recommendations are taken from CDC publications on the use of PPE during COVID-19 with special considerations for non-US healthcare settings or other low-resource contexts.^{8,9} The highest appropriate PPE protection is to ensure that healthcare workers do not default to the most convenient option but try to seek the greatest protection. Removing damaged or soiled PPE is intended to reduce the risk of self-contamination. Similarly, touching the outside of PPE increases risk for self-contamination, so hand hygiene following contact with potentially-contaminated PPE is necessary. Sharing of masks, gowns, and gloves produces an opportunity for cross contamination between healthcare workers, including with non-COVID pathogens. Therefore, this practice is not advised.¹⁰

Hand Hygiene

Although the guidance on hand hygiene during COVID does not differ from standard recommendations in healthcare settings, they are included on the infographic because of the risk of contact transmission of SARS-CoV2.^{5,7,11} Hand hygiene remains one of the foremost measures of healthcare worker and patient protection, regardless of PPE use and availability. The following are the recommendations related to hand hygiene that are depicted on the infographic:

- Effective hand hygiene can prevent transmission even when gloves are not available. Perform hand hygiene: before touching a patient, before clean/aseptic procedures, after body fluid exposure/risk, after touching a patient, after touching patient surroundings, before eating, after using the bathroom.
- Wash with soap and water (20-30 seconds) or alcohol-based hand rub (15-20 seconds).
- When gloves are worn, perform hand hygiene before and after glove use.

The aforementioned recommendations derive from the WHO's 5 moments of hand hygiene campaign, which are intended as part of universal precautions, in addition to CDC guidance on general handwashing in the community.^{12,13} Because there is growing concern about fecal-oral spread of SARS-CoV2 to HCWs, we felt that it was important to include the general handwashing guidance.¹⁴ According to WHO and CDC, performing hand hygiene with either soap and water or alcohol-based hand rub (ABHR) are acceptable protection against SARS-CoV2 in the healthcare setting.^{15,16} In regards to use of ABHR, 15 seconds is non-inferior to 30 seconds in terms of bacterial log reduction across multiple studies and improves compliance, which is why we have presented the 15-20 second range.¹⁷⁻²⁰ For hand washing with soap and water, the main guidance for 20-30 seconds comes from CDC recommendations and is based on duration needed to achieve the requisite 2-log reduction of bacterial counts for hand antisepsis in healthcare.^{13,21-24}

Gloves

Use of disposable medical gloves is standard practice in health facilities to protect healthcare workers from blood and bodily fluids and to prevent cross-transmission of pathogens. Under typical conditions, use of medical gloves for multiple patients is not advised. However, the PPE shortages during the COVID-19 pandemic illustrate one situation in which extended use of gloves may be necessary. The following are the recommendations related to glove disinfection and extended use that are depicted on the infographic:

- Use: For patient care and cleaning in COVID-19 wards. Remove or decontaminate gloves before touching non-contaminated items and surfaces (e.g. phones) and between patients. Do not reuse gloves. Perform hand hygiene immediately after removal.
- Can I use hand sanitizer on my gloves?: If using latex or nitrile gloves, hand sanitizer can be used up to 10 times to decontaminate gloves if not visibly soiled or damaged.

In 2009, the World Health Organization, recognizing that glove reuse is practiced in settings with limited resources, identified a number of outstanding questions related to use of gloves, including: (1) How many times could gloves be reused?; (2) What types of gloves could be reused?; (3) Could gloves be decontaminated between different patients? How?²⁵ Although there's a growing body of evidence to answer these questions, knowledge gaps still remain.

CDC guidelines for healthcare workers treating Ebola patients recommend that the wearer disinfect their medical gloves with ABHR multiple times during the PPE doffing procedure, to reduce the risk of self contamination.²⁶ Subsequent research determined that disinfecting latex and nitrile gloves at least 6 times (the maximum cycles tested) with ethanol-based-hand-rub had a negligible effect on glove integrity, as measured by tensile strength and elongation.²⁷ In a 2018 Letter to the Editor in the *Annals of Laboratory Medicine*, researchers described a small study in which they applied ethanol-based hand sanitizer to five brands of latex and nitrile gloves, rubbed and dried them, and checked for leaks. All brands of gloves were leak-free after 30 cycles, and one brand of latex gloves was leak-free after 100 cycles of disinfection with 83% ethanol.²⁸ This indicates that disinfection of gloves with ethanol-based hand sanitizer does not quickly compromise mechanical integrity. However, hand contamination risk may increase after 10 disinfection cycles. Our recommendation, therefore, is conservatively to disinfect gloves up to 10 times.

Less is known about disinfection effectiveness against specific pathogens on gloves over repeated disinfection cycles. Disinfection of non-sterile, latex gloves with chlorhexidine or alcohol-based hand rub was more effective at reducing contamination on gloves than 10 seconds of washing with soap.²⁹

Measured hand contamination after glove doffing, regardless of disinfection, indicates the necessity of hand hygiene following glove removal.²⁹

Overall, evidence indicates that limited disinfection and reuse of gloves is appropriate when supplies are limited. However, as with hand hygiene on bare hands, appropriate hygiene of gloved hands requires user adherence to hygiene behaviors.

Gowns

WHO and CDC recommend gowns as standard PPE for any healthcare worker, cleaner, or visitor entering the room of a suspected or confirmed COVID-19 patient to limit contact transmission. Gowns are additionally recommended as PPE for laboratory staff processing respiratory samples.³⁰ A 2011 Cochrane systematic review confirmed that gowns as part of a set of physical barriers (also including masks, gloves, and face protection) can reduce transmission of respiratory viruses.³¹

There are no specific requirements for materials with which gowns must be constructed, though fluid-resistant fabrics are recommended when splashes or sprays are anticipated and during aerosol-generating procedures. When standard gowns are not available, CDC and WHO recommend alternatives such as laboratory coats, patient gowns, and disposable aprons.^{30,32}

The following are the recommendations related to gown use and reuse that are depicted on the infographic:

- Use: For patient care and cleaning in COVID-19 wards.
- Decontamination and reuse: For cloth gowns or lab coats, remove gown when leaving patient care area. Launder gowns according to routine procedures when soiled and at least daily.
- If gowns are not available, what else can be used?
 - Laboratory coats
 - Disposable aprons
 - Layered clothing, preferably with long sleeves and closures that can be fastened

According to the CDC, no data exist to compare the effectiveness of coveralls versus gowns as barrier protection. However, some evidence from the Ebola pandemic suggests that coveralls may increase the risk of self-contamination because they are harder to remove and more likely to be doffed incorrectly. Studies of donning and doffing procedures for Ebola found that gown/apron removal is a doffing step with risk for self-contamination, and removing elasticated hoods is a particularly vulnerable step.^{33,34} Therefore, we advocate for simple, easy-to-remove long gowns rather than coveralls or hazmat suits. To improve PPE, a recent Cochrane review concluded that some evidence exists to suggest that a close fit of gowns at the neck and wrists reduces contamination.³⁵

Masks

N95/FFP2

WHO recommends filtering facepiece respirators (FFR) such as an N95, FFP2, FFP3 or standard equivalent for HCWs providing care to COVID-19 positive patients where aerosol-generating procedures (AGP) take place. AGPs may include tracheal intubation, non-invasive ventilation, cardiopulmonary resuscitation, suctioning of respiratory secretions, cough-inducing procedures, tracheotomy, bronchoscopy, some dental procedures, and nebulized medication administration.³⁶⁻⁴⁰

Because of limited supply of FFRs, extended use and reuse of FFRs is recommended by WHO and CDC. Extended use is the practice of wearing the same respirator continuously with several different patients, without removing it between patients. This practice is well suited for situations where COVID-19 positive patients are cohorted together.

Overall, evidence supports that extended use does not compromise the filtration efficiency of the respirator material.^{41,42} Based on experience in non-healthcare industry with extended use of FFRs, the CDC has stated that good function can be expected with use for longer than 8 hours, and perhaps up to weeks or months in healthcare settings, “with replacement guided by considerations of hygiene, damage, and breathing resistance.”^{43,44} Similarly, WHO allows for extended use of N95/FFP respirators of up to 6 hours while caring for COVID-19 patients.³⁰ Typically, tolerability by healthcare providers, rather than compromised functionality, is the time-limiting factor for FFR use.

The main risk related to reuse of respirators is the possibility of self-contamination. However, the actual risk for contamination is likely minimal as more than 99.8% of pathogens remain trapped on the respirator after handling or following a simulated cough or sneeze.^{42,44–46} Regardless, reducing risk for contamination can be accomplished by combining reuse with effective decontamination strategies. While no decontamination methods have been formally endorsed by WHO or CDC, WHO lists the evidence in support of various methods that could be considered.³⁰ Additionally, the FDA has issued Emergency Use Authorizations for decontamination processes of N95s.⁴⁷

Multiple donnings and doffings can stress components, such as elastic straps and nose pieces, and potentially impair fit. Therefore, limitations for reuse are dictated by appropriate fit. CDC recommends following manufacturer’s recommendations for the maximum number of times a respirator can be reused. If no recommendation is provided, limit to a maximum of five uses.⁴² A 2012 study by Bergman and colleagues on the effect of multiple donnings on FFR fit concluded that of the models tested, five consecutive donnings can be performed before a drop in fit test performance is noted.⁴⁸

The following guidelines on the infographic are in accordance with these recommendations:

- Use: For aerosol-generating procedures (intubation, CPR, collection of nasal or oral swabs, use of high-flow oxygen/non-invasive ventilation).
- Reuse: Can be worn up to 6 hours and reused following decontamination if face seal is maintained and no obvious damage or difficulty breathing through mask. Perform hand hygiene after removal.

Surgical

Surgical masks are recommended for healthcare workers and cleaners providing care or entering the room of a COVID-19 positive patient. In the setting of a limited supply of surgical masks, CDC and WHO support extended use of masks when caring for multiple patients with COVID-19.¹⁰ WHO specifically allows for up to 6 hours of continuous wear, though there is no reliable data to support time limits on surgical mask use.³⁰

Accordingly, recommendations in the infographic are listed as follows:

- Use: For patient care and cleaning in COVID-19 wards.
- Reuse: Can be worn up to 6 hours if not soiled, damaged, or hard to breathe through. Perform hand hygiene after removal.

Cloth

Homemade masks are not considered PPE for HCWs, as filtration efficiency is unknown due to the high variability of fabric and weaving standards. They should only be used when surgical masks are not available, and ideally in combination with a face shield that covers the entire front and sides of the face.¹⁰ However, use of cloth masks by patients may be another strategy to reduce viral spread within a healthcare facility.⁴⁹

In general, cloth face coverings should be washed regularly (e.g., daily and whenever soiled) using water and a mild detergent, dried completely, and stored in a clean container or bag. Between uses, masks should be folded so that the outer surface is held inward and against itself to reduce contact with the outer surface. The infographic reflects these recommendations:

- Can I use a cloth mask? For patient care activities only when surgical mask is not available. Use with face shield, if possible. Can also be worn by patients and caregivers to reduce transmission. When soiled or at least daily, wash with soap and water. Dry before reusing.

Face protection

Face protection is an important part of protection for healthcare workers as it reduces exposures of mucous membranes to droplets. The guidance for facial protection provided on the infographic includes the following instructions:

- Use: For patient care and cleaning in COVID-19 wards.
- Decontamination and reuse: Wearing gloves, wipe the inside using a clean cloth saturated with detergent, hospital disinfectant, 0.5% chlorine, or 70% alcohol solution, then wipe the outside.
- Wearing a face shield with a mask increases respiratory protection and reduces external contamination of the mask.
- What if I don't have a face shield?: Face shields can be made out of common plastic materials such as soda bottles. Ensure the shield covers eyes, nose, and mouth and extends from ear to ear.

The use of facial protection is recommended by CDC and WHO for any healthcare worker who is providing direct care to patients with COVID-19. This also applies to individuals responsible for cleaning COVID-19 wards, particularly if splashes or sprays are anticipated. Goggles and face shields are both considered acceptable forms of face protection. For reuse of facial protection devices, a range of decontamination solutions are suggested by WHO and CDC, including dilute chlorine solutions and 70% alcohol solutions, as long as they do not degrade the PPE or interfere with visibility.^{30,50}

While no distinction is made between types of facial protection by WHO and CDC, studies have demonstrated additional benefits from face shields over goggles, including full-face protection, less touching of one's face, reduced contamination of face masks, and enhanced respiratory protection when combined with face masks.^{51–53} Thus, face shields can potentially provide greater protection to healthcare workers compared with goggles, which becomes especially critical if masks are of uncertain quality or fit. Additionally, face shields can be inexpensively produced with locally-available materials if no standard PPE for face protection is available.³⁰ For these reasons, we have chosen to highlight face shields over goggles and have provided ideas for how to make them.⁵⁴

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