Rational use of personal protective equipment for coronavirus disease (COVID-19) and considerations during severe shortages

Interim guidance

6 April 2020

World Health Organization

Background

This document summarizes WHO's recommendations for the rational use of personal protective equipment (PPE) in health care and home care settings, as well as during the handling of cargo; it also assesses the current disruption of the global supply chain and considerations for decision making during severe shortages of PPE.

This document does not include recommendations for members of the general community. See here: for more information about WHO advice of use of masks in the general community.

In this context, PPE includes gloves, medical/surgical face masks - hereafter referred as "medical masks", goggles, face shield, and gowns, as well as items for specific procedures-filtering facepiece respirators (i.e. N95 or FFP2 or FFP3 standard or equivalent) - hereafter referred to as "respirators" - and aprons. This document is intended for those involved in distributing and managing PPE, as well as public health authorities and individuals in health care and home care settings involved in decisions about PPE use and prioritization; it provides information about when PPE use is most appropriate, including in the context of cargo handling.

This document has been updated to address key considerations for decision making processes during severe shortages of PPE.

Preventive measures for COVID-19 disease

Based on current evidence, the COVID-19 virus is transmitted between people through close contact and droplets. Airborne transmission may occur during aerosol-generating procedures and support treatments (e.g. tracheal intubation, non-invasive ventilation, tracheotomy, cardiopulmonary resuscitation, manual ventilation before intubation, bronchoscopy)[1]; thus, WHO recommends airborne precautions for these procedures.

For all, the most effective preventive measures include:

- maintaining physical distance (a minimum of 1 metre) from other individuals;
- performing hand hygiene frequently with an alcohol-based hand rub if available and if your hands are not visibly dirty or with soap and water if hands are dirty;
- avoiding touching your eyes, nose, and mouth;
- practicing respiratory hygiene by coughing or sneezing into a bent elbow or tissue and then immediately disposing of the tissue;
- wearing a medical mask if you have respiratory symptoms and performing hand hygiene after disposing of the mask;
- routine cleaning and disinfection of environmental and other frequently touched surfaces.

In health care settings, the main infection prevention and control (IPC) strategies to prevent or limit COVID-19 transmission include the following:[2]

1. ensuring triage, early recognition, and source control (isolating suspected and confirmed COVID-19 patients);
2. applying standard precautions[3] for all patients and including diligent hand hygiene;
3. implementing empiric additional precautions (droplet and contact and, wherever applicable for aerosol-generating procedures and support treatments, airborne precautions) for suspected and confirmed cases of COVID-19;
4. implementing administrative controls;
5. using environmental and engineering controls.[4]

Standard precautions are meant to reduce the risk of transmission of bloodborne and other pathogens from both recognized and unrecognized sources. They are the basic level of infection control precautions to be used, as a minimum, in the care of all patients.

Additional transmission-based precautions are required by health care workers to protect themselves and prevent transmission in the health care setting. Contact and droplets precautions should be implemented by health workers caring for patients with COVID-19 at all times. Airborne precautions should be applied for aerosol-generating procedures and support treatments.

Although use of PPE is the most visible control used to prevent the spread of infection, it is only one of the IPC measures and should not be relied on as a primary prevention strategy. In the absence of effective administrative and engineering controls, PPE has limited benefit, as described in WHO's Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care. These controls are summarized here.

- **Administrative controls** include ensuring resources for infection prevention and control (IPC measures, such as appropriate infrastructure, the development of clear IPC policies, facilitated access to laboratory testing, appropriate triage and placement of patients, including separate waiting areas/rooms dedicated to patients with respiratory symptoms, and adequate staff-to-patient ratios, and training of staff. In the case of COVID-19, consideration should be given, wherever possible, to establish differentiated care pathways that minimize mixing of known or suspected COVID-19 patients with other patients (e.g. through separate health facilities, wards, waiting, and triage areas).
- **Environmental and engineering controls** aim at reducing the spread of pathogens and the contamination of surfaces and inanimate objects. They include providing adequate space to allow social distance of at least 1 m to be maintained between patients and health care workers and ensuring the availability of well-ventilated isolation rooms for patients with suspected or confirmed COVID-19, as well as adequate environmental cleaning and disinfection.[4]

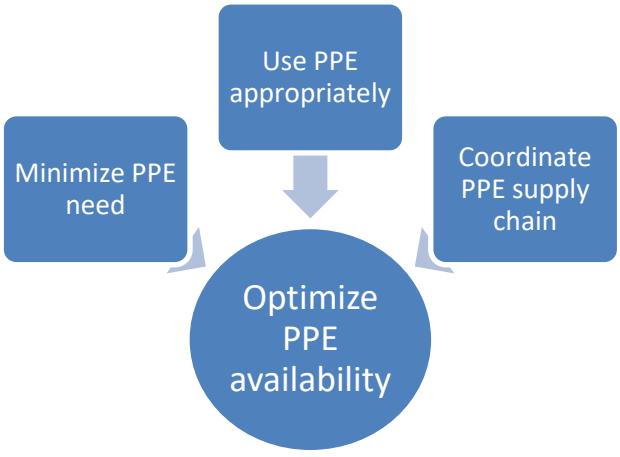
Coveralls, double gloves, or head covers (hood) that cover the head and neck used in the context of filovirus disease outbreaks (e.g. Ebola virus) are not required when managing COVID-19 patients.

Recommendations for optimizing the availability of PPE

The protection of our frontline health workers is paramount and PPE, including medical masks, respirators, gloves, gowns, and eye protection, must be prioritized for health care workers and others caring for COVID-19 patients.

In view of the global PPE shortage, strategies that can facilitate optimal PPE availability include minimizing the need for PPE in health care settings, ensuring rational and appropriate use of PPE, and coordinating PPE supply chain management mechanisms (Figure 1).

Figure 1. Strategies to optimize the availability of personal protective equipment (PPE)



1. Minimize the need for PPE in health care settings

The following interventions can minimize the use and need for PPE while ensuring that the protection health care workers and others from exposure to the COVID-19 virus in health care settings is not compromised.

- Wherever feasible, use telemedicine and telephone hotlines to initially evaluate suspected cases of COVID-19[5], thus minimizing the need for these persons to go to health care facilities for evaluation.
- Use physical barriers to reduce exposure to the COVID-19 virus, such as glass or plastic windows. This approach can be implemented in areas of the health care setting where patients will first present, such as triage and screening areas, the registration desk at the emergency department, or at the pharmacy window where medication is collected.
- Postpone elective, non-urgent procedure, and hospitalizations, reduce frequency of visits for chronic patients, apply telemedicine and telephone solutions where possible so that health care workers, wards, and PPE can be redistributed to services in which COVID-19 patients receive care.
- Cohort confirmed COVID-19 patients without co-infection with other transmissible microorganisms in the same room in order to streamline the workflow and facilitate extended use of PPE (see below).
- Designate dedicated health care workers/teams only for COVID-19 patient care so that they can use PPE for longer periods of time (extended use of PPE), if necessary (see considerations section below for details).
- Restrict the number of health care workers from entering the rooms of COVID-19 patients if they are not involved in providing direct care. Streamline the workflow and reduce to a safe level care that requires face-to-face interaction between health worker and patient. To do so, consider bundling activities to minimize the number of times a room is entered (e.g. check vital signs during medication administration or have food delivered by health care workers while they are performing other care) and plan which activities will be performed at the bedside.
- Consider using specific PPE only if in direct close contact with the patient or when touching the environment (e.g. wearing a medical mask and face shield, not using gloves or gown over the scrub suit, if entering the patient's room only to ask questions or make visual checks).
- Visitors should not be allowed to visit confirmed or probable COVID-19 patients, but if strictly necessary, restrict the number of visitors and the time allowed; provide clear instructions about what PPE is required to be used during the visit, about how to put on and remove PPE, and perform hand hygiene to ensure that visitors avoid exposure.

2. Ensure rational and appropriate use of PPE

PPE should be used in combination with administrative and engineering controls. The indications for PPE should be

based on the setting, target audience, risk of exposure (e.g. type of activity) and the transmission dynamics of the pathogen (e.g. contact, droplet, or aerosol). The overuse or misuse of PPE will have a further impact on supply shortages. Observing the following recommendations will ensure rational use of PPE:

- The type of PPE used when caring for COVID-19 patients will vary according to the setting, type of personnel, and activity (Table 1).
- Health care workers involved in the direct care of patients should use PPE according to indications (Table 1).
- Specifically, for aerosol-generating procedures and support treatments (tracheal intubation, non-invasive ventilation, tracheotomy, cardiopulmonary resuscitation, manual ventilation before intubation, and bronchoscopy)[1] health care workers should use respirators, eye protection, gloves and gowns; aprons should also be used if gowns are not fluid-resistant.[4]
- Among the general public, persons with symptoms suggestive of COVID-19 or those caring for COVID-19 patients at home should receive medical masks and instructions on their use. For additional information, see Home care for patients with COVID-19 presenting with mild symptoms and management of their contacts.[6]
- For additional information, see Advice on the use of masks in the community, during home care, and in health care settings in the context of COVID-19.[7]

3. Coordinate PPE supply chain management mechanisms.

The management of PPE should be coordinated through essential national and international supply chain management mechanisms that include but are not restricted to:

- Using PPE forecasts based on rational quantification models to ensure the rationalization of requested supplies;
- Monitoring and controlling PPE requests from countries and large responders;
- Promoting a centralized request management approach to avoid duplication of stock and ensuring strict adherence to essential stock management rules to limit wastage, overstock, and stock ruptures;
- Monitoring the end-to-end distribution of PPE;
- Monitoring and controlling the distribution of PPE from medical facilities stores.

Handling cargo from affected countries

An experimental study conducted in a laboratory evaluated the survival of the COVID-19 virus on different surfaces and reported that the virus can remain viable up to 72 hours on plastic and stainless steel, up to four hours on copper, and up to 24 hours on cardboard.[8] To date, there are no data to suggest that contact with goods or products shipped from countries affected by the COVID-19 outbreak have been the source of COVID-19 infection in humans. WHO will continue to closely monitor the evolution of the COVID-19 outbreak and will update recommendations as needed.

The rationalized use and distribution of PPE when handling cargo from and to countries affected by the COVID-19 outbreak includes the following recommendations:

- Wearing a mask of any type is not recommended when handling cargo from an affected country.
- Gloves are not required unless they are used for protection against mechanical hazards, such as when manipulating rough surfaces.
- Importantly, the use of gloves does not replace the need for appropriate hand hygiene, which should be performed frequently, as described above.
- When disinfecting supplies or pallets, no additional PPE is required beyond what is routinely recommended.
- Hand hygiene should be practiced

Table 1. Recommended PPE during the outbreak of COVID-19 outbreak, according to the setting, personnel, and type of activity[a]

Setting	Target personnel or patients	Activity	Type of PPE or procedure
Health care facilities			
Inpatient facilities			
Screening[i] Clinical triage for prioritization of care according to severity (e.g. Manchester classification) should be performed in separate area for individuals with symptoms and signs	Health care workers	Preliminary screening not involving direct contact[c].	• Maintain physical distance of at least 1 metre. • Ideally, build glass/plastic screens to create a barrier between health care workers and patients • No PPE required. • When physical distance is not feasible and yet no patient contact, use mask and eye protection.
	Patients with symptoms suggestive of COVID-19	Any	• Maintain physical distance of at least 1 metre. • Provide medical mask if tolerated by patient. • Immediately move the patient to an isolation room or separate area away from others; if this is not feasible, ensure spatial distance of at least 1 metre from other patients. • Perform hand hygiene and have the patient perform hand hygiene
	Patients without symptoms suggestive of COVID-19	Any	• No PPE required • Perform hand hygiene and have the patient perform hand hygiene
Patient room/ward	Health care workers	Providing direct care to COVID-19 patients, in the absence of aerosol-generating procedures	• Medical mask • Gown • Gloves • Eye protection (goggles or face shield) • Perform hand hygiene
	Health care workers	Providing direct care to COVID-19 patients in settings where aerosol-generating procedures are frequently in place[ii]	• Respirator N95 or FFP2 or FFP3 standard, or equivalent. • Gown • Gloves • Eye protection • Apron • Perform hand hygiene
	Cleaners	Entering the room of COVID-19 patients	• Medical mask • Gown • Heavy-duty gloves • Eye protection (if risk of splash from organic material or chemicals is anticipated) • Closed work shoes • Perform hand hygiene
	Visitors[b]	Entering the room of a COVID-19 patient	• Maintain physical distance of at least 1 metre • Medical mask • Gown • Gloves • Perform hand hygiene

[i] The screening procedure refers to prompt identification of patients with signs and symptoms of COVID-19.
[ii] AGP: tracheal intubation, non-invasive ventilation, tracheotomy, cardiopulmonary resuscitation, manual ventilation before intubation, bronchoscopy.

Areas of transit where patients are not allowed (e.g. cafeteria, corridors)	All staff, including health care workers.	Any activity that does not involve contact with COVID-19 patients	• Maintain physical distance of at least 1 metre • No PPE required • Perform hand hygiene
Laboratory	Lab technician	Manipulation of respiratory samples Specimen handling for molecular testing would require BSL-2 or equivalent facilities. Handling and processing of specimens from cases with suspected or confirmed COVID-19 infection that are intended for additional laboratory tests, such as haematology or blood gas analysis, should apply standard precautions[9]	• Maintain physical distance of at least 1 metre • Medical mask • Eye protection • Gown • Gloves • Perform hand hygiene
Administrative areas	All staff, including health care workers.	Administrative tasks that do not involve contact with COVID-19 patients.	• Maintain physical distance of at least 1 metre • No PPE required • Perform hand hygiene

Outpatient facilities			
Screening/triage	Health care workers	Preliminary screening not involving direct contact[c].	• Maintain physical distance of at least 1 metre. • Ideally, build a glass/plastic screen to create a barrier between health care workers and patients • No PPE required • When physical distance is not feasible and yet no patient contact, use mask and eye protection. • Perform hand hygiene
	Patients with symptoms suggestive of COVID-19	Any	• Maintain spatial distance of at least 1 metre. • Provide medical mask if tolerated. • Perform hand hygiene
	Patients without symptoms suggestive of COVID-19	Any	• No PPE required • Perform hand hygiene
Waiting room	Patients with symptoms suggestive of COVID-19	Any	• Provide medical mask if tolerated. • Immediately move the patient to an isolation room or separate area away from others; if this is not feasible, ensure spatial distance of at least 1 metre from other patients. • Have the patient perform hand hygiene
	Patients without respiratory symptoms	Any	• No PPE required • Have the patient perform hand hygiene
Consultation room	Health care workers	Physical examination of patient with symptoms suggestive of COVID-19	• Medical mask • Gown • Gloves • Eye protection • Perform hand hygiene
	Health care workers	Physical examination of patients without symptoms suggestive of COVID-19	• PPE according to standard precautions and risk assessment. • Perform hand hygiene
	Patients with symptoms suggestive of COVID-19	Any	• Provide medical mask if tolerated. • Hand hygiene and respiratory etiquette

	Patients without symptoms suggestive of COVID-19	Any	• No PPE required • Have the patient perform hand hygiene
	Cleaners	After and between consultations with patients with respiratory symptoms.	• Medical mask • Gown • Heavy-duty gloves • Eye protection (if risk of splash from organic material or chemicals). • Closed work shoes • Perform hand hygiene
Administrative areas	All staff, including health care workers	Administrative tasks	• Maintain physical distance of at least 1 metre between staff • No PPE required • Perform hand hygiene
Home care			
Home	Patients with symptoms suggestive of COVID-19	Any	• Maintain physical distance of at least 1 metre. • Provide medical mask if tolerated, except when sleeping. • Hand and respiratory hygiene
	Caregiver	Entering the patient's room, but not providing direct care or assistance	• Maintain physical distance of at least 1 metre • Medical mask • Perform hand hygiene
	Caregiver	Providing direct care or when handling stool, urine, or waste from COVID-19 patient being cared for at home	• Gloves • Medical mask • Apron (if risk of splash is anticipated) • Perform hand hygiene
	Health care workers	Providing direct care or assistance to a COVID-19 patient at home	• Medical mask • Gown • Gloves • Eye protection
Points of entry at airports, ports and ground crossing as applicable			
Administrative areas	All staff	Any	• No PPE required
Screening area	Staff	First screening (temperature measurement) not involving direct contact[c].	• Maintain physical distance of at least 1 metre. • Ideally, build a glass/plastic screen to create a barrier between health care workers and patients • No PPE required • When physical distance is not feasible, yet no patient contact, use mask and eye protection. • Perform hand hygiene
	Staff	Second screening (i.e. interviewing passengers with fever for clinical symptoms suggestive of COVID-19 disease and travel history)	• Maintain physical distance of at least 1 metre. • Medical mask • Gloves • Perform hand hygiene
	Cleaners	Cleaning the area where passengers with fever are being screened	• Medical mask • Gown • Heavy duty gloves • Eye protection (if risk of splash from organic material or chemicals). • Boots or closed work shoes • Perform hand hygiene
Temporary isolation area	Staff	Entering the isolation area, but not providing direct assistance	• Maintain physical distance of at least 1 metre. • Medical mask

			• Gloves
	Staff, health care workers	Assisting or caring for passenger being transported to a health care facility as a suspected COVID -19 cases	• Medical mask • Gown • Gloves • Eye protection • Perform hand hygiene
	Cleaners	Cleaning isolation area	• Maintain physical distance of at least 1 metre. • Medical mask • Gown • Heavy duty gloves • Eye protection (if risk of splash from organic material or chemicals). • Closed work shoes • Perform hand hygiene
Ambulance or transfer vehicle	Health care workers	Transporting suspected COVID-19 patients to the referral health care facility	• Medical mask • Gowns • Gloves • Eye protection • Perform hand hygiene
	Driver	Involved only in driving the patient with suspected COVID-19 disease and the driver's compartment is separated from the COVID-19 patient	• Maintain physical distance of at least 1 metre. • No PPE required • Perform hand hygiene
		Assisting with loading or unloading patient with suspected COVID-19	• Medical mask • Gowns • Gloves • Eye protection • Perform hand hygiene
		No direct contact with patient with suspected COVID-19, but no separation between driver's and patient's compartments	• Medical mask • Perform hand hygiene
	Patient with suspected COVID-19.	Transport to the referral health care facility.	• Medical mask if tolerated • Have the patient perform hand hygiene
	Cleaners	Cleaning after and between transport of patients with suspected COVID-19 to the referral health care facility.	• Medical mask • Gown • Heavy duty gloves • Eye protection (if risk of splash from organic material or chemicals). • Boots or closed work shoes • Perform hand hygiene

Special considerations for rapid-response teams assisting with public health investigations[d]			
Anywhere	Rapid-response team investigators	Remote interview of suspected or confirmed COVID-19 patients or their contacts.	• No PPE if done remotely (e.g. by telephone or video conference). • Remote interview is the preferred method.
		In-person interview of suspected or confirmed COVID-19 patients or contacts without direct contact	• Medical mask • Maintain physical distance of at least 1 metre. • The interview should be conducted outside the house or outdoors, and confirmed or suspected COVID-19 patients should wear a medical mask if tolerated. • Perform hand hygiene

[a] In addition to using the appropriate PPE, frequent hand hygiene and respiratory etiquette should always be performed. PPE should be discarded in an appropriate waste container after use according to local guidance, and hand hygiene should be performed before putting on and after taking off PPE.

[b] the number of visitors should be restricted. If visitors must enter a COVID-19 patient's room, they should be provided with clear instructions about how to put on and remove PPE and about performing hand hygiene before putting on and after removing PPE; this should be supervised by a health care worker.

[c] This category includes the use of no-touch thermometers, thermal imaging cameras, and limited observation and questioning, all while maintaining a spatial distance of at least 1 m.

[d] All rapid-response team members must be trained in performing hand hygiene and how to put on and remove PPE to avoid -self-contamination.

For PPE specifications, refer to WHO's disease commodity package.

Disruptions in the global supply chain of PPE

The current global stockpile of PPE is insufficient, particularly for medical masks and respirators, and the supply of gowns, goggles, and face shields is now insufficient to satisfy the global demand. Surging global demand—d riven not only by the number of COVID-19 cases but also by misinformation, panic buying, and stockpiling—has resulted in further shortages of PPE globally. The capacity to expand PPE production is limited, and the current demand for respirators and masks cannot be met, especially if widespread inappropriate use of PPE continues.

However, with manufacturing companies in some of the main exporting countries restarting their production, and an established global coordination mechanism that WHO anticipates will contribute to addressing the global shortage. Dedicated assistance and international solidarity mechanisms are required to meet the needs of the most vulnerable countries, which may face affordability issues in a context of rising prices determined by an unprecedented surge in demand, coupled with supply and distribution disruptions.

Members States and large responders can forecast their supply needs using the Essential Supplies forecasting tool.

Considerations for decision making processes during severe shortages of PPE

In the context of severe PPE shortages despite application of the above-mentioned strategies, it is crucial to ensure a "whole of society" response and to protect frontline health care workers. This includes advocating for the urgent increased production of PPE, including, if needed, through advance market commitments, public-sector mandated scale up of production by the private sector, pursuing donation options, international solidarity through financial support of PPE purchase and distribution for the needs of the most vulnerable countries, and engaging with the general public to prevent irrational use of PPE at community level, among other strategies.

Any alternative approach to find temporary solutions to mitigate critical shortages of PPE should be based on scientific evidence, the principles of safe care delivery and health care safety, workload minimization for health care workers, and avoiding a false sense of security.

Based on current evidence, in consultation with international experts and other agencies in the field of IPC, WHO carefully considered **last-resort temporary measures** in crisis situations to be adopted **only** where there might be serious shortages of PPE or in areas where PPE may not be available.

WHO stresses that these temporary measures should be avoided as much as possible when caring for severe or critically ill COVID-19 patients, and for patients with known co-infections of multi-drug resistant or other organisms transmitted by contact (e.g. Klebsiella pneumoniae) or droplets (e.g. influenza virus).

The following temporary measures could be considered independently or in combination, depending on the local situation:

1. PPE extended use (using for longer periods of time than normal according to standards);
2. Reprocessing followed by reuse (after cleaning or decontamination/sterilization) of either reusable or disposable PPE;
3. Considering alternative items compared with the standards recommended by WHO.

An additional consideration is the use of PPE beyond the manufacturer-designated shelf life or expiration date for a limited time. The items should be inspected before use to be sure they are in good condition with no degradation, tears, or wear that could affect performance. N95 respirators that are past their designated shelf life are no longer NIOSH-approved, as all manufacturer-designated conditions of use must be met to maintain the NIOSH approval. An expired respirator can still be effective at protecting health care provider if the straps are intact, there are no visible signs of damage, and they can be fit-tested. Health care providers should inspect the mask and perform a seal check before use.

The reuse of any item without a reprocessing/ decontamination process is considered inadequate and unsafe. The reprocessing should be performed by trained staff in the sterile services department of a health care facility or at bigger scale under controlled and standardized conditions. Many medical devices are designed to be reusable, hence their compatibility with decontamination methods; this is not the case for face shields, medical masks, and respirators. Normally, for any reprocessing methods, cleaning before disinfection and sterilization is required. This is a problem for masks and respirators because they cannot be cleaned without losing their proprieties.

Methods for reprocessing masks or respirators are not well established nor standardized, and therefore should be considered only when there is critical PPE shortage or lack of PPE. Issues to take into consideration when reprocessing include:

1. efficacy of the process to guarantee disinfection or sterilization
2. reprocessing method not resulting in residual toxicity for health care workers
3. maintenance of functional integrity and shape of item. Further, when considering reprocessing and reuse, manufacturers' instructions for reprocessing should be followed, if available. In addition, systems should be put in place to routinely inspect, repair (if applicable) and dispose of reused PPE when necessary (e.g. damaged, no longer suitable for reuse).

In the current exceptional crisis scenario of the COVID-19 pandemic, reprocessing of disposable PPE is an evolving area where research and development is ongoing and urgently needed. In this document, only methods that have been tested and either published in peer-reviewed journals or commissioned by the US Food and Drug Administration (FDA) are reported. However, WHO is aware of ongoing studies that are testing promising approaches (e.g. steam or heat sterilization of medical masks if performed in standardized conditions). As more evidence becomes available, WHO will update these considerations accordingly and hence this document should be considered interim guidance.

Alternative materials

As of the date of publication, the replacement of standard PPE with items produced with materials not having the necessary requirements (e.g. cotton cloth masks to replace medical masks or respirators) has not been proven to be effective and is discouraged (see below). If production of any PPE for use in health care settings is proposed locally in situations of shortage or stock out, a local authority should assess the proposed PPE according to specific minimum standards and technical specifications.

Each of these measures carries significant risks and limitations and thus should be considered only as **a last resort when all other strategies for rational and appropriate use and procurement of PPE (see Figure 1) have been exhausted.**

Summary of temporary measures in the context of severe PPE shortage

Table 2 summarizes temporary measures in the context of severe PPE shortage or stock-out. For each option, there is a description of how the measure should be used, what the limitations are, criteria for PPE removal and precautions, and feasibility. The latter mainly takes into consideration costs and local capacity (e.g. infrastructures, equipment, human resources) to undertake the measure in the safest and most standardized conditions possible, and it refers to feasibility for high-income countries (HIC) vs low and middle-income countries (LMIC).

Irrespective of the measure implemented, health care workers must have the required IPC education and training about the correct use of PPE and other IPC precautions, including demonstration of competency in appropriate procedures for putting on and removing PPE required for direct care of patients with COVID-19 and other tasks - see: WHO | How to put on and take off Personal Protective Equipment (PPE).

Table 2. Options for temporary measures due to the shortage of Personal Protective Equipment (PPE): extended use, reprocessing, or use of alternative PPE

Type of PPE	Measure	Description	Limitations/risks/removal criteria	Feasibility considerations
Medical mask use by health workers	1) Extended use	The use without removing for up to 6h, when caring for a cohort of COVID-19 patients	Risks: • Extended use of medical mask may increase risk of contamination of the mask with COVID-19 virus and other pathogens • Wearing the mask for a prolonged period may increase the chance of the health care worker touching the mask or having inadvertent under-mask touches; if the mask is touched/adjusted, hand hygiene must be performed immediately • Damage to or reactions of face skin tissue may occur with prolonged use of medical masks • Filtration media of the medical mask may become clogged, thereby increasing breathing resistance and the risk of breathing unfiltered ambient air from the sides of the medical mask • Extended periods of time in active patient wards required for health care workers Removal criteria and precautions: • If the mask becomes wet, soiled, or damaged, or if it becomes difficult to breathe through • If the mask is exposed to splash of chemicals, infectious substances, or body fluids • If the mask is displaced from face for any reason. • If the front of the mask is touched to adjust it • Follow the safe procedure for removal and do not touch the front of the mask • The mask needs to be removed whenever providing care outside a designated cohort of COVID-19 patients • Follow the safe procedure for removal and do not touch the front of the mask • Use of the same medical mask by a health care worker between a patient with COVID-19 and a patient who does not have COVID-19 is not recommended owing to the risk of transmission to another patient who would be susceptible to COVID-19	Feasible in all countries Minimum requirements include definition of standard procedure, training and follow up to ensure good practices

Type of PPE	Measure	Description	Limitations/risks/removal criteria	Feasibility considerations
	2) Reprocessing	No quality evidence is available to date on medical mask reprocessing and is not advised	NA	NA
	3) Alternative items in absence of medical masks	i) FFP1 respirator	Removal criteria and precautions: • If the mask becomes wet, soiled, or damaged, or if it becomes difficult to breathe through • If the mask is exposed to splash of chemicals, infectious substances, or body fluids • If the mask is displaced from face for any reason • If the front of the mask is touched to adjust it • The mask needs to be removed whenever providing care outside of designated cohort of COVID-19 patients • Follow the safe procedure for removal and do not touch the front of the mask	
		ii) Face shield with proper design to cover the sides of the face and below the chin To be used only in the critical emergency situation of lack of medical masks	Risks: Protective against direct direct exposure of mouth, nose and eyes to droplets; however depends on the design and on the positioning of HCW in relation to the patient Removal criteria: • If face shield is contaminated by splash of chemicals, infectious substances, or body fluids • If face shield obstructs health care worker safety or visibility of health care environment • Follow the safe procedure for removal and do not touch the front of the face shield	Feasible in HIC and LMIC Potential of local production Minimum requirements include definition of standard procedure, training, and follow up to ensure good practices
Respirators (FFP2, FFP3 or N95)	1) Extended use	The use without removing up to 6h, when caring for a cohort of COVID-19 patients.	Risks: • Extended use of respirators may increase risk of contamination with COVID-19 virus and other pathogens • The prolonged period may increase the chance of health care workers touching the respirator or having inadvertent under-respirator touches; if respirator masks are touched/adjusted, hand hygiene must be performed immediately	Feasible in HIC and LMIC Minimum requirements include definition of standard procedure, training and follow up to ensure good practices

Type of PPE	Measure	Description	Limitations/risks/removal criteria	Feasibility considerations
			• Facial dermatitis, respirator-induced acne, respiratory fatigue, impaired work capacity, increased oxygen debt, early exhaustion at lighter workloads, elevated levels of CO_2, increased nasal resistance, and increased non-compliance with best practices while wearing a respirator (adjustments, mask or face touches, under-the-respirator touches, and eye touches), have been reported after prolonged use of respirators. • Extended use may clog the filtration media, leading to increased breathing resistance <u>Removal criteria and precautions:</u> • If respirator becomes wet, soiled, damaged, or difficult to breathe through. • If exposed to splash of chemicals, infectious substances, or body fluids • If displaced from the face for any reason. • If the front of the respirator is touched to adjust it • Follow the safe procedure for removal and do not touch the front of the respirator • Use of the same respirator by a health care worker between a patient with COVID-19 and a patient who does not have COVID-19 is not recommended owing to the risk of transmission to another patient who would be susceptible to COVID-19	
	2) Reprocessing (see Annex 1 for evidence)	Process to decontaminate a respirator using disinfection or sterilization methods. <u>Methods (not validated) for respirator reprocessing (see Annex 1):</u> • vapor of hydrogen peroxide • ethylene oxide • UV radiation lamp	<u>Limitations/ Risks:</u> • Reprocessing methods have not been validated by substantial research and there are currently no standardized methods or protocols for ensuring the effectiveness nor integrity of the respirators after reprocessing • Shelf-life of reprocessed respirators is unknown; however, degradation of the filtration media or elastic strap after one or more sterilization cycles affects the fit of a respirator to the face • Damage to the shape of respirators due to the reprocessing may affect fit and protection properties • Number of reprocessing cycles highly variable, depending on the reprocessing method used and the respirator brand/model <u>Disposal criteria and precautions:</u> • After a pre-defined number of reuses the respirator should be discarded in appropriate contained waste receptacle according to local guidance/policy	Feasible in HIC Potentially feasible in LMIC; Human resources, equipment installation, procurement of consumables, health care worker safety during the reprocessing should be considered. Minimum requirements include defining a standard operating procedure, training, and follow up to ensure good practices

Type of PPE	Measure	Description	Limitations/risks/removal criteria	Feasibility considerations
			• When a respirator is removed from the face, it should be immediately placed in a designated container for reprocessing and labeled with the original wearer's name. • The respirator should be returned to original wearer after reprocessing cycle.	
Gowns used by health workers	1) Extended use	The use without removing, when providing care of a cohort of patients with COVID-19. Not applicable if the patient has multidrug resistant microorganisms or other type of disease requiring contact precautions. In such case, the gowns should be changed between patients	Risks • Extended use of gowns may increase risk of contamination with COVID-19 virus • The extended use of gowns may increase the risk of transmission of other pathogens between patients Removal criteria and precautions: • If gown becomes wet, soiled, or damaged • If gown is exposed to splash of chemicals, infectious substances, or body fluids • When providing care outside designated cohort of COVID-19 patients • Follow the safe procedure for removal of gowns to prevent contamination of environment • Use of the same gown by a health care worker between a patient with COVID-19 and a patient who does not have COVID-19 is not recommended due to the risk of transmission to another patient who would be susceptible to COVID-19	Feasible in HIC and LMIC Minimum requirements include definition of standard procedure, training, and follow up to ensure good practices
	2) Reprocessing	Process to decontaminate a cotton gown by washing and disinfection methods. Reprocessing can be done with cotton gowns. Wash and disinfect cotton gowns: washing by machine with warm water (60-90°C) and laundry detergent is recommended for reprocessing of the gown. If machine washing is not possible, linen can be soaked in hot water and soap in a large drum, using a stick to	Risk • In hot and humid weather, the cotton gown can lead to discomfort and sweating Removal criteria: • If gown becomes wet, soiled, or damaged	Feasible in HIC and LMIC Requires additional support staff, gown reprocessing inventory; laundry equipped with hot water or manual washing with water and soap, followed by soaking in disinfectant

Type of PPE	Measure	Description	Limitations/risks/removal criteria	Feasibility considerations
		stir, avoiding splashing. Then soak linen in 0.05% chlorine for approximately 30 minutes. Finally, rinse with clean water and let it dry fully in the sunlight		
	3) Alternatives	i) Disposable laboratory coats Only for brief contact with the patients; should not be used for prolonged contact or when performing aerosol-generating procedures and support treatments	<u>Risks:</u> • Disposable laboratory coats are less durable than gowns, so there is a risk of damage during the patient care <u>Removal criteria and precautions:</u> • If disposable alternatives to gowns become wet, soiled, or damaged • If alternative to gown is exposed to splash of chemicals, infectious substances, or body fluids • Follow the safe procedure for removal of laboratory coat to prevent contamination of environment • Use of the same laboratory coat by a health care worker between a patient with COVID-19 and a patient who does not have COVID-19 is not recommended due to the risk of transmission to another patient who would be susceptible to COVID-19	Feasible in HIC and LMIC
		ii) Disposable impermeable plastic aprons Should be avoided when performing aerosol-generating procedures and support treatments	<u>Risks:</u> • Plastic aprons do not protect arms and the back of the torso, which can be exposed to splashes <u>Removal criteria and precautions:</u> • If disposable alternatives to gowns become wet, soiled, or damaged • If alternative to gown is exposed to splash of chemicals, infectious substances, or body fluids • Follow the safe procedure for removal of apron to prevent contamination of environment	Potentially feasible in HIC and LMIC Requires procurement of aprons with proper design for health care Potentially feasible in HIC and LMIC
		iii) Reusable (washable) patient gowns, reusable (washable) laboratory coats (see above recommendations for laundry of gowns)	<u>Risk</u> • Design and thickness may not be compatible with the full protection of the torso or arms <u>Removal criteria:</u>	Requires additional support staff, gown reprocessing inventory; laundry equipped with hot water or manual washing with water and soap, followed by soaking in disinfectant

Type of PPE	Measure	Description	Limitations/risks/removal criteria	Feasibility considerations
			• If gown or coat becomes wet, soiled, or damaged	
Goggles or safety glasses used by health workers	1) Extended use	The use without removing during the shift period, when caring for a cohort of COVID-19 patients.	Risks: • Extended use of goggles may increase the discomfort and fatigue of health care workers • Skin tissue damage may occur to face with prolonged goggle use Removal criteria and precautions: • If goggles are contaminated by splash of chemicals, infectious substances, or body fluids • If goggles obstruct health care worker safety or svisibility of health care environment or become loose • Follow the safe procedure for removal of goggles to prevent contamination of eyes • Use of the same goggles by a health care worker between a patient with COVID-19 and a patient who does not have COVID-19 is not recommended due to the risk of transmission to another patient who would be susceptible to COVID-19	Feasible in both HIC and LMIC
	2) Reprocessing	Clean goggles with soap/detergent and water followed by disinfection using either sodium hypochlorite 0.1% (followed by rinsing with clean water) or 70% alcohol wipes Goggles may be cleaned immediately after removal and hand hygiene is performed OR placed in designated closed container for later cleaning and disinfection.	Risks: • Residual toxicity of sodium hypochlorite can occur if not thoroughly rinsed after disinfection. • Increases health care worker workload (limitation) Removal criteria: • If contaminated by splash of chemicals, infectious substances, or body fluids • If goggles obstruct health care worker safety or visibility of health care environment	Potentially feasible in HIC and LMIC Requires procurement of disinfectants and adequate clean space for the procedure

Type of PPE	Measure	Description	Limitations/risks/removal criteria	Feasibility considerations
		Ensure cleaning of goggles takes place on a clean surface by disinfecting the surface before cleaning of goggles. Appropriate contact time with disinfectant (e.g. 10 minutes when using sodium hypochlorite 0.1%) should be adhered to before reuse of goggles. After cleaning and disinfection, they must be stored in a clean area to avoid recontamination		
	3) Alternative items	Safety glasses (e.g. trauma glasses) with extensions to cover the side of the eyes.	Removal criteria and precautions: • If contaminated by splash of chemicals, infectious substances, or body fluids • If goggles obstruct health care worker safety or visibility of health care environment	Feasible in HIC and LIMC Minimal requirements include definition of standard procedure, training and follow up to ensure good practices
Face shield * used by health workers	1) Extended use *Face shield must be designed to cover the side of the face and to below the chin	The use without removing during the shift period, when caring for a cohort of COVID-19 patients.	Risks: • Extended use of face shield may increase discomfort and fatigue • Skin tissue damage may occur to face with prolonged google use Removal criteria and precautions: • If contaminated by splash of chemicals, infectious substances, or body fluids • If face shield obstructs health care worker safety or visibility of healthcare environment • Follow the safe procedure for removal of goggles to prevent contamination of the face and eyes • Use of the same face shield by a health care worker between a patient with COVID-19 and a patient who does not have COVID-19 is not recommended due to the risk of transmission to another patient who would be susceptible to COVID-19	Feasible in both HIC and LMIC Minimal requirements include definition of standard procedure, training and follow up to ensure good practices

Type of PPE	Measure	Description	Limitations/risks/removal criteria	Feasibility considerations
	2) Reprocessing	Cleaning with soap/detergent and water and disinfection with 70% alcohol or sodium hypochlorite 0.1%; finally rinsing with clean water if sodium hypochlorite used after contact time of 10 min Face shield may be cleaned immediately after appropriate doffing and hand hygiene is performed OR placed in designated closed container for later cleaning and disinfection Ensure cleaning of face shield takes place on surface without contamination. Disinfection of surface for cleaning of face shield is advised. Appropriate contact time with disinfectant should be adhered to before reuse of face shield. After cleaning and disinfection, they must be stored in a clean area to avoid recontamination	Limitations/Risks: • Damage to plastic, resulting in reduced visibility and integrity • Residual toxicity of the sodium hypochlorite can occur if not thoroughly rinsed after disinfection. Removal criteria and precautions: • If contaminated by splash of chemicals, infectious substances, or body fluids • If face shield obstructs health care worker safety or visibility of healthcare environment • Follow the safe procedure for removal of goggles to prevent contamination of the face and eyes	Feasible in both HIC and LMIC Minimal requirements include definition of standard procedure, training and follow up to ensure good practices Human resource requirements, equipment installation, procurement of consumables, HCW safety during the chemical manipulation should be considered.
	3) Alternative	Local production of face shield	Limitations/Risks: • Suboptimal quality, including inadequate shape to ensure face protection Removal criteria: • If contaminated by splash of chemicals, infectious substances, or body fluids • If face shield obstructs health care worker safety or visibility of health care environment	Minimal requirements include definition of standard procedure, availability of material, human resource requirements, training, and follow up to ensure good practices

Options not recommended by WHO: What WHO does and does NOT recommend:

1. Gloves: gloves should be worn when providing direct care for a COVID 19 case and then removed, followed by hand hygiene between COVID-19 patients. Using the same gloves for a cohort of COVID-19 cases (extended use) must not be done. Changing gloves between dirty and clean tasks during care to a patient and when moving from a patient to another, accompanied by hand hygiene, is absolutely necessary. Double gloving is not recommended, except for surgical procedures that carry a high risk of rupture.

2. The reuse of masks, gowns, or eye protection without appropriate decontamination/sterilization is strongly discouraged. The removal, storage, re-donning, and reuse of the same, potentially contaminated PPE items without adequate reprocessing is one of the principal sources of risk to health care workers.

3. The use of cotton cloth masks as an alternative to medical masks or respirators is not considered appropriate for protection of health care workers.[10] Fabric thickness and weaving standards vary widely; hence, the barrier (filtration efficiency) against microorganisms passing through the fabric is unknown. In addition, cotton cloth masks are not fluid-resistant and thus may retain moisture, become contaminated, and act as a potential source of infection.[10] Although some studies have been carried out for cloth masks using synthetic, hydrophobic materials on the outer layer, there is no current evidence to show that these perform adequately as PPE for health settings.[11] As for other PPE items, if production of masks for use in health care settings is proposed locally in situations of shortage or stock out, a local authority should assess the proposed PPE according to specific minimum standards and technical specifications. As evidence becomes available WHO will update these considerations accordingly.

Annex 1: Studies on medical masks and respirators reprocessing methods

Table 1 presents a summary of studies on reprocessing options for respirators; only one study testing medical masks was found. This study, from 1978, used ethylene oxide sterilizer (EtO) with a single warm cycle (55°C and 725 mg l-1 100% EtO gas) with exposure for 1 hour followed by 4 hours of aeration time.[13] The study was however performed with restricted sampling of nonwoven masks, and it therefore not generalizable.

When considering whether to adopt described methods, the handling of masks and respirators for the decontamination procedure is a critical step; excessive manipulation must be avoided. In addition, systems should be in place to carefully inspect the items before every reprocessing cycle to check their integrity and shape maintenance; if damaged or not suitable for reuse, they should be immediately disposed of. The key aspects to be considered for considering a reprocessing method as acceptable are: 1) the efficacy of the method to disinfect/sterilize the equipment; 2) the preservation of the respirator's filtration; 3) the preservation of the respirator's shape and thus, of its fit; and 4) the safety for the person wearing the respirator (e.g. toxic effect after reprocessing).

Some methods should be avoided due to the damage to the mask, toxicity, or loss of filtration efficiency: washing, steam sterilization at 134°C, disinfection with bleach/sodium hypochlorite or alcohol, or microwave oven irradiation.[14] Microwave ovens have shown some biocidal effect when combined with moisture to combine radiation with steam heat; however, problems that require careful consideration include: i) a lack of substantial review of standard microwave oven radiation capacities with respirator disinfection, ii) an inability to ensure controls for uniform distribution of steam, and iii) concern that the metal noseband of respirators may combust.[15,16]Although gamma irradiation demonstrated experimental efficacy against emerging virus, this method was not evaluated specifically for masks or respirators .[17]

Both vapor of hydrogen peroxide [14,18,19] and ethylene oxide were favorable in some studies but limited by the models of respirators evaluated. The use of UV radiation can be a potential alternative; however, the low penetration power of UV light may not reach inner materials of respirator or penetrate through pleats or folds.[20] The parameters of disinfection by using UVC light is not yet fully standardized for the purpose of reprocessing masks and respirators; this requires a validation procedure to ensure that all surfaces inside and outside masks are reached by the UVC light with appropriate irradiation time.[20,21] Comparison among studies regarding methods is limited owing to different outcomes and evaluation methods. Further, the implications for practical considerations must include the feasibility of the control of all parameters of the methods.

Table 1. Studies on medical mask and respirators reprocessing methods

Method	Equipment Parameters	Medical/ Respirator - Test method/Outcome Evaluated	Author, year	Limitations/Considerations	Pertinent Study Conclusion
Hydrogen Peroxide Vaporized	STERRAD NX100 Express cycle - Vaporized hydrogen peroxide low pressure gas sterilization Chamber temperature <55 °C. Hydrogen Peroxide concentration 26.1mg/L. 6-minute sterilant exposure time. Total dose of 157 (mg/L x exposure time). 24 minutes	• FFP2 (3M) - Sodium chloride 'fit test' for total inward leakage used after each reprocessing cycle	RIVM, 2020 [19]	• Not to be used with any material containing celluloses. • Soiled respirators were not used in this study. • Shelf life of reprocessed respirators not determined.	Filtration efficacy for an unused respirator is retained after 2 sterilization cycles
Hydrogen Peroxide Vaporized	Room Bio-Decontamination Service (RBDS™, BIOQUELL UK Ltd, Andover, UK), Clarus® R hydrogen peroxide vapor generator utilizing 30% H2O2) +	• N95 (six models)	Bergman, et al, 2010[24]	• No observable physical changes	Control and decontamination treatment groups, had mean % penetration (P) <

	Clarus R20 aeration unit, The Clarus® R was placed in a room (64 m3). The hydrogen peroxide concentration, temperature, and relative humidity within the room monitored: Room concentration= 8 g/m3, 15-min dwell, 125-min total cycle time. Following exposure, the Clarus R20 aeration unit was run overnight inside the room to catalytically convert the hydrogen peroxide into oxygen and water vapor.	•Study evaluated physical appearance, odour, and laboratory filtration performance. • 8130 Automated fit test (NaCl aerosol) •Filter air flow resistance Control group: 4-hour 3x submersion in deionized water			4.01%, which is similar to penetration levels found in untreated
Hydrogen Peroxide Gas plasma	STERRAD 100S Gas Plasma Sterilizer 55 minutes standard cycle	• N95 and P100 - Automated Filter Tester used to measure initial filter aerosol penetration post-decontamination.	Viscusi et al, 2009 [14]	• Not to be used with any material containing celluloses. • Standardized sterilization cycle performed at commercial facility, not by primary researcher • If cotton is present in head straps or mask layers; they may absorb hydrogen peroxide and cause the STERRAD cycle to abort due to low hydrogen peroxide vapor concentration. • Soiled respirators were not used in this study	Did not significantly affect the aerosol penetration or filter airflow resistance.
Hydrogen Peroxide Vaporized	Bioquell Clarus C hydrogen peroxide vapor generator Generator was used in a closed chamber built for the experiment. Cycle: 10 min conditioning phase, 20 min gassing phase at 2 g/min, 150 min dwell phase at 0.5 g/min, 300 min aeration phase. Total cycle duration of 480 min (8 hr).	• N95 (3M) - Decontamination efficacy after inoculation of Geobacillus stearothermophilius droplets; 50 repeated aerosol inoculation/decontamination cycles	Batelle, 2016 [18]	• Some degradation in elastic respirator straps noted following 30 cycles	Study showed performance of N95 FFR (respirator) continued to exceed 95% efficiency after 50 repeated inoculation and decontamination cycles. Approach allowed >50 respirators to be decontaminated simultaneously

Hydrogen Peroxide gas plasma	3 cycles STERRAD® 100S H2O2 Gas Plasma Sterilizer (Advanced Sterilization Products, Irvine, CA) 59% Hydrogen Peroxide Cycle time ~55-min (short cycle); 45°C–50°C. Samples were packaged in Steris Vis-U-Tyvek®/polypropylene–polyethylene Heat Seal Sterilization pouches	• N95 (six models) •Study evaluated physical appearance, odour, and laboratory filtration performance. • 8130 Automated fit test (NaCl aerosol) •Filter air flow resistance Control group: 4-hour 3x submersion in deionized water	Bergman et al, 2010[24]	• Physical damage varied by treatment method. • No observable physical changes	After 3 cycles of treatments resulted in mean penetration levels > 5% for four of the six FFR models, which was bigger than other methods and the control group.
Ethylene Oxide	Steri-Vac 5XL sterilizer 55 °C 725 mg/L 100% ethylene oxide gas 1-hour exposure 4 hours aeration	• N95 and P100 - Automated Filter Tester (AFT) used to measure initial filter aerosol penetration post-decontamination.	Viscusi et al, 2009 [14]	• Standardized sterilization cycle performed at commercial facility, not by primary researcher • 5 hours processing cycle	Decontamination did not affect the filter Aerosol penetration, filter airflow resistance, or physical appearance of masks in this study.
Ethylene Oxide	Gas concentration of 800 mg/L 60 ° C Relative humidity 55% 4 hours sterilization, 1-hour aeration	• Medical mask (2 commercial nonwovens; 3 cotton gauze masks (3 layers); 1 gauze mask - % of Bacterial Efficiency Filtration was measured for aerosol of bacteria (Staphylococcus aureus and Serratia marcescens)	Furuhashi, 1978 [13]	• Standardized sterilization cycle performed at commercial facility, not by primary researcher • 5 hours processing cycle • Restricted sampling of nonwoven masks	Synthetic nonwoven masks had higher bacterial filtration efficiency than cotton or gauze masks There was no difference in the bacterial filtration efficiency after sterilization of nonwoven medical masks
Ethylene oxide	Amsco® Eagle® 3017 100% Ethylene oxide sterilizer/Aerator (STERIS Corp., Mentor, OH) 55°C; 1-hour exposure (736.4 mg/L) followed by 12-hour aeration. Samples were packaged in Steris Vis-U-Tyvek®/polypropylene-polyethylene	• N95 (six models) •Study evaluated physical appearance, odour, and laboratory filtration performance. • 8130 Automated fit test (NaCl aerosol)	Bergman, et al, 2010[24]	• No observable physical changes	Control and decontamination treatment groups, had mean % of penetration (P) < 4.01%, which is similar to penetration levels found in untreated

		•Filter air flow resistance Control group: 4-hour 3x submersion in deionized water			
Ultraviolet irradiation	SterilGARD III model SG403A A low-pressure mercury arc lamp (5.5 mg Hg; lamp type, TUV 36TS 4P SE; lamp voltage, 94 Volts; lamp wattage, 40 Watts; wavelength, 253.7 nm) 5-hour irradiation time Final doses: • Low 4.32-5.76 J/cm^2 • High: ≥7.20 J/cm^2	• N95 (Honeywell) - Respirator masks uniformly loaded with nebulized MS2 droplets generated with six-jet Collison nebulizer. Coupons were cut from respirator masks for viral detection.	Vo et al, 2009 [20]	• Author mentions potential limitation of pleats or folds in the respirator for UV light penetration • Efficacy demonstrated only for decontamination of single virus (MS2) in study	Low UV irradiation doses resulted in 3.00- to 3.16-log reductions Higher UV irradiation doses resulted in no detectable MS2 virus in this study.
Ultraviolet irradiation (UV)	Sterilgard III laminar flow cabinet (The Baker Company, Sanford, ME, USA) fitted with a 40-W UV-C light (average UV intensity experimentally measured to range from 0.18 to 0.20 mW cm2). Fifteen-minute exposure to each side (outer and inner) Final doses: 176–181 mJ/cm^2 exposure to each side of FFR.	• 9 FFR models Model 8130 Automated Filter Tester used to measure initial filter aerosol penetration post-decontamination, filter airflow resistance or physical appearance	Viscusi et al, 2009 [14]	• Limited by the available working surface area of a biosafety cabinet equipped with a UV-C source or other area being irradiated by a UV source.	the treatment did not affect the filter aerosol penetration, filter airflow resistance, or physical appearance of the FFRs.
Ultraviolet irradiation (UV)	15-W UV-C (254-nm wavelength) lamp Height of 25 cm above the cabinet's working surface Irradiance range: 1.6 to 2.2 mW/cm^2 (milliWatts per square centimeter) 15 min exposure on external panel of respirator Final dose: 1.8 J/cm^2	• N95 (3M) Quantitative real-time polymerase chain reaction (qRT-PCR) for decontamination efficiency of H5N1 virus NaCl penetration with 0.3µm particle size	Lore et al, 2012 [16]	• Study did not examine decontamination effect on the straps or nose clip of the two respirators	qRT-PCR indicated decontamination resulted in lower levels of detectable viral RNA compared with other two methods (microwave-generated steam and moist heat) Filtration efficiency was maintained with <5% penetration of NaCl
Ultraviolet irradiation (UV)	A 120-cm, 80-W UV-C (254 nm, (nanometer) lamp was adjusted to a height of 25 cm. The range of UV to which the FFR was exposed varied from 1.6 mW/cm^2 to 2.2 mW/cm^2 (Joules per square centimeter) Final dose: 1.8 J/cm^2(Joules per square centimeter) 15 Minutes	• N95 Laboratory applied H1N1 added to exterior surface of respirator. Circular coupons were cut from respirator and placed in medium to detect viable H1N1 in $TCID_{50}$ assay.	Heimbuch et al, 2011 [15]	• Two instances in which viable virus were recovered in study can possibly be attributed to mask shielding • Authors note that hundreds of FFR models exist but only 6 FFR were tested in study; other FFRs may perform differently • Efficacy demonstrated for decontamination of single virus (H1N1) in study	Average log reduction of 4.69, virus reduced to values below the detection limit with no obvious signs of deterioration or deformation.

Ultraviolet irradiation (UV)	FFRs were placed on a laboratory stand inside a Sterilgard III laminar flow cabinet, fitted with a 40 W UV-C bulb. Intensity 1.8 mW/cm^2 measured with a UVX Digital Radiometer with model UVX-25 sensor (254 nm filter). 15 min exposure to outer side of FFR Final dose; 1.6-2.0 mW/cm^2	• Surgical N95 (fluid resistance N95): 3M 1860, 3M 1870, KC PFR95- 270 (46767) • Respirator fit AND face seal leakage were measured with 10 participants using PORTACOUNT® Plus Model 8020A Respirator Fit Tester with an N95 Companion™ Model 8095 accessory	Bergman et al, 2011[25]	• Study use an abbreviated fit-test protocol, only three FFR models, and a small group (n = 10) of respirator test subjects per FFR model. • Subjects wore their FFRs for a shorter total test time of ~5 min (which includes the 3-min acclimatization period) using the modified protocol compared with the standard OSHA-accepted protocol (~12 min) •	Respirator fit was maintained throughout three decontamination cycles alternating with four donning/doffing cycles. Face seal leakage value was maintained at below 1%
Ultraviolet irradiation (UV)	Custom UV device made of polished aluminum measuring 40-in L × 16-in W × 13-in H with a tunnel extension measuring 18-in L × 8-in W × 6-in H. Eight 32-in 254-nm UV-C bulbs with an irradiance of 0.39 W/cm2 at 1 m to deliver a UV dose of 1 J/cm2 in ~1 minute. A sliding wire mesh rack was used to position the FFR during UV treatment. Air circulation system with high-airflow fans. Mean UV dose per FFR 1.1 ± 0.1 J/cm2, mean temperature 21°C ± 2°C, mean relative humidity 48% ± 6% within the UV device.	• N95 (3M, Alpha Protech, Gerson Kimberly-Clark Moldex, Precept Prestige Ameritech, Sperian, U.S. Safety) - Study artificially contaminated N95 with H1N1 influenza. Artificial saliva (mucin buffer) and artificial skin oil (sebum) were applied directly over influenza contamination. Coupons cut from mask for viral detection.	Mills, et al, 2018 [22]	• Study conducted at 100x theoretical highest real-world respirator viral contamination levels estimated in other studies.	Mean log reduction ranged from 1.25-4.64 log $TCID_{50}$ for sebum-soiled facepieces and 0.08-4.40 log $TCID_{50}$ for sebum-soiled straps.
Ultraviolet irradiation (UV)	Ultraviolet light with a primary wavelength of 254 nm (UV-C) Custom-made chamber of 91 cm × 31 cm × 64 cm high chamber. Two 15-Watt T-150 254 nm UV-C lamps in a reflective housing lined with black felt. UV doses from 120–950 J/cm^2 (coupons) and 590-2360 J/cm^2 (straps)	• Four models of N95 (3M, Gerson, Middleboro, Kimberley & Clark) - 37mm coupons were punched + 2 straps from each respirator Determination of filter penetration and flow resistance before and after exposure to UV	Lindsley, et al, 2015 [21]	• Study found dramatic differences in the bursting strength of the layered materials that make up the respirator • Study tested exterior of respirators, not interior but estimates this would require a high dose UV to penetrate to inside layers and would require testing the specific respirator used	UV exposure led to small increase in particle penetration (1.25%) at UV doses from 120–950 J/cm2 with little to no effect on flow resistance. Some degradation of the elastic straps used in different respirator designs when exposed to higher UV levels.

Ultraviolet irradiation (UV)	Mineralight® XX-20S 20-W UV bench lamp Average UV output of 4.2 ± 0.0 mW/cm2 Effective UVGI dose of 1 × 106 µJ/cm2 A laboratory-scale UVGI was built for the purpose	• N95 – 15 models (3M, Kimberley Clark, Moldex, Precept, Gerson, Sperian, US Safety, Alpha Protect, Prestige Ameritech) - Influenza; MERS-CoV, SARS-CoV-1. Presence of either artificial saliva or artificial skin oil 50% tissue culture infectious dose per mL (TCID50/mL)	Heimbuch, 2019 [23]	• Decontamination the presence of soiling agents on N95 can be effective but is dependent on the material being treated. • The shapes of respirators, their materials, and UV light arrangement can significantly affect decontamination efficacy	UV dose of 1 J/cm2 was found to be the minimum dose providing maximum disinfection Up to 20 cycles of UV treatment (approximately 1 J/cm2 per cycle) does not have a meaningfully significant effect on, fit, air flow resistance, or particle
Ultraviolet irradiation (UV)	UV Bench Lamp (UV-C, 254 nm, 40 W), Model XX-40S (UVP, LLC, Upland, CA). The UV intensity; mean of 27 measurements over the rectangular area used at the surface of the hood using a UVX Digital Radiometer with a model UVX-25 Sensor (254 nm filter) 45-min exposure at intensity 1.8 mW/cm2 (UVP, LLC, Upland, CA).	• N95 (six models) •Study evaluated physical appearance, odour, and laboratory filtration performance. • 8130 Automated fit test (NaCl aerosol) •Filter air flow resistance	Bergman et al, 2010[24]	• No observable physical changes	Control and decontamination treatment groups, had mean %P < 4.01%, which is similar to penetration levels found in untreated
Ultraviolet irradiation (UV)	Sterigard cabinet flow cabinet (The Baker Company, Sanford, Maine fitte with 40 W UV-C Bulb, intensity 1.8mW/cm2, 245nm Total exposure 30min (15 min each FFR side)	• FFR (6 model, 3M, Moldex, Kimberley Clark) - Phase 1: fit test to identify fit factor Phase 2: Physically examined for degradation and smell	Viscusi et al, 2011[26]	• Each FFR model is constructed uniquely, which may affect the impact that decontamination has on that model. • No physical damage • One subject reported strong odour • The MDFF were lower than the control depending on the model	No significant changes in fit, odour detection, comfort, or donning difficulty with each of the six models.

		Multidonning fit-test procedure – metal nose bridge was return to the original position – multidonning fit factor (MDFF) 10 subjects x 6 FFR models x 4 treatment Subjective questionnaires Standard visual analog scale			
Moist heat incubation	Caron model 6010 laboratory incubator (Marietta, OH) 30-min incubation at 60°C, 80% relative humidity Following the first incubation, the samples were removed from the incubator and air-dried overnight. Following the second and third incubations, samples were removed from the incubator and air-dried for 30 min with the aid of a fan.	• N95 (six models) •Study evaluated physical appearance, odour, and laboratory filtration performance. • 8130 Automated fit test (NaCl aerosol) •Filter air flow resistance Control group: 4-hour 3x submersion in deionized water	Bergman et al, 2010[24]	• Some samples to experience partial separation of the inner foam nose cushion from the FFR Possible sparking during microwave heating caused by the metallic FFR nose bands.	Control and decontamination treatment groups, had mean %P < 4.01%, which is similar to penetration levels found in untreated
Moist Heat Incubation	15 min incubation at 60 °C (upper temp. limit), 80% relative humidity in a Caron model 6010 laboratory incubator	• Surgical N95 (fluid resistance N95): 3M 1860, 3M 1870, KC PFR95- 270 (46767) • Respirator fit AND face seal leakage were measured with 10 participants using PORTACOUNT® Plus Model 8020A Respirator Fit Tester with an N95 Companion™ Model 8095 accessory	Bergman et al, 2011[25]	• Study utilized an abbreviated fit test protocol, only three FFR models and a small group (n = 10) of respirator test subjects per FFR model. • Subjects wore their FFRs for a shorter total test time of ~5 min (which includes the 3 min acclimatization period) using the modified protocol compared to the standard OSHA-accepted protocol (~12 min) • MHI decontamination cycle was shorter than previous study.	Slight separation of the inner foam nose cushion was not exacerbated with multiple MHI treatments compared to a single treatment. Respirator fit was maintained throughout three MHI decontamination cycles alternating with four donning/doffing cycles. Face seal leakage value was maintained at below 1%

Moist heat incubation	Caron Model 6010 laboratory incubator (Marietta, Ohio= 60°C, 30 min, 80% relative humidity.	• FFR (6 model, 3M, Moldex, Kimberley Clark) - Phase 1: fit test to identify fit factor Phase 2: Physically examined for degradation and smell Multidonning fit test procedure – metal nose bridge was return to the original position – multidonning fit factor (MDFF) 10 subjects x 6 FFR models x 4 treatment Subjective questionnaires Standard visual analog scale	Viscusi et al, 2011[26]	• Each FFR model is constructed uniquely, which may affect the impact that decontamination has on that model. • Any physical damage or strong odour • The MDFF were lower than the control depending on the mode	No significant changes in fit, odour detection, comfort, or donning difficulty with each of the six models.

TCID50 = 50% tissue culture infectious dose

References

1. Tran, K., Cimon, K., Severn, M., Pessoa-Silva, C. L., & Conly, J. (2012). Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. PloS one, 7(4). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3338532/
2. Infection prevention and control during health care when novel coronavirus (nCoV) infection is suspected. Interim Guidance. Geneva: World Health Organization; 2020.
3. Standard precautions in health care. Geneva: World Health Organization; 2007 (accessed 2 April 2020).
4. Infection prevention and control of epidemic-and pandemic-prone acute respiratory infections in health care. Geneva: World Health Organization; 2014 (accessed 27 February 2020).
5. Telemedicine: opportunities and developments in Member States: report on the second global survey on eHealth. Geneva: World Health Organization; 2009 (Global Observatory for eHealth Series, 2 (accessed 27 February 2020).
6. Home care for patients with COVID-19 presenting with mild symptoms and management of their contacts: interim guidance. Geneva: World Health Organization; 2020 (accessed 27 February 2020).
7. Advice on the use of masks in the community, during home care, and in health care settings in the context of COVID-19: interim guidance (accessed 27 February 2020).
8. van Doremalen N, Bushmaker T, Morris DH et al. Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. N Engl J Med. 2020 Mar 17. doi: 10.1056/NEJMc2004973.
9. Laboratory biosafety guidance related to coronavirus disease 2019 (COVID-19). Geneva: World Health Organization; 2020 (accessed 2 April 2020).
10. MacIntyre, C. R., Seale, H., Dung, T. C., Hien, N. T., Nga, P. T., Chughtai, A. A., Rahman, B., Dwyer, D. E., & Wang, Q. (2015). A cluster randomised trial of cloth masks compared with medical masks in healthcare workers. BMJ Open, 5(4), e006577. https://doi.org/10.1136/bmjopen-2014-006577
11. Neupane, B. B., Mainali, S., Sharma, A., & Giri, B. (2019). Optical microscopic study of surface morphology and filtering efficiency of face masks. PeerJ, 7, e7142. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6599448/
12. Chughtai, A. A., Seale, H., & MacIntyre, C. R. (2013). Use of cloth masks in the practice of infection control—evidence and policy gaps. Int J Infect Control, 9(3).
13. Furuhashi, M. (1978). A study on the microbial filtration efficiency of surgical face masks--with special reference to the non-woven fabric mask. The Bulletin of Tokyo Medical and Dental University, 25(1), 7–15. https://www.ncbi.nlm.nih.gov/pubmed/343940
14. Viscusi, D., Bergman, M., Elmer, B., & Shaffer, R. (2009). Evaluation of Five Decontamination Methods for Filtering Facepiece Respirators. The Annals of Occupational Hygiene. https://doi.org/10.1093/annhyg/mep070
15. Heimbuch, B. K., Wallace, W. H., Kinney, K., Lumley, A. E., Wu, C.-Y., Woo, M.-H., & Wander, J. D. (2011). A pandemic influenza preparedness study: Use of energetic methods to decontaminate filtering facepiece respirators contaminated with H1N1 aerosols and droplets. American Journal of Infection Control, 39(1), e1–e9. https://doi.org/10.1016/j.ajic.2010.07.004
16. Lore, M., Heimbuch, B. K., Brown, T. L., Wander, J. D., & Hinrichs, S. (2011). Effectiveness of Three Decontamination Treatments against Influenza Virus Applied to Filtering Facepiece Respirators. The Annals of Occupational Hygiene. https://doi.org/10.1093/annhyg/mer054
17. Feldmann, F., Shupert, W. L., Haddock, E., Twardoski, B., & Feldmann, H. (2019). Gamma Irradiation as an Effective Method for Inactivation of Emerging Viral Pathogens. The American Journal of Tropical Medicine and Hygiene, 100(5), 1275–1277. https://doi.org/10.4269/ajtmh.18-0937
18. Final Report for the Bioquell Hydrogen Peroxide Vapor (HPV) Decontamination for Reuse of N95 Respirators. Prepared by Battelle Columbus, Ohio. Prepared under Contract No. HHSF223201400098C. Study Number 3245. Prepared for the FDA. July 2016. Accessed, March 26, 2020 from https://www.fda.gov/media/136386/download
19. Reuse of FFP2 masks. (2020). The Dutch National Institute for Public Health and the Environment (RIVM National Institute for Public Health and the Environment). https://www.rivm.nl/en/documenten/reuse-of-ffp2-masks
20. Vo, E., Rengasamy, S., & Shaffer, R. (2009). Development of a Test System to Evaluate Procedures for Decontamination of Respirators Containing Viral Droplets. Applied and Environmental Microbiology, 75(23), 7303–7309. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2786399/
21. Lindsley, WG, SB Martin, Jr., RE Thewlis, K Sarkisian, JO Nwoko, KR Mead and JD Noti (2015). Effects of Ultraviolet Germicidal Irradiation (UVGI) on N95 Respirator Filtration Performance and Structural Integrity. J Occup Environ Hyg 12(8): 509-17. https://www.ncbi.nlm.nih.gov/pubmed/25806411
22. Mills, D., Harnish, D. A., Lawrence, C., Sandoval-Powers, M., & Heimbuch, B. K. (2018). Ultraviolet germicidal irradiation of influenza contaminated N95 filtering facepiece respirators. American Journal of Infection Control, 46(7), e49–e55. https://doi.org/10.1016/j.ajic.2018.02.018
23. Heimbuch, B. K., & Harnish, D. (2019). Research to Mitigate a Shortage of Respiratory Protection Devices During Public Health Emergencies. Applied Research Associates. https://www.ara.com/sites/default/files/MitigateShortageofRespiratoryProtectionDevices.pdf
24. Bergman, M. S., Viscusi, D. J., Heimbuch, B. K., Wander, J. D., Sambol, A. R., & Shaffer, R. E. (2010). Evaluation of multiple (3-cycle) decontamination processing for filtering facepiece respirators. Journal of Engineered Fibers and Fabrics, 5(4), 155892501000500405. https://journals.sagepub.com/doi/abs/10.1177/155892501000500405

25. Bergman, M. S., Viscusi, D. J., Palmiero, A. J., Powell, J. B., & Shaffer, R. E. (2011). Impact of three cycles of decontamination treatments on filtering facepiece respirator fit. *Journal of the International Society of Respiratory Protection*, *28*(1), 48. https://onlinelibrary.wiley.com/doi/abs/10.1002/ajim.20970?casa_token=X0uvnWbRNawAAAAA:AXUI-ZxhnoTx9FvTnQOwfNlwX3_f06Vy5CQEuPw_XNktLwEDTmarC-cuzHX0HaRczwlMTrIN7CSmyw
26. Viscusi, D. J., Bergman, M. S., Novak, D. A., Faulkner, K. A., Palmiero, A., Powell, J., & Shaffer, R. E. (2011). Impact of three biological decontamination methods on filtering facepiece respirator fit, odour, comfort, and donning ease. *Journal of occupational and environmental hygiene*, *8*(7), 426-436. https://www.tandfonline.com/doi/abs/10.1080/15459624.2011.585927

Acknowledgements

This document was developed in consultation with WHO Health Emergencies Program (WHE) Ad-hoc Experts Advisory Panel for Infection Prevention and Control (IPC) Preparedness, Readiness and Response to COVID-19 and other international experts including (alphabetical order):

Elizabeth Bancroft, Centers for Disease Control and Prevention, Atlanta, GA, USA; Gail Carson, ISARIC Global Support Centre, Director of Network Development, Consultant in Infectious Diseases, and Honorary Consultant with Public Health England, United Kingdom; John M Conly, Department of Medicine, Microbiology, Immunology and Infectious Diseases, Calvin, Phoebe and Joan Snyder Institute for Chronic Diseases, Faculty of Medicine, University of Calgary, Calgary, Canada; Barry Cookson, Division of Infection and Immunity, University College London, United Kingdom; May Chu, Clinical Professor Colorado School of Public Health, USA; Nizam Damani, UK; Katherine Defalco, Infection Control Expert, Public Health Agency of Canada; Kathleen Dunn, Manager, Healthcare-Associated Infections and Infection Prevention and Control Section, Centre for Communicable Disease Prevention and Control, Public Health Agency of Canada; Alison Holmes, Head of IPC, Imperial College, London, UK; Joost Hopman, Head of IPC and Quality, Radboud University Medical Center, Nijmegen, The Netherlands; Paul Hunter, University of East Anglia, Norwich, UK¸Fernanda Lessa, Epidemiologist, Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, Atlanta, GA, USA; Dale Fisher, National university of Singapore, Singapore; Anna Sara Levin, Hospital das Clinicas, Faculdade de Medicina, University of Sao Paulo, Brazil; Moi Lin Ling, Director, Infection Control Department, Singapore General Hospital, Singapore, and President of Asia Pacific Society of Infection Control; Mary-Louise McLaws, University of New South Wales, Australia; Shaheen Mehtar, Infection Control Africa Network, South Africa; Mauro Orsini, National IPC Program, Ministry of Health, Santiago, Chile ; Didier Pittet, Director, Infection Control Program and WHO Collaborating Centre on Patient Safety, University of Geneva Hospitals, and Faculty of Medicine, Geneva, Switzerland; Mathias Pletz, Professor for Infectious Diseases, Jena University Hospital, Jena, Germany; Fernando Otaiza O'Ryan, Head, National IPC Program, Ministry of Health, Santiago, Chile, Ben Park, Centers for Disease Control and Prevention, Atlanta, GA, USA.; Molly Patrick, Centers for Disease Control and Prevention, Atlanta, GA, USA.; Diamantis Plachouras, Unit of Surveillance and Response Support, European Centre for Disease Prevention and Control, Solna, Sweden; Wing Hong Seto, Department of Community Medicine, School of Public Health, University of Hong Kong, China, Hong Kong Special Administrative Region; Mitchell J. Schwaber, Director, National Center for Infection Control Israel Ministry of Health; Nandini Shetty, Consultant Microbiologist, Reference Microbiology Services, Health Protection Agency, Colindale, United Kingdom; Nalini Singh, Professor of Pediatrics, Global Health, Epidemiology, The George Washington University, Washington, DC, USA; Rachel M. Smith, Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, Atlanta, GA, USA; Mark Sobsey, University of North Carolina, Chapel Hill, USA; Paul Tambyah, Singapore; Sara Tomczyk, Robert Koch Institute;

From WHO we also thank:
Benedetta Allegranzi, Gertrude Avortri, April Baller, Hanan Balkhy, Anjana Bhushan, Richard Brown, Alessandro Cassini, Ana Paula Coutinho Rehse, Carmem Da Silva, Nino Dal Dayanguirang, Janet Diaz, Sergey Eremin, Rebeca Grant, Tom Grein, Jonas Gonseth, Ivan Ivanov, Pierre Clave Kariyo, Ying Ling Lin, Takeshi Nishijima, Mekdim Ayana, Madison Moon, Maria Clara Padoveze, Kevin Babila Ousman, Guillaume Queyras, Alice Simniceanu, Maha Tallat Ismail, Anthony Twywan, Joao Paulo Toledo, Pillar Ramon-Pardo, Sharon Salmon, Masahiro Zakoji, Bassim Zayed, Nahoko Shindo, Fred Urlep, Maria Van Kerkhove and Bassem Zayed.

WHO continues to monitor the situation closely for any changes that may affect this interim guidance. Should any factors change, WHO will issue a further update. Otherwise, this interim guidance document will expire 2 years after the date of publication.

WHO reference number: WHO/2019-nCov/IPC_PPE_use/2020.3