**Supplementary material 04**

**Table 3. Decontamination protocols for the 17 studies included:**

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| **Method** | **Study** | **Protocol** | **Commercial mask model** | **Target microorganism** | **Results and conclusions of the study authors** |
| **1. Hydrogen Peroxide** | | | | | |
|  | Viscusi et al, 200921 | STERRAD® 100S H2O2 Gas Plasma Sterilizer (Advanced Sterilization Products, Irvine, CA, USA), single 55-min standard cycle. FFRs and a chemical indicator placed in an individual Mylar/Tyvekä self-seal pouch. FFRs were shipped to and from a commercial facility specializing in low-temperature sterilization methods and were tested within 72h of receipt. | Random sampling from those N95 FFR models present in the US Strategic National Stockpile (SNS) and from models commercially available at the time of the study and included because they were considered likely to be more resistant to filtration efficiency degradation and thus offer a more rigorous basis of comparison. | None. | Metallic nosebands were slightly tarnished and visibly not as shiny when compared with their as-received counterparts. |
|  | Salter et al, 201022 | (1) Hydrogen peroxide 3%: Three FFRs of each model were submerged in liquid decontamination agents in a chemical fume hood for 30 min at room temperature. A volume of 200 mL of decontaminant per FFR was used. After a 30-min soak, the FFRs were removed from the solutions, placed on trays, and allowed to off-gas for 18 hr in a chemical fume hood. Following the off-gassing period, 10 14-mm-diametersamples were punched from areas equally spaced on each respirator and separately weighed in 20-mL glass scintillation vials. In addition, the straps, nose cushions, and metal nosepieces were cut into∼12-mm pieces and separately weighed in scintillation vials.  (2) Vaporized hydrogen peroxide (Sterrad 100S System): Triplicate FFRs of each model, packaged individually in sterilization pouches that contained sterilization indicator strips, were exposed to Vaporized hydrogen peroxide for 55 min at 45–55 Cina STERRAD 100S system (Advanced Sterilization Products, Irvine, Calif.) according to supplier directions. Following the sterilization cycle, 14-mm-diameter samples were punched from areas equally spaced on each respirator and weighed in a 20-mL scintillation vial. In addition, the straps, nose cushions, and metal nosepieces were cut into ∼ 12-mm pieces and separately weighed in vials. Samples were analyzed by IBT, and pentane extracts were analyzed by GC-MS. | NIOSH, FDA-approved N95, Surgical FFR, NIOSH-approved N95 and Particulate FFR | None. | (1) Similar amounts of oxidant remained after treatment with 3% hydrogen peroxide on all FFRs except S3, on which no oxidant was detected.  (2) The S1, S2, P1, and P2 models treated with VHP retained∼3 times as much oxidant as the other two models. |
|  | Bergman et al, 201023 | **Multiple (3-Cycle) of:**  (1) Hydrogen peroxide gas plasma (HPGP): STERRAD® 100S H2O2 Gas Plasma Sterilizer (Advanced Sterilization Products, Irvine, CA), 59% H2O2 cycle time ~55-min (short cycle); 45°C–50°C. Samples were packaged in Steris Vis-U-All Low Temperature Tyvek® /polypropylene–polyethylene Heat Seal Sterilization pouches (six samples per pouch with a chemical indicator strip). Samples were processed at a university medical center (one treatment per day in three consecutive days). The same pouch was used for all three treatments.  (2) Hydrogen Peroxide Vapor (HPV): Room Bio-Decontamination Service (RBDS™, BIOQUELL UK Ltd, Andover, UK), which utilizes four portable modules: the Clarus® R HPV generator (utilizing 30% H2O2), the Clarus R20 aeration unit, an instrumentation module and a control computer. The Clarus® R was placed in a room (64 m3). The HPV concentration, temperature and relative humidity within the room were measured by the instrumentation module and monitored by a control computer situated outside the room. Room concentration= 8 g/m3, 15- min dwell, 125-min total cycle time. FFRs were hung on a string stretching across the length of room. Following HPV exposure, the Clarus R20 aeration unit was run overnight inside the room to catalytically convert the HPV into oxygen and water vapor. The treatments were performed in three consecutive days (one treatment per day). Biological indicators containing *Geobacillus stearothermophilus* spores were placed in five separate locations inside the room and a 6-log spore reduction was measured following the 3X treatment.  (3) Liquid hydrogen peroxide\* (LHP): 30-min submersion in 6% (one part hydrogen peroxide to four parts of deionized water) solution of hydrogen peroxide. Manufacturing specification: 30% hydrogen peroxide; Cat No. H325-500, CAS Nos. 7722-84-1, 7732-18-5, 12058-66-1 (Fisher Scientific, Fair Lawn, NJ). \*Liquid submersion methods. Following each exposure, FFRs were hung on a laboratory peg board and dried for a minimum of 16 hours with the aid of a fan before repeating the treatment or performing the laboratory aerosol filtration test. | Six models [three N95 FFR models (N95-A, N95-B, and N95-C) and three surgical N95 respirator models (SN95-D, SN95-E, and SN95-F)] | None. | (1) In this study, the 3XHydrogen peroxide gas plasma (HPGP) treatments resulted in mean penetration levels > 5% for four of the six FFR models. Of the 36 samples that underwent HPGP processing, nine samples had % penetration levels > 5%.  (2) 3X Hydrogen Peroxide Vapor (HPV) did not cause any observable physical changes to the FFRs.  (3) For those models which had staples (N95-B, N95-C, SN95-E and SN95-F), liquid hydrogen peroxide treatment caused staples to oxidize to varying degrees; this effect was not observed following the 3X HPGP and HPV treatments. |
|  | Cheng et al, 202024 | Attempt to disinfect N95 respirator using SteraMist™ Binary Ionization Technology® (BIT™) solution delivered through SteraMist™ Surface Unit, which was registered with the U.S. Environmental Protection Agency. The main constituent contains 7.8% H2O2 solution which converts to ionized H2O2 (iHP) after passing through a cold plasma arc, and moving like a gas throughout the surface of N95 respirator. The by-product of iHP is oxygen and water in form of humidity. The experiment was conducted a well-ventilated room with 6 air-change-per-hour inside the biosafety level-2 microbiology laboratory with operator wearing coverall protection gown. | 3M1870 and 3M1860s | Influenza A virus subtype H1N1. | The virus was eluted from the N95 respirators for viral culture in Madin-Darby Canine Kidney (MDCK) cell line. Cytopathic changes of MDCK cells were observed daily for 7 days by light microscopy. All iHP-treated pieces of N95 respirators did not demonstrate cytopathic changes suggestive of presence of life influenza A virus. They were sub-cultured to MDCK cell line again for another 7 days for cytopathic changes observation. No sign of cytopathic changes was observed after 7 days and it was finally confirmed by a negative influenza A antigen detection by an immunofluorescence staining procedure. This experiment showed that the spray of iHP could kill influenza A virus, at moderate to high level of inoculum. Influenza A virus was chosen because it is an enveloped RNA virus which has similar virological characteristics of coronavirus. Healthcare workers should be reminded not to reuse the N95 respiratory immediately after disinfection. In our experiment, the level of H2O2 on the inner surface of the N95 respirator was 0.6ppm (lower than the safety limit of <1ppm) at 2 hour and undetectable at 3 hour. |
|  | Fisher et al, 202025 | Vaporized hydrogen peroxide (VHP) - Plates with fabric and steel discs were placed into a Panasonic MCO-19AIC-PT (PHC Corp. of North America Wood Dale, IL) incubator with VHP generation capabilities and exposed to hydrogen peroxide (approximately 1000 ppm). The exposure to VHP was 10 minutes, after the inactivation of the hydrogen peroxide, the plate was removed and 1 mL of cell culture medium was added. | AOSafety N9504C respirators (Aearo Company Southbridge, MA). | HCoV-19 nCoV-WA1-2020 (MN985325.1) was the SARS-CoV-2 strain used in the comparison | Vaporized hydrogen peroxide yielded extremely rapid inactivation both on N95 and on stainless steel. Filtration performance of the N95 respirator was not markedly reduced after a single decontamination. The VHP-treated masks retained comparable filtration performance to the control group after two rounds of decontamination, and maintained acceptable performance after three rounds. |
|  | Schwartz et al, 202026 | The Hydrogen Peroxide Vapor run consisted of the following five stages: Conditioning, Pre‐gassing, Gassing, Gassing Dwell and Aeration. The existing RBL Hydrogen Peroxide Vapor standard operating procedure (SOP) was employed and requires that the processing room attain 480+ ppm level of Hydrogen Peroxide Vapor with a “Gassing” time of 25 minutes and a “Gassing Dwell” time of 20 minutes. At the end of a cycle, during the aeration stage, fresh air is introduced into the room to increase the rate of catalytic conversion of hydrogen peroxide vapor into oxygen and water. This procedure leaves no residue other than water. When sufficient time had passed, we used a PortaSens II™ sensor to ensure hydroen peroxide levels were below the OSHA Permissible Exposure Limit3 (PEL) of 1.0ppm prior to entering the room. | *Geobacillus stearothermophilus* spores | 3MTM 1860 N95 | At approximately 4 hours, the levels decreased below the PortaSens IITM level of detection (0 ppm). Three individuals did a qualitative smell test to determine if there were any noticeable odors and none were detected. |
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| **2. Ultraviolet germicidal irradiation** | | |  |  |  |
|  | Viscusi et al, 200921 | FFRs placed on the working surface of a 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 cm−2). Fifteen-minute exposure to each side (outer and inner), 176–181 mJ cm−2 exposure to each side of FFR | Random sampling from those N95 FFR models present in the US Strategic National Stockpile (SNS) and from models commercially available at the time of the study and included because they were considered likely to be more resistant to filtration efficiency degradation and thus offer a more rigorous basis of comparison. | None. | No visible changes were observed for all samples. |
|  | Salter et al, 201022 | Ultraviolet light (254 and 302 nm,∼2.7X105J/m2. Triplicate 38-mm-diameter circles were cut from each FFR model. A multi-wavelength, 8-watt lamp (Ultra Violet Products) was used to expose triplicate samples of each FFR model to UV light. Samples were placed 1 inch from the lamp source and were irradiated with 4.0 mW/cm2 of UV-B (302 nm) and 3.4 mW/cm2 UV-C (254 nm) for 1 hr each. A UV meter (Ultra Violet Products) was used to measure irradiance. After exposure, samples were weighed in 20-mL glass scintillation vials and extracted with pentane as described for liquid decontaminants. | NIOSH, FDA-approved N95, Surgical FFR, NIOSH-approved N95 and Particulate FFR | None. | UV irradiation produced the greatest number of unique peaks; however, many of these appear to be constituents of the pentane solvent. |
|  | Bergman et al, 201023 | **Multiple (3-Cycle) of:**  UV Bench Lamp (UV-C, 254 nm, 40 W), Model XX-40S (UVP, LLC, Upland, CA). 45-min exposure at intensity 1.8 mW/cm2 (note: one 45-min continuous exposure constitutes the 3X cycle). Test tube racks were placed beneath both ends of the lamp to lift the lamp ~ 25 cm from the working surface of a laboratory hood. The UV intensity was reported as the 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) (UVP, LLC, Upland, CA). Only the exteriors of the FFRs were exposed. The duck bill and flat fold style FFRs were placed over beakers to facilitate exposure to the FFR surface | Six models [three N95 FFR models (N95-A, N95-B, and N95-C) and three surgical N95 respirator models (SN95-D, SN95-E, and SN95-F)] | None | The 3X UVGI treatment had similar mean % penetration to 1X treated samples tested previously for the same six models (no visible changes were observed for all samples). |
|  | Fisher et al, 201129 | The αIFM was used to categorize FFRs as most shielded (≤5%), moderately shielded (>5% but ≤30%) and least shielded (>30%). UV-C decontamination of MS2 was determined for FFR coupons excised from two FFR models from each shielded category. For models C and F, the MS2-contaminated coupons were exposed to UV-C (25 ± 1.0Wm-2) for combined bidirectional treatment times of 1, 2, 4 and 10 min (0.5, 1, 2, 5 min per side). Only the 10-min exposure was performed on model A because of a low αIFM. A supplemental experiment for Model A was performed using a bidirectional treatment time of 5 h. Specific UV-C doses (J m-2) to the IFM (DIFM) doses ranging from 38 to 4707 J m-2. | The six FFR models, used in this study, are NIOSH-approved N95 FFRs: Cardinal N95‐ML (Model A), Wilson SAF‐T‐FIT® Plus (Model B), 3MTM8210 (Model C), 3MTM1860 (Model D), Kimberly‐Clark PFR95‐174 (Model E) and 3MTM1870 (Model F) | MS2 bacteriophage. | DIFMs and measured log reductions (LR) of MS2 of Models A, C and F for the bidirectional treatment times of 1, 2, 4 and 10 min: The supplied dose at each treatment time was the same for each FFR model, but the DIFM varied because of the model-specific αIFM values. LRs within a given treatment time differed among the FFR models. A 10-min treatment (the only treatment condition with data for all three models) produced LRs of 0.1 (model A), 2.9 (model C), and >4.8 (model F). Across models A, C and F and within models C and F, LR increased with increasing DIFMs.  The calculated treatment times and log reductions (LR) for models B, D and E: The treatment times required to reach the targeted DIFMs of 300, 1000 and 3000 J m-2 differed for each model. LRs were statistically different among the models for DIFMs of 300 J m-2 (P=0.006) and 3000 J m-2 (P<0.001). The results for the 1000 J m-2 treatment among the models were statistically similar (P=0.79). LRs increased with increased DIFM for models B (P<0.001) and D (P<0.001). The LRs reported for model E did not differ significantly among all three doses (P=0.18). Exposure times required to achieve a DIFM of 1000 J m-2 for each model-specific αIFM with a UV-C irradiance of 25 W m-2, which ranged from 266 to 2 min.. LRs for the approximate 1000 J m-2 DIFM ranged from 2.86 to 3.59,with the lowest LR value (2.86) corresponding to the lowest DIFM (917 J m-2). |
|  | Heimbuch et al, 201130 | A 120-cm, 80-W UV-C (254 nm) lamp (Ultraviolet Products, Upland, CA) was adjusted to a height of 25 cm. Output from the lamp was measured using a radiometer (Ultraviolet Products). The range of UV irradiation to which the FFR was exposed varied from 1.6 mW/cm2 to 2.2 mW/cm2.The exterior surface of H1N1-contaminated FFRs was irradiated for 15 minutes, which provided an average dose of 18 kJ/m2 | 6 FFR models (3 particulate, designated P1-P3, and 3 surgical, designatedS1-S3). | H1N1 influenza virus. | Provided an average >4-log reduction of viable H1N1 influenza virus against both the droplet and aerosol challenges for all 6 FFRs. No other FFRs showed noticeable deterioration or deformation. |
|  | Viscusi et al, 201131 | FFRs placed on a laboratory stand inside a Sterilgard III laminar flow cabinet (The Baker Company, Sanford, Maine) fitted with a 40W UV-C bulb, Intensity 1.8 mW/cm2 measured with a UVX Digital Radiometer with MODEL UVX-25 sensor (254 nm filter) (VWR Lab Shop, Batavia, Ill.). Total exposure was 30 min (15 min each FFR side) | (1) 3M 8000, (2) 3M 8210, (3) Moldex 2200, (4) 3M 1860, (5) 3M 1870, and (6) Kimberly Clark PFR95–270. | None. | Test technicians did not report any unusual or strong odor from FFRs following the decontamination method. |
|  | Lore et al, 201220 | A 126- (L) X 15.2- (W) X 10.8-cm (H), dual-bulb, 15-W UV-C(254-nm wavelength) lamp (Ultraviolet Products, Upland, CA, USA) was placed in a Labgard class II, type A2, laminar flow cabinet (NuAire, Inc., Ply-mouth, MN, USA) set to a height 25 cm above the cabinet’s working surface. Measured by a UVX digital radiometer (UVP Inc., Upland, CA, USA), the lamp’s UV-C wavelength irradiance ranged between1.6 mW cm-2 and 2.2 mW cm-2 | 3M models 1860s and 1870 | Influenza A H5N1 virus. | This study showed that the decontamination method (ultraviolet germicidal irradiation) satisfactorily decontaminated the 3M1860s and 1870 FFRs as measured by a virus culture method. Within the constraints of the experiment, the three methods were all completely effective for the decontamination of FFRs as assessed by a culture method. |
|  | Lindsley et al*,* 201532 | Respirator coupons and straps were exposed to ultraviolet light with a primary wavelength of 254 nm (UV-C) in a custom-made 91 cm × 31 cm × 64 cm high chamber. The chamber was fitted with two 15 Watt T-150 254 nm UV-C lamps in a reflective housing and lined with black felt to minimize reflections. UV-C irradiance was measured using a radiometer (ILT-1700, International Light Technologies, Peabody, MA). Eight respirator coupons were placed on a horizontal surface so that the coupons and the sensor were approximately 6.2 cm below the lamps. A section of filter cassette was attached to the sensor head of the radiometer so that the irradiation of the sensor head would match that of the coupons. Calibration measurements using the radiometer showed that the irradiance of the eight positions varied by no more than ±4%. Samples were also rotated once among the positions when they were flipped so that the mean exposures for the different groups were within ±0.1% of each other. The respirator coupons were exposed to 0, 120, 240, 470, or 950 J/cm2 of UV-C on each side (one side was exposed at a time). To expose the respirator straps, eight straps were laid side-by-side horizontally on a support surface at the same height as the sensor and each side was exposed to 0, 590, 1180, or 2360 J/cm2 in a similar manner to the coupons. Temperature and humidity in the chamber were monitored using a humidity and temperature transmitter (HMT330, Vaisala, Helsinki, Finland). The mean temperature during coupon exposures was 27°C (SD 1.7) and the mean relative humidity was 25% (SD 6.5). The exposure system was controlled using a custom-written computer program (LabVIEW 2013, National Instruments, Austin, TX) | 3M-1860, 3M-9210, Gerson-1730 and Kimberly-Clark-46727. | None. | Ultraviolet germicidal irradiation had a small effect on filtration performance and essentially no effect on flow resistance at doses up to 950 J/cm2, while the structural integrity of the respirators showed a noticeable decrease at lower doses. The strength of the respirator straps was less affected by UVGI than the strength of the body material. |
|  | Mills et al*,* 201833 | The custom UVGI device was made of polished aluminum (Alloy6061-T6 and Alloy 2024-T3; OnlineMetals.com, Seattle, WA) and measuring 40-in L×16-in W×13-in H with a tunnel extension measuring 18-in×8-in W×6-in H. The polished aluminum alloys were selected because they are UV reflective surfaces that do not alter the wavelength of the reflected light. Eight 32-in 254-nm UV-Cbulbs with an irradiance of 0.39 W/cm2 at 1 m (Fresh-Aire UV; Jupiter,FL) were incorporated into the device to deliver a UV dose of 1 J/cm2 in approximately 1 minute | N95 FFR models: 3M 1860, 3M 1870, 3M VFlex 1805, Alpha Protech 695, Gerson 1730, Kimberly-Clark PFR, Moldex 1512, Moldex 1712, Moldex EZ-22, Precept 65-3395, Prestige Ameritech RP88020, Sperian HC-NB095, Sperian HC-NB295F, U.S. Safety AD2N95A. | Influenza A H1N1 virus. | Across all 180 FFRs tested, the mean UV dose per FFR was 1.1±0.1 J/cm2, the mean temperature was 21°C±2°C, and the mean relative humidity was 48%±6% within the UV device. For mucin-soiled straps, the mean viable virus recovered from UV-treated samples was statistically significantly lower than control samples for all FFR models tested except the VFlex 1805 (3MCompany, Maplewood, MN), Alpha Protech 695 (Alpha Protech, Markham Canada), Moldex EZ 22, and the U.S. Safety AD2N95A (Dentech Safety Specialists, Lenexa, KS). The log reduction values observed for all mucin-soiled FFR straps were statistically significantly lower than their respective FFR facepieces. For sebum-soiled FFR facepieces, the mean viable influenza re-covered from control surfaces was 4.10±0.56 log TCID50; for sebum-soiled FFR straps, the mean viable influenza recovered from control surfaces was 3.90±0.65 log TCID50. The mean log reduction ranged from 1.25-4.64 log TCID50 for sebum-soiled facepieces and 0.08-4.40 log TCID50for sebum-soiled straps. For sebum-soiled facepieces, the mean viable virus recovered from UV-treated samples was significantly lower than control samples for all FFR models tested. For sebum-soiled straps, the mean viable virus recovered from UV-treated samples was significantly lower than control samples for all FFR models tested except the 3M 1860, Alpha Protech, and Moldex EZ 22.The log reduction values observed for the sebum-soiled FFR straps were significantly lower than the respective FFR facepieces. |
|  | Lin et al, 201834 | An N95 FFR was placed 10 cm below a6Whandheld UV lamp (modelUVGL-58, VUP LLC, Upland, CA) that emitted a wavelength of 254nm (UVC, 18.9 mW/cm2) or 365nm (UVA, 31.2 mW/cm2). Both sides of each N95 FFR were exposed for different times -1, 2, 5, 10and20 min-in a BSC. The UV intensity was measured using a handheld laser power and energy meter (OPHIR NOVAII, model Nova II PD300-UV) and was reported as a mean of five measurements over a 10X10mm aperture with a swivel mount and a removable filter | N95 FFR (8210,3M, St. Paul, MN) | *Bacillus subtilis* Spores | This study found that UVC 254 nm had a strong decontamination effect, with a 100% bactericidal effect. No colony was recovered after exposure to UVC for as little as 5 min. However, relative survival remained above 20% after 20min of irradiation by UVA 365 nm, exponentially decaying with increased exposure time |
|  | Fisher et al, 202025 | Plates with fabric and steel discs were placed under an LED high power UV germicidal lamp (effective UV wavelength 260-285nm) without the titanium mesh plate (LEDi2, Houston, Tx) 50 135 cm from the UV source. At 50 cm the UVAB power was measured at 5 μ W/cm2 using a General UVAB digital light meter (General Tools and Instruments New York, NY). Plates were removed at 10, 30 and 60 minutes and 1 mL of cell culture medium added. | AOSafety N9504C respirators (Aearo Company Southbridge, MA). | HCoV-19 nCoV-WA1-2020 (MN985325.1) was the SARS-CoV-2 strain used in the comparison | UV inactivated SARS-CoV-2 rapidly from steel but more slowly on N95 fabric, likely due its porous nature. Filtration performance of the N95 respirator was not markedly reduced after a single decontamination. The UV-treated masks retained comparable filtration performance to the control group after two rounds of decontamination, and maintained acceptable performance after three rounds. |
|  | Liao et al, 202027 | Samples were placed into a UV sterilizer cabinet (CHS-208A), with a 254 nm, 8 W lamp, and 475 cm2 internal area. Samples were irradiated for 30 minutes and let to stand under ambient conditions for 10 minutes per cycle. Samples were either returned to the chamber for the next cycle or tested. | 3M 8210 (NIOSH N95), 4C Air, Inc. (GB2626 KN95), ESound (GB2626 KN95) and Onnuriplan (KFDA KF94). | None. | After three treatments of this method, the meltblown fabric still has characteristics similar to the initial sample. The UV-C light areal intensity distribution is not uniform inside the cabinet and its exact value needs to be measured in the future for dose determination, as the necessary radiation to inactivate SARS-CoV was previously found to be above ~3.6 J/cm2. At ten cycles, the data is in agreement with the NIOSH report, but eventually decays to 93% at twenty cycles and makes it unsuitable for N95-grade FFRs by itself. |
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| **3. Ethylene oxide** | | | | | |
|  | Viscusi et al, 200921 | Steri-Vac 5XL sterilizer (3M, St Paul, MN, USA). Single warm cycle (55°C and 725 mg l-11100% EtOgas). FFRs and a chemical indicator placed in an individual standard poly/paper pouch. EtO exposure for 1 h followed by 4 h of aeration. FFRs were shipped to and from a commercial facility specializing in low-temperature sterilization methods and were tested within 72 h of receipt. | Random sampling from those N95 FFR models present in the US Strategic National Stockpile (SNS) and from models commercially available at the time of the study and included because they were considered likely to be more resistant to filtration efficiency degradation and thus offer a more rigorous basis of comparison. | None. | No visible changes were observed for all samples. |
|  | Salter et al, 201022 | Ethylene oxide (Amsco Eagle 3017): Triplicate FFRs of each model were exposed to EO in an Amsco Eagle 3017 EO sterilizer (Steris Corp., Mentor, Ohio)according to supplier directions, for 3 hr at 54◦C, followed by a12-hr aeration cycle at 54◦C. FFRs were packaged individually in sterilization pouches that contained sterilization indicators trips, which verified that the sterilizer performed adequately. Following the aeration period, each respirator was dismantled and the respiratory components were weighed. Ten 14-mm-diameter samples were punched from areas equally spaced on each respirator, placed in separate Supelco (Sigma-Aldrich, St.Louis, Mo.) 20-mL headspace vials and weighed. Straps, nose cushions, and metal nosepieces were cut into∼12-mm pieces and weighed in individual headspace vials. GC-MS analysis for EO used guidance from the ISO standard AAMI/ANSI/ISO10993–7. | NIOSH, FDA-approved N95, Surgical FFR, NIOSH-approved N95 and Particulate FFR | None. | The total ion chromatograms were examined in a window from 4.0–6.5 min because time to elution of EO itself gradually decreased from∼5.6to5.2minastrimmingaway of contaminated sections at the front of the column progressively decreased its working length. This wide time window also accommodated variations in chromatography, such as retention time shifts or peak fronting/tailing. No residual EO was detected in any of the respirators or respirator components tested. Diacetone alcohol was found in 11samples, 2-hydroxyethyl acetate (HEA) in 15 samples, and cyclohexanone in 2 samples. All 15 occurrences of HEA were on straps, and all gave an identifiable mass spectrum. However, all were measured in trace amounts (≤3 times the S/N of the baseline), so a more sensitive measurement of concentration will be needed before the significance of these traces can be evaluated. |
|  | Bergman et al, 201023 | **Multiple (3-Cycle) of:**  Amsco® Eagle® 3017 100% EtO Sterilizer/Aerator (STERIS Corp., Mentor, OH) on HI-TEMP setting (55°C); 1-hr EtO exposure (736.4 mg/L) followed by 12-hr aeration. Samples were packaged in Steris Vis-U-All Low Temperature Tyvek®/polypropylene-polyethylene Heat Seal Sterilization pouches (six samples per pouch with a chemical indicator strip). All samples were physically accommodated by a single EtO cycle. Samples were processed at a university medical center (one treatment per day in three consecutive days). The same pouch was used for all three treatments. | Six models [three N95 FFR models (N95-A, N95-B, and N95-C) and three surgical N95 respirator models (SN95-D, SN95-E, and SN95-F)] | None. | 3X EtO treatments had similar mean % penetration to 1X treated samples tested previously for the same six models (no visible changes were observed for all samples). |
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| **4. Dry heat** | | |  |  |  |
|  | Fisher et al, 202025 na temperatura de 70ºC | Plates with fabric and steel discs were placed in a 70°C oven. Plates were removed at 10, 20, 30 and 60 minutes and 1 mL of cell culture medium added. | AOSafety N9504C respirators (Aearo Company Southbridge, MA). | HCoV-19 nCoV-WA1-2020 (MN985325.1) was the SARS-CoV-2 strain used in the comparison | Heat caused more rapid inactivation on N95 than on steel; inactivation rates on N95 were comparable to UV. Filtration performance of the N95 respirator was not markedly reduced after a single decontamination. Subsequent rounds of decontamination caused a slightly lesser degree in filtration performance of the heat-treated masks. |
|  | Liao et al, 202027 | Samples were loaded into a pre-heated 5-sided heating chamber (Across International, LLC or SH-642, ESPEC) for the temperatures and times given in the main text. Dry heat was applied using the Across International vacuum heating oven under ambient conditions. In the case of the SH-642, the humidity was set the lowest value (30% RH up to 85 °C, above 85 °C the humidity is <30% but cannot be controlled). High humidity (100% RH) was simulated via sealing meltblown fabrics, or FFRs, inside a polyethylene bag with 0.3 mL of water and placing them inside the SH-642 chamber. The resting time between cycles was 10 minutes for the 75 °C and 85 °C treatments and 5 minutes for the 100 °C and 125 °C treatments. After resting, the samples were returned to the chamber to begin the next cycle. We initially chose 75 ℃ due to the presence of blanket warming ovens in hospital environments that can reach ~80 ℃. Further experiments used 85 ℃, in the event that 75 ℃ is not enough to inactivate SARS-CoV-2. | 3M 8210 (NIOSH N95), 4C Air, Inc. (GB2626 KN95), ESound (GB2626 KN95) and Onnuriplan (KFDA KF94). | None. | They performed multiple humidity experiments (30%, 70%, and 100% RH) at 85 °C (20 minutes/cycle), observing that no appreciable degradation of efficiency at any humidity level. At 85 °C, 30% RH, we observed no efficiency degradation over fifty cycles on a meltblown fabric. Using less harsh conditions (75 °C, dry heat), the results are expectedly in agreement. Testing conditions for the FFRs were under a flow rate of 85 L/min. From all the FFRs, it was observed little change in the filtration properties, as all FFRs with filtration efficiency >95% were able to retain filtration efficiencies >95% after 20 cycles of heat treatment, even in a humid environment. There is little to no change in the filtration efficiency and pressure drop up to 100 °C in low moisture conditions. However, at 125 °C, there is a sharp drop in the filtration efficiency while maintaining a constant pressure drop at around cycle 5.  Heat was a very promising scalable method that may be suitable for FFR reuse. They concluded that the highest subjectable temperature to the FFR for repeated use with ≥95% efficiency is <100 °C. At temperatures ≤85 °C, humidity does not seem to play a crucial role in the filtration properties, as FFRs tested at a near 100% RH at 85 °C were unaffected. However, as steam results in a decrease in efficiency, the humidity should be kept low if approaching 100 °C. |
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| **5. Moist heat / Pasteurization** | | |  |  |  |
|  | Bergman et al, 201023 | **Multiple (3-Cycle) of:**  Moist heat incubation / pasteurization (MHI) - 30-min incubation at 60°C, 80% RH in a Caron model 6010 laboratory incubator (Marietta, OH). 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. | Six models [three N95 FFR models (N95-A, N95-B, and N95-C) and three surgical N95 respirator models (SN95-D, SN95-E, and SN95-F)] | None. | Moist heat incubation / pasteurization (MHI) caused all SN95-E samples to experience partial separation of the inner foam nose cushion from the FFR. Two of the SN95-D samples experienced a slight melting of the head straps following the first 2-minute cycle. |
|  | Viscusi et al, 201131 | Moist heat incubation (MHI) - FFRs incubated for 30 min at 60ºC (upper temp. limit), 80% RH in a Caron Model 6010 laboratory incubator (Marietta, Ohio). Following treatment, FFRs dried overnight on a laboratory benchtop. | (1) 3M 8000, (2) 3M 8210, (3) Moldex 2200, (4) 3M 1860, (5) 3M 1870, and (6) Kimberly Clark PFR95–270. | None. | Test technicians did not report any unusual or strong odor from FFRs following the decontamination method. The 3M Model 1870 (3M, St. Paul, Minn.) samples experienced a slight separation of the inner foam nose cushion (some to a lesser or greater degree) from the FFR body following moist heat incubation (MHI) treatment. |
|  | Heimbuch et al, 201130 | For warm moist heat a 6-L sealable container (17 cm h X 19 cm wX 19 cm l) was filled with 1 L of tap water. A plastic support rack was placed in the water to isolate the FFR from the liquid. Before the test, the container was warmed in an oven to 65ºC for a minimum of 3 hours. The container was removed from the oven, and an H1N1-contaminated FFR was placed on the rack. The containers were sealed and returned to the oven for 30 minutes. | 6 FFR models (3 particulate, designated P1-P3, and 3 surgical, designatedS1-S3). | H1N1 influenza virus. | Provided an average >4-log reduction of viable H1N1 influenza virus against both the droplet and aerosol challenges for 5 FFRs, but not on the P1 FFR model. No other FFRs showed noticeable deterioration or deformation. |
|  | Lore et al, 201220 | Moist heat - A 6-l sealable container (19X19X17cm) was filled with 1l of tap water, placed in an oven (Thermo Fisher Scientific Inc., Marietta, OH, USA), and heated to 65±5°C for 3h. This allowed the liquid to reach the desired temperature prior to any decontamination tests. For testing, the container was removed from the oven and a single virus-contaminated respirator was placed on the rack. For each decontamination procedure, the container was opened and the FFR placed onto the rack with the convex surface pointed to-ward the water layer. The container was then sealed and returned to the oven for the 20-min treatment. | 3M models 1860s and 1870 | Influenza A H5N1 virus. | This study showed that the decontamination method (moist heat) satisfactorily decontaminated the 3M1860s and 1870 FFRs as measured by a virus culture method. Within the constraints of the experiment, the three methods were all completely effective for the decontamination of FFRs as assessed by a culture method. |
|  | Liao et al, 202027 | Steam: Three samples were stacked on top of a beaker with boiling water inside (at around 15 cm above the water). The samples were left on top of the beaker and steamed for ten minutes, afterwards they were left to air dry completely (to touch). Samples were either tested or placed back on top of the beaker to continue the next treatment cycle. | 3M 8210 (NIOSH N95), 4C Air, Inc. (GB2626 KN95), ESound (GB2626 KN95) and Onnuriplan (KFDA KF94). | None. | After three treatments of this method, the meltblown fabric still has characteristics similar to the initial sample. However, after five steam treatments, the efficiency has a sharp drop which continues at cycle. Filtration efficiency based on steam treatment in a meltblown after cycle 5 has a significant drop. Steam clearly had degradation in the filtration efficiency and pressure drop after ten-cycles of treatment. |
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| **6. Ethanol** | | |  |  |  |
|  | Lin et al, 201735 | 10 min submersion in 70% ethanol solution. Following each exposure, masks were placed in a laboratory chemical hood and allowed to air-dry overnight before performing the laboratory aerosol filtration test. | Not specified N95. | None. | Submersion in in 70% ethanol solution significantly changed the penetration through the N95 masks. |
|  | Lin et al, 201834 | Ethanol with various concentrations and volumes was added to the center of the surface of the N95 FFR using a pipette, the FFR was then dried in a petri dish that was placed in a biosafety cabinet(BSC)for 10 min. | N95 FFR (8210,3M, St. Paul, MN) | *Bacillus subtilis* Spores | A relative survival of 89+6% was obtained after spiking with 50% ethanol, and 73+5%was obtained after spiking with 70% ethanol. The lowest RS of 68+3% was obtained when the concentration of ethanol was 80%. The result that was obtained using 95% ethanol (RS=73+7%) was close to that obtained using 70% ethanol although the samples that were spiked with 95% ethanol sometimes yielded slightly higher values of RS than were obtained using the 80% ethanol samples. A relative survival of 59+8%was obtained in24h without decontamination. The 50%, 70%, 80%, and 95% ethanol-treated samples had relative survival values of33+8%,22+8%, 20+2%and 26+7% after24 h, respectively. Just after spiking with ethanol, the RS was found to have declined from 100% to 68-75%. When 0.4 ml (αaq=0.23) of 70% ethanol was applied, the RS fell to 22% in 24 h. The relative survival fell to 20% when 80% ethanol was used. |
|  | Fisher et al, 202025 | Fabric and steel discs were placed into the wells of one 24 well plate per time-point and sprayed with 70% ethanol to saturation. The plate was tipped to near vertical and 5 passes of ethanol were sprayed onto the discs from approximately 10 cm. After 10 minutes, 1 mL of cell culture medium was added. | AOSafety N9504C respirators (Aearo Company Southbridge, MA). | HCoV-19 nCoV-WA1-2020 (MN985325.1) was the SARS-CoV-2 strain used in the comparison | Ethanol yielded extremely rapid inactivation both on N95 24 and on stainless steel. Filtration performance of the N95 respirator was not markedly reduced after a single decontamination. Subsequent rounds of decontamination caused sharp drops in filtration performance of the ethanol-treated masks. |
|  | Liao et al, 202027 | Samples were immersed into a solution of 75% ethanol and left to air dry (hanging) and subsequently tested. | 3M 8210 (NIOSH N95), 4C Air, Inc. (GB2626 KN95), ESound (GB2626 KN95) and Onnuriplan (KFDA KF94). | None. | From the first disinfection, they can clearly noted that the ethanol drastically degraded the filtration efficiency to unacceptable levels, while the pressure drop remained comparable. |
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| **7. Isopropanol solution** | | |  |  |  |
|  | Lin et al, 201735 | 10 min submersion in 100% isopropanol solution. Following each exposure, masks were placed in a laboratory chemical hood and allowed to air-dry overnight before performing the laboratory aerosol filtration test. | Not specified N95. | None. | Treatment of N95 masks with isopropanol increased the penetration of particles larger than 50nm, owing to a reduction in the charge density of the filter. |
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| **8. Microwave** | | | | | |
|  | Viscusi et al, 200921 | Commercially available 2450 MHz, Sharp Model R-305KS (Sharp Electronics, Mahwah, NJ, USA) microwave oven with revolving glass carousel, 1100 W (manufacturer rated); 750 W ft-3 experimentally measured; 2-min total exposure (1 min each side of FFR). A paper towel was placed on the revolving glass plate for insulation to protect the FFRs from melting onto the glass plate. Using a power setting of 10 (maximum power), FFRs were placed faceseal-side down, initially, to reduce the risk of faceseal component materials melting onto the paper towel due to elevated temperatures reached by the glass plate when microwaved for 2 min. Ambient cooling of the glass plate was maintained between trials | Random sampling from those N95 FFR models present in the US Strategic National Stockpile (SNS) and from models commercially available at the time of the study and included because they were considered likely to be more resistant to filtration efficiency degradation and thus offer a more rigorous basis of comparison. | None. | All three physical samples of two different models (SN95-E and P100-I) melted partially.SN95-E filtration material melted in areas adjacent to the metallic nosebands. P100-Imelted in various locations of the inner foam face seal comfort lining. Both models were considered unwearable following treatment and subsequently were not evaluated for filter aerosol penetration or filter airflow resistance. |
|  | Bergman et al, 201023 | **Multiple (3-Cycle) of:**  Commercially available 2,450-MHz, Sharp Model R-305KS (Sharp Electronics, Mahwah, NJ) microwave oven with revolving glass carousel, 1,100 W (manufacturer rated); 750 W/ft3 experimentally measured; 2-min total exposure duration at a power setting of 10 (maximum power). Two pipette tip boxes placed side-by-side (each 11.7 cm x 8.0 cm x 5.0 cm) filled with 50 mL room-temperature tap water (~ 20°C). FFR is placed outer-side down on top of pipette-tip boxes. FFR samples dried 1 hr between each exposure. | Six models [three N95 FFR models (N95-A, N95-B, and N95-C) and three surgical N95 respirator models (SN95-D, SN95-E, and SN95-F)] | None. | 3X Microwave oven generated steam (MGS) all SN95-E samples to experience partial separation of the inner foam nose cushion from the FFR. Two of the SN95-D samples experienced a slight melting of the head straps following the first 2-minute cycle. Some concerns have been raised about possible sparking during microwave heating caused by the metallic FFR nose bands. In these experiments where water basins were placed in the microwave with the FFR, no sparking was observed. Sparking has previously been observed only one time in our laboratory when microwaving an FFR for one minute without using a water basin. |
|  | Viscusi et al, 201131 | Commercially available 2450 MHz, Sharp Model R-305KS (Sharp Electronics, Mahwah, N.J.) microwave oven with revolving glass carousel, 1100 W (manufacturer rated); 750 W/ft3 experimentally measured; 2 min total exposure at a power setting of 10 (maximum power). FFR placed outer-side down on top of two side-by-side pipette tip boxes, centered, (each box 11.7 cm × 8.0 cm × 5.0 cm) with 50 ml room temperature tap water (∼20ºC). Following treatment, FFRs dried overnight on a laboratory benchtop. | (1) 3M 8000, (2) 3M 8210, (3) Moldex 2200, (4) 3M 1860, (5) 3M 1870, and (6) Kimberly Clark PFR95–270. | None. | Test technicians did not report any unusual or strong odor from FFRs following the decontamination method. While five of the six FFR models included in this study contained metallic nosepieces (only the Moldex 2200 did not), no sparking occurred from microwaving during the MGS processing. There was no melting of an FFR or any of its components. The 3M Model 1870 (3M,St. Paul, Minn.) samples experienced a slight separation of the inner foam nose cushion (some to a lesser or greater degree)from the FFR body following microwave-generated steam (MGS) treatment. |
|  | Heimbuch et al, 201130 | For microwave-generated steam, two plastic reservoirs (4.5 cm h X 12 cm w X 8 cm l) with perforated tops (192 holes of 6 mm diameter, spaced uniformly over the entire surface) were filled with 50 mL of tap water at 22ºC-25ºC. The reservoirs were placed together, and the H1N1-contaminated FFR was set atop the center of the assembly, with the exterior of the FFR resting on the surface of the reservoir. The reservoir assembly and FFR were loaded into the center of a 1250-watt microwave oven and irradiated at full power for 2 minutes. After treatment, the reservoir was replenished with fresh tap water (22ºC-25ºC C), and the next FFR was processed. | 6 FFR models (3 particulate, designated P1-P3, and 3 surgical, designatedS1-S3). | H1N1 influenza virus. | Provided an average >4-log reduction of viable H1N1 influenza virus against both the droplet and aerosol challenges for all 6 FFRs. No other FFRs showed noticeable deterioration or deformation, and no arcing in the microwave was observed during treatment. |
|  | Fisher et al, 201136 | Two brands of MSBs used for this study, namely, the Medela Quick CleanTM MICRO-STEAMTM BAGS (Medela, McHenry, IL) and the Munchkin® Steam Guard TM Bags (Munchkin Inc., North Hills, CA). These bags will be denoted as ‘‘MSB X’’ or ‘‘MSB Y’’ for the former and later, respectively. Both steam bag brands have similar design structures which include a zipper lock seal, a steam exhaust port, internal pleat, and a volume of approximately 2.2 L. The manufacturer’s instructions for use with baby feeding accessories were applied to the steam treatment of FFRs. The instructions were the same for each steam bag brand. Individual FFRs were placed inside separate bags filled with 60 ml of tap water. The bags were sealed, using the bag’s integrated zipper lock seal and placed in a commercially available Sharp Model R-305KS (2450 MHz, 1100 W) microwave oven (Sharp Electronics, Mahwah, NJ, USA). The FFRs in the sealed steam bags were irradiated on high power for 90 s; the prescribed time for a microwave with a rating of 1100 W. | 3M 1860, 3M 8210, Cardinal Health N95, 3M 1870, Kimberly-Clark PFR95 and Moldex 2200 | MS2 Bacteriophage | After one cycle of steam bag decontamination using the MSB X bags: All of the six FFR models (one sample per model) surpassed the filtration efficiency requirements of 95%. The absorption values for models 3M 1860, 3M 8210 and the Cardinal Health N95 were roughly an order of magnitude higher than the values for 3M 1870, Kimberly-ClarkPFR95, and Moldex 2200. The models 3M 1860, 3M 8210 and the Cardinal Health N95 remained wet after the 60 min drying period and were eliminated from further testing. The FFR models, 3M 1870, Kimberly-Clark PFR95, and Moldex2200, passed the filtration efficiency testing after three cycles of decontamination using both steam bag brands. For theMSB X bags, the filtration efficiencies of the experimental models were statistically similar to the controls for both the 3M 1870(p = 0.19) and the Moldex 2200 (p = 0.40), while the treated Kimberly-Clark PFR95 models were statistically different from thecontrols (p = 0.01). MSB Y bags produced statistically similar results for the control and treated samples for each model; 3M1870 (p = 0.19) Moldex 2200 (p = 0.40) and Kimberly-ClarkPFR95 (p = 0.42). The results for drying of the FFRs were simil r for 30 min compared to the 60 min drying time. The average decontamination efficacy resulting from the use of MSB X bags was greater than 99.9% (3 logs) for all three FFR models tested(Table 3). The average decontamination efficacy for the Moldex model was greater than 99.99% or 4 logs. The MS2 challenge concentration for the Moldex models was more than 2 logs higher than the Kimberly Clark (7.1) or 3M 1860 (7.6). MSB Y bags achieved 99.9% reduction of MS2 for two FFR models while the results of the third model measured greater than or equal to99.86%. |
|  | Lore et al, 201220 | Microwave-generated steam (MGS): A 1250-W (2450MHz) commercially available microwave oven (Panasonic Corp., Secaucus, NJ, USA) with a rotating glass plate was used to irradiate a single respirator per treatment. Samples were placed above a plastic box filled with 50 ml of room temperature tap water. The top of the box was perforated with holes (7 mm diameter) evenly distributed over the entire surface to allow MGS to vent through the respirator. The virus-contaminated respirator was placed with the convex surface pointed toward the steam source and the FFR was then irradiated for 2 min at full power. | 3M models 1860s and 1870 | Influenza A/H5N1 (VNH5N1) | This study showed that the decontamination method (microwave-generated steam) satisfactorily decontaminated the 3M1860s and 1870 FFRs as measured by a virus culture method. Within the constraints of the experiment, the three methods were all completely effective for the decontamination of FFRs as assessed by a culture method. |
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| **9. Sodium hypochlorite** | | |  |  |  |
|  | Viscusi et al, 200921 | Thirty minutes submersion in 0.6% (one part bleach to nine parts of deionized water) aqueous solution of sodium hypochlorite (original concentration = 6% available as Cl2). Manufacturing specification: 6.00–0.06% (w/w) available chlorine; Cat no. 7495.7-1, CAS no. 7732-18-5 (Ricca Chemical Company, Pequannock, NJ, USA). After treatment, FFRs were hung on a laboratory pegboard and allowed to air-dry overnight with assistance from a freestanding fan. | Random sampling from those N95 FFR models present in the US Strategic National Stockpile (SNS) and from models commercially available at the time of the study and included because they were considered likely to be more resistant to filtration efficiency degradation and thus offer a more rigorous basis of comparison. | None. | Metallic nosebands were slightly tarnished and visibly not as shiny when compared with their as-received counterparts. SN95-E inner nose comfort cushion was discolored. Following air-drying overnight (16 h), all FFRs were dry to the touch and all still had a characteristic smell of bleach. |
|  | Bergman et al, 201023 | **Multiple (3-Cycle) of:**  30-min submersion in 0.6% (one part bleach to nine parts of deionized water) solution of sodium hypochlorite (original concentration = 6% available as Cl2). Manufacturing specification: 6.00 ± 0.06% w/w) available chlorine; Cat No. 7495.7-1, CAS No. 7732-18-5 (Ricca Chemical Company, Pequannock, NJ). Following each exposure, FFRs were hung on a laboratory peg board and dried for a minimum of 16 hours with the aid of a fan before repeating the treatment or performing the laboratory aerosol filtration test. | Six models [three N95 FFR models (N95-A, N95-B, and N95-C) and three surgical N95 respirator models (SN95-D, SN95-E, and SN95-F)] | None. | Bleach exposure caused various effects: for all FFR models, metallic nosebands were slightly tarnished and visibly not as shiny when compared with their as-received counterparts. For those models with staples (N95-B, N95-C, SN95-E and SN95-F staples were oxidized to varying degrees. Three models (N95-A, SN95-E, and SN95-F) had discolored (yellowed) inner nose pads. The nose pad of model SN95-E samples dissolved (only 50% remained). Discoloring of other areas of the FFR were observed in models SN95-F (bleeding of printed ink lettering), SN95-E (material adjacent to nose pad became yellowed), and SN95-D (area adjacent to nose clip discolored). Following air-drying between exposure cycles (at least 16 hr), all FFRs which were exposed to bleach were dry to the touch and all still had a characteristic bleach odor. |
|  | Salter et al, 201022 | Sodium hypochlorite (0.6%) | NIOSH, FDA-approved N95, Surgical FFR, NIOSH-approved N95 and Particulate FFR | None. | All FFR models treated with 0.6% hypochlorite retained similar amounts of oxidant with the exception ofS3, on which none was detected. |
|  | Lin et al, 201735 | 10 min submersion in 0.5% sodium hypochlorite solution (original concentration = available as Cl2). Manufacturing specification: 0.5% (w/w) available chlorine. Following each exposure, masks were placed in a laboratory chemical hood and allowed to air-dry overnight before performing the laboratory aerosol filtration test. | Not specified N95. | None. | Submersion in bleach significantly changed the penetration through the N95 masks. |
|  | Lin et al, 201834 | A 0.4 ml volume of bleach with various concentrations(5.4%(w/w)as Cl2: original; 2.7%: one part bleach to one part of deionized water; 0.54%: one part bleach to nine parts of deionized water[13]) was added to the center of the surface of the N95 FFR using a pipette[21], the FFR was then dried in a petri dish in a BSC for 10 min. | N95 FFR (8210,3M, St. Paul, MN) | *Bacillus subtilis* Spores | In the bleach decontamination test, no colony was recovered after 5.4%, 2.7% or 0.54% NaOCl was used, constituting no dilution, two-fold, and ten-fold dilution, respectively. This study found that NaOCl, even when diluted ten-fold from standard bleach, had a strong decontamination effect, with a 100% bactericidal effect. |
|  | Liao et al, 202027 | Samples were sprayed with approximately 0.3-0.5 mL of household chlorine-based disinfectant (~2% NaClO). Samples were left to air dry and off-gas completely, hanging. Samples were tested. | 3M 8210 (NIOSH N95), 4C Air, Inc. (GB2626 KN95), ESound (GB2626 KN95) and Onnuriplan (KFDA KF94). | None. | From the first disinfection, we can clearly note that chlorine-based solution) drastically degraded the filtration efficiency to unacceptable levels, while the pressure drop remained comparable. |
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| **10. Autoclave** | | |  |  |  |
|  | Lin et al, 201735 | Set the temperature at 121ºC with 1.06 kg cm−2 for 15 minutes. | Not specified N95. | None. | Wet heat in the autoclave had little effect on that of the N95 mask. |
|  | Lin et al, 201834 | The N95 FFR was heated for 15 min at 121°C and 103 kPa. | N95 FFR (8210,3M, St. Paul, MN) | *Bacillus subtilis* Spores | Effectively sterilized almost 100% of the bacteria. |
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| **11. Electric rice cooker** | | |  |  |  |
|  | Lin et al, 201735 | Place the test masks in a traditional electric rice cooker using dry heat for 3minutes (149~164 C, without adding water). | Not specified N95. | None. | The experimental results indicate that decontamination by dry heat in a rice cooker had little effect on the penetration of particles through N95 mask. |
|  | Lin et al, 201834 | The N95 FFR was placed in an electric rice cooker for dry heating for 3 min (149-164°C, without added water). | N95 FFR (8210,3M, St. Paul, MN) | *Bacillus subtilis* Spores | Effectively sterilized almost 100% of the bacteria. |
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| **12. Cleaning Wipes** | | |  |  |  |
|  | Heimbuch et al, 201437 | Wipe products selected for this study were 504/07065 Respirator Cleaning Wipes (3M Company, St Paul, MN), which contain benzalkonium chloride (BAC); Hype-Wipes (Current Technologies, Inc, Crawfordsville, IN), which contain 0.9% hypochlorite (OCL); and Pampers wipes (Proctor & Gamble, Cincinnati, OH), which contain no active antimicrobial ingredients (ie, inert). BAC and other quaternary ammonium disinfectants commonly appear in wipe products; the examples chosen are labeled for use on respirators. OCL was shown to decontaminate FFRs without significantly degrading performance, but created odor and oxidation problems. The OCL wipe was included to measure the ability of a limited application (wiping vs immersion) to remove contaminants and minimize incompatibilities with FFRs. Alcohol- and soap-based wipe products were avoided because they are known to decrease FFR performance. | 3M-1860S (FFR A); 3M-1870 (FFR A); Kimberly-Clark-46727-PFR (FFR A) | *Staphylococcus aureus* | Reduction in viable S aureus varied among wipe—FFR component pairs. The mean loading concentration of S aureus on FFR samples was 6.72 × 105 CFU/cm2. The inert wipes captured 81.56%–96.53% of *Staphylococcus aureus* from the base fabrics of all FFR models tested. REs were low for the exterior surface of perforated edge strips from FFR C (59.37%), and FFR B’s nose pad (69.28%). OCL wipes reduced viability below the detection limit (>5-log attenuation) for 7 of 10 samples among the 3 FFR models. Two remaining samples (interior fabrics of FFRs B and C) lost >4 logs in viability, the last sample (nose pad of FFR B) showing the smallest decrease (98.98%) of the sample set. BAC wipes produced 2 samples below the detection limit (interior surface of perforated edge strip from FFR C, interior fabric of FFR B); 5 other samples showed 3–5 log reductions in viability. Attenuation on FFR B’s nose pad again was the least (68.92%) of the sample set. Mean particle penetration of each thrice-cleaned FFR model was <5%, NIOSH’s N95 certification criterion. For all 3 FFR models tested, BAC wipes caused more penetration than the other wipes; for FFRs A and B, this difference was significant (P < 0.05). Of the models tested, FFR C showed the greatest penetration—1 replicate exceeded the 5% threshold (5.6%) after cleaning with a BAC wipe—and the differences were not significant. |