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 Removal criteria and precautions: • 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. Methods (not validated) for respirator reprocessing (see Annex 1): • vapor of hydrogen peroxide • ethylene oxide • UV radiation lamp	Limitations/ Risks: • 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 Disposal criteria and precautions: • 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	Risks: • Disposable laboratory coats are less durable than gowns, so there is a risk of damage during the patient care Removal criteria and precautions: • 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	Risks: • Plastic aprons do not protect arms and the back of the torso, which can be exposed to splashes Removal criteria and precautions: • 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
		iii) Reusable (washable) patient gowns, reusable (washable) laboratory coats (see above recommendations for laundry of gowns)	Risk • Design and thickness may not be compatible with the full protection of the torso or arms Removal criteria:	Potentially 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
			• 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% H_2O_2) +	• 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/cm² 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/cm²	• 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/cm² (coupons) and 590-2360 J/cm² (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

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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.

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