Decontamination Interventions for the Reuse of Surgical Mask Personal Protective Equipment (PPE): A Protocol for an Updated Systematic Review

PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist (1)

Section/Topic	Item No.	Checklist Item	Protocol Information
Administrative Information			
Title			
Identification	1a	Identify the report as a protocol of a systematic review	Decontamination Interventions for the Reuse of Surgical Mask Personal Protective Equipment (PPE): A Protocol for an Updated Systematic Review
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	This is an update of an original systematic review published on July 9, 2020 (2).
Registration	2	If registered, provide the name of the registry (e.g., PROSPERO) and registration number in the abstract	The systematic review protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) on February 11, 2021 (registration number pending). The protocol will be uploaded in pre-print to Open Science Framework (OSF).
Authors			
Contact	3a	Provide name, ORCID, institutional affiliation, and e-mail address of all protocol authors; provide physical mailing address of corresponding author	<p><u>Corresponding author:</u> David Zorko (zorkodj@mcmaster.ca) Department of Pediatrics, McMaster University McMaster Children's Hospital, Room 3E20 1280 Main Street West Hamilton, Ontario, Canada L8N 3Z5 ORCID: 0000-0002-6971-8542</p> <p>Karen Choong (choongk@mcmaster.ca) McMaster University ORCID: 0000-0002-4608-4508</p> <p>James Dayre McNally (dmcnally@cheo.on.ca) Children's Hospital of Eastern Ontario ORCID: 0000-0001-8103-9967</p> <p>Katie O'Hearn (kohearn@cheo.on.ca) Children's Hospital of Eastern Ontario Research Institute ORCID: 0000-0002-1149-2843</p> <p>Lindsey Sikora (lindsey.sikora@uottawa.ca) University of Ottawa ORCID: 0000-0002-9715-8634</p> <p>Tri Dinh (tri.dinh@medportal.ca) McMaster University ORCID: 0000-0002-6720-058X</p> <p>Jess Gibson (jgibson@cheo.on.ca) Children's Hospital of Eastern Ontario Research Institute ORCID: 0000-0001-5517-4540</p>
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	<p>Zorko ✓ Conceptualization ✓ Methodology ✓ Validation ✓ Investigation ✓ Data curation ✓ Writing 1st draft</p>

			✓ Revising and editing ✓ Visualization ✓ Project administration
			Choong ✓ Conceptualization ✓ Methodology ✓ Validation ✓ Investigation ✓ Data curation ✓ Revising and editing ✓ Visualization ✓ Supervision ✓ Project administration ✓ Guarantor
			O’Hearn ✓ Conceptualization ✓ Methodology ✓ Validation ✓ Investigation ✓ Data curation ✓ Revising and editing ✓ Visualization ✓ Project administration
			McNally ✓ Conceptualization ✓ Methodology ✓ Validation ✓ Investigation ✓ Data curation ✓ Revising and editing ✓ Visualization ✓ Project administration
			Sikora ✓ Methodology ✓ Validation ✓ Investigation ✓ Data curation ✓ Revising and editing ✓ Visualization
			Dinh ✓ Methodology ✓ Validation ✓ Investigation ✓ Data curation ✓ Revising and editing ✓ Visualization
			Gibson ✓ Methodology ✓ Validation ✓ Investigation ✓ Data curation ✓ Revising and editing ✓ Visualization
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	Protocol amendments for this systematic review and will be documented in OSF and PROSPERO with date, description, and rationale.
Support			
Sources	5a	Indicate sources of financial or other support for the review	This systematic review has not received any specific funding. David Zorko was funded by a Canadian Institutes of Health Research (CIHR) Canada Graduate Scholarship. James Dayre McNally was awarded a Children’s Hospital Academic Medical Organization (CHAMO) Innovation Fund (IFPOC number: CHA-20-011).
Sponsor	5b	Provide name for the review funder and/or sponsor	
Role of sponsor/ funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	
Introduction			
Rationale	6	Describe the rationale for the review in the context of what is already known	The novel coronavirus (COVID-19) pandemic has created an unprecedented global demand for facemask personal protective equipment (PPE), including both N95 filtering facepiece respirators (FFRs) and surgical masks.

As a result, much attention came to mask decontamination as a potential crisis capacity strategy when faced with critical facemask PPE shortages (3). At the outset of the COVID-19 pandemic, little was known regarding the efficacy or safety of surgical mask decontamination interventions. Assumptions that decontamination methods effective in N95 FFRs can be extrapolated to surgical masks are challenged by evidence that decontamination interventions can variably impact mask performance amongst different mask types (2) and surgical masks perform differently than N95 FFRs with aerosol challenges (4, 5).

Therefore, our group conducted a systematic review to summarize the state of evidence for interventions facilitating the reuse of surgical masks (2). Conducted at the beginning of the COVID-19 pandemic, we identified a paucity of evidence evaluating interventions to decontaminate surgical masks for the purposes of reuse. Seven studies were included in the analysis with only one study evaluated decontamination interventions, specifically the effects of heat and chemical disinfectants on mask performance (5). Another six studies were identified that evaluated interventions applied prior to mask use to enhance their performance and/or antimicrobial properties (6-11). Both the scant body of evidence on decontamination interventions for surgical masks and the heterogeneity in the methods of included studies prevented us from making any actionable conclusions regarding surgical mask decontamination interventions.

The COVID-19 pandemic has placed surgical and medical facemask PPE in high demand. Their use spans a variety of healthcare settings (12-14) and many hospitals have implemented universal masking policies (14, 15). Furthermore, the emergence of COVID-19 variants with greater transmissibility and infectivity has led some countries to recommend or mandate widespread public use of 3-layer medical masks in lieu of homemade masks or face coverings (16). Since the publication of our original systematic review, COVID-19-related literature has evolved from >2000 citations in mid-March 2020 to >80,000 citations by the beginning of December 2020. Coupled with the protracted course of the COVID-19 pandemic continuing to threaten facemask PPE supply and demand, an updated systematic review on decontamination interventions for surgical masks is needed to reflect critical new evidence in order to best inform clinicians, infection control experts, and public health administrators on how best to advise safe decontamination and reuse practices.

Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions,	This updated systematic review is a product of a larger living scoping review seeking to identify all original research on N95 FFR and surgical mask decontamination and reuse, and create an open-access database of the
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		comparators, and outcomes (PICO)	existing literature (17). The objective of this systematic review is to update a previously conducted systematic review (2) and identify and synthesize new data from published studies evaluating interventions used to decontaminate or treat surgical mask PPE for the purposes of reuse.
Methods			
Eligibility criteria	8	Specify the study characteristics (e.g., PICO, study design, setting, time frame) and report characteristics (e.g., years considered, language, publication status) to be used as criteria for eligibility for the review	<p>Population: Original publications evaluating medical or surgical facemask PPE (i.e., whole masks or pieces of whole masks) or their components (i.e., individual mask layers). For the purposes of this systematic review, the type of facemask PPE must be identified as a medical or surgical facemask approved for use in the hospital setting by healthcare providers. We will exclude studies that evaluated interventions isolated to N95 FFRs, or types of facemask PPE not routinely used in a hospital setting (e.g., non-medical masks, fabric masks [e.g., cotton, cloth], homemade facemasks).</p> <p>Intervention: Any intervention used to decontaminate, sterilize or treat surgical face masks (i.e., an intervention applied after mask use), to enable the reuse of the mask as PPE.</p> <p>Comparator: Any or none.</p> <p>Outcome: Efficacy of the intervention, as measured by any one of the following:</p> <ol style="list-style-type: none"> 1. Mask filtration performance (i.e., effect on droplet or particle penetration/filtration efficiency and airflow resistance) 2. Reduction in pathogen load (including viral, bacterial, fungal, and bacteriophage loads) 3. Mask appearance or physical degradation 4. Adverse effects as experienced by the wearer (e.g., skin irritation) 5. Feasibility of the intervention (e.g., time, cost, resource utilization) 6. Clinical infection prevention rates with use decontaminated masks (e.g., animal or human models) <p>Publication Characteristics: We will include English or French original publications examining any method of surgical mask PPE decontamination. We will also include systematic reviews of any method of medical and/or surgical mask PPE decontamination. Editorial reviews, narrative reviews, grey literature, clinical practice guidelines, patents and books will be excluded.</p>
Information sources	9	Describe all intended information sources (e.g., electronic databases, contact with study authors, trial registers, or other grey literature sources) with planned dates of coverage	Eligible citations were identified through a living scoping review of N95 and surgical facemask PPE decontamination interventions (17). An updated search of electronic databases will be conducted from their dates of inception in March 2021. Consistent with the a priori methods of the living scoping review, the search strategy

			<p>was reviewed and updated to reflect changes identified in the literature, terminology and indexing (17).</p> <p>The following databases will be searched by the core investigator team and a health research librarian (LS, KO): Medline and Medline in Process via OVID, Embase Classic + Embase via OVID, Cochrane CENTRAL and Global Health via CAB Direct, and Senton Hall. The search strategy was developed in Medline, and then translated into the other databases, as appropriate (see Protocol Section 10). Language will be restricted to English or French, with no other publication restrictions. Reference lists of included studies will be examined for potential eligible citations that may have evaded the database search.</p>
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	<p>Medline</p> <ol style="list-style-type: none"> 1. Respiratory Protective Devices/ 2. Personal Protective Equipment/ 3. (filtering adj3 (facepiece or face piece or facepieces or face pieces)).tw,kf. 4. (N95 or N 95).tw,kf. 5. (ffr or ffrs).tw,kf. 6. Masks/ 7. (surgical mask* or medical mask* or cough mask* or face mask* or (mask* and (personal or ppe or gown* or glove*))).tw,kf. 8. or/1-7 9. Decontamination/ 10. exp Sterilization/ 11. Equipment Reuse/ 12. (decontamin* or steriliz* or deactivat* or inactivat*).tw,kf. 13. ((product or equipment or mask*) adj2 (reuse or recycl* or reusabilit* or reprocess*)).tw,kf. 14. Ultraviolet Rays/ 15. ((ultraviolet or ultra violet or UV or actinic) adj3 (ray or rays or radiation or irradiation or decontaminat* or light)).tw,kf. 16. UVGI.tw,kf. 17. Microwaves/ 18. (microwav* or micro wav*).tw,kf. 19. ((ehf or extremely high frequenc*) adj2 (wave or waves)).tw,kf. 20. ((ultrahigh or ultra high) adj2 (wave or waves)).tw,kf. 21. Steam/ or Hot Temperature/ 22. (Heat or heated or heating or moist or steam or oven or pasteuriz* or autoclave).tw,kf. not (Body Temperature/ or Body Temperature Regulation/ or exp Heat Stress Disorders/) 23. Sodium Hypochlorite/ or Disinfectants/ or Sodium Chloride/ 24. Hydrogen Peroxide/ 25. (bleach* or clorox or antiformin or oxygenated water or hydrogen peroxyde or hydroperoxide or peroxygen).tw,kf.

26. sodium hypochlorite.tw,kf. 27. hydrogen peroxide.tw,kf. 28. Ethanol/ 29. 2-Propanol/ 30. Ethylene Oxide/ 31. (ethanol* or isopropanol or iso-propanol or 2-propanol or isopropyl alcohol or ethylene oxid* or oxirane or rubbing alcohol*).tw,kf. 32. disinfect*.tw,kf. 33. Nanotechnology/ 34. exp Nanoparticles/ch [Chemistry] 35. (nanotechnolog* or nanostructur*).tw,kf. 36. Ozone/ 37. Gamma rays/ 38. ozone.tw,kf. 39. (gamma adj2 (ray* or radiation*)).tw,kf. 40. (nuclear adj2 (x-ray*)).tw,kf. 41. exp Detergents/ 42. detergent*.tw,kf. 43. (cleansing adj2 agent*).tw,kf. 44. or/9-43 45. 8 and 44 46. limit 45 to (english or french)			
Study Records			
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	Records will be downloaded into Endnote for duplicate removal and exported to insightScope (www.insightscope.ca) for screening. Data abstraction will be performed using pre-piloted data abstraction forms created in Microsoft Excel from our original systematic review (2).
Selection process	11b	State the process that will be used for selecting studies (e.g., two independent reviewers) through each phase of the review (i.e., screening, eligibility, and inclusion in meta-analysis)	<p>Previously piloted inclusion and exclusion will be used for this updated systematic review (2). Citation screening was performed as part of a living scoping review of N95 and surgical facemask PPE decontamination interventions (17). For the purposes of this updated systematic review, only records reporting on surgical or medical facemask PPE decontamination interventions were included.</p> <p>Screening will be performed in two steps (title and abstract, full text) against inclusion criteria by two independent reviewers. Excluded citations at full text screening will be recorded with reasons. Resolution of conflicts will be performed by consensus and/or consultation with a third reviewer, where necessary. The study selection process will be documented using a PRISMA flow diagram (1).</p>
Data collection process	11c	Describe planned method of extracting data from reports (e.g., piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	Previously piloted electronic data abstraction forms created in Microsoft Excel will be used for this updated systematic review (2). Prior to formal data abstraction, reviewers will be provided with training. Data will be abstracted by two independent reviewers in duplicate. Data will be abstracted from the full text publication and any related publications, referenced published protocols, or supplementary materials. Where necessary, graphical data will be extracted by one reviewer using SourceForge

			Plot Digitizer (http://plotdigitizer.sourceforge.net) and checked by the second reviewer for accuracy. Resolution of conflicts will be performed by consensus and/or consultation with a third reviewer, where necessary. In the event of missing or unclear data, a maximum of three attempts will be made to contact study authors for clarification.
Data items	12	List and define all variables for which data will be sought (e.g., PICO items, funding sources), any pre-planned data assumptions and simplifications	<p>a) Study demographics</p> <ul style="list-style-type: none"> • Author name and contact information • Title • Country of origin • Journal and year of publication <p>b) Study design</p> <ul style="list-style-type: none"> • Type of study (e.g., Pre and post, post only) • Controlled versus uncontrolled <p>c) PPE tested</p> <ul style="list-style-type: none"> • Mask type and model • Full mask or components • Type of pathogen and method of mask contamination <p>d) Decontamination intervention</p> <ul style="list-style-type: none"> • Method of mask treatment or decontamination (e.g., microwave/heat methods, UV germicidal irradiation, etc.) • Frequency, duration, intensity (as applicable to intervention) of decontamination protocol • Method of supporting/suspending masks • Drying/post-decontamination process <p>e) Outcomes</p> <ul style="list-style-type: none"> • Outcome measurement tool (e.g., penetration test used, airflow resistance test used) • Penetration (absolute percentage, change relative to baseline) • Airflow resistance and pressure drop • Absolute and relative change in pathogen number • Absolute and relative change in clinical infection rate • Observations of physical degradation or odour • Adverse events experienced by the user following wear of the treated mask (e.g., skin irritation, shortness of breath) • Time, cost, and resources required for decontamination protocol <p>f) Modifying factors</p> <ul style="list-style-type: none"> • Intervention and outcome evaluated against soiling measures
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	<p>The major outcomes for which data will be sought are:</p> <ol style="list-style-type: none"> 1. Filtration efficiency (FE; absolute values and change pre- and post-use and intervention). Study results reporting percentage particle penetration were converted to FE units (i.e., $FE\% = 100 - \text{particle penetration}$) for comparability (18).

			<ol style="list-style-type: none"> 2. Airflow resistance (absolute values and change pre- and post-use and intervention) 3. Pathogen load on the mask surface (absolute and relative change, when comparator group was included). Reduction in pathogen load will be reported as a log10 reduction factor from a time zero post inoculation to a subsequently measured time-point, in addition to absolute value or change. If log10 reductions are not reported by the study, we will calculate them using the study data provided (e.g., colony counts), where possible. A log10 reduction factor ≥ 3 will be used as a reference indicating good germicidal effect (19). <p>The minor outcomes for which data will be sought are:</p> <ol style="list-style-type: none"> 4. Changes in physical appearance, as defined by the study investigators (i.e., mask appearance or physical degradation, strap/ear-loop damage) 5. Adverse effects experienced by the wearer, as defined by the study investigators (e.g., skin irritation) 6. Feasibility, as defined by the study investigators (e.g., outcomes related to time, cost, and resource utilization for the intervention) 7. In-vivo infection rates following use of decontaminated masks (absolute and relative change, when comparator group was included)
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	<p>Given the absence of standard tools with which to assess risk of bias in this body of literature, risk of bias will be assessed using a systematic tool used in previous systematic reviews evaluating facemask PPE decontamination interventions (2, 20-22). Risk of bias will be assessed by two reviewers independently and in duplicate at the study level by outcome in the following domains: study design, methodological consistency, population heterogeneity, sampling bias, outcome evaluation, and selective reporting (Appendix A). Resolution of conflicts will be performed by consensus and/or consultation with a third reviewer, where necessary. If insufficient detail is provided to confidently assess risk of bias, a maximum of three attempts will be made to contact study authors for clarification. The impact of risk of bias on the summarized evidence will be addressed in the discussion section of the manuscript.</p>
Data synthesis	15a	Describe criteria under which study data will be quantitatively synthesized	<p>The following data will be synthesized quantitatively, stratified by decontamination intervention, provided that sufficient evidence exists:</p> <ol style="list-style-type: none"> 1. <u>FE and airflow resistance outcomes</u>: Data will need to be available from at least three independent studies using approved testing methods to consider quantitative synthesis. Where results were presented for multiple experimental conditions, the summary of results conducted at the harshest testing conditions

		<p>were reported, to allow a conservative interpretation of the outcomes evaluated (18).</p> <ol style="list-style-type: none"> 2. <u>Germicidal outcome</u>: Significant heterogeneity is expected in methodology related to pathogen type (e.g., virus versus bacteria) and method of evaluation of decontamination (e.g., culture versus PCR). We will quantitatively synthesize this outcome if similar data is provided from three studies using concordant pathogen and testing. 3. <u>Mask degradation (fibre or other mask components)/physical appearance</u>: It is expected that studies will subjectively evaluate this outcome, and thus significant heterogeneity is expected in the evaluation of physical characteristics. We will quantitatively synthesize this outcome if similar data is provided from three studies using approved, objective testing methods to consider quantitative synthesis. 4. <u>User adverse event rate</u>: Significant heterogeneity is expected in the methodology related to method of decontamination and adverse event measured. We will quantitatively synthesize this outcome if similar data is provided from three studies evaluating a concordant decontamination method and evaluating the same adverse event. 5. <u>Feasibility</u>: Significant heterogeneity is expected in the methodology related to method of decontamination and choice and measurement of a feasibility outcome. We will quantitatively synthesize this outcome if similar data is provided from three studies evaluating a concordant decontamination method and the same feasibility outcome. 6. <u>Clinical infection prevention rate</u>: Significant heterogeneity is expected in methodology related to pathogen type (e.g., virus versus bacteria) and method of evaluation of decontamination (e.g., culture versus PCR). We will quantitatively synthesize this outcome if similar data is provided from three studies using concordant pathogen and testing.
15b	<p>If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data, and methods of combining data from studies, including any planned exploration of consistency (e.g., I^2, Kendall's tau)</p>	<p>For the particle penetration and airflow resistance outcomes of interest, the data is anticipated to be primarily presented as an absolute value. If presented as a percent change, and sufficient data is provided, we will calculate the absolute value.</p> <p>For the germicidal outcomes of interest, heterogeneity is expected with respect to methods and outcomes related to contamination and decontamination. The data is anticipated to be reported as absolute and/or relative change, when comparator group was included. In order to account for differences in methods, pooled results will be summarized in terms of a log10 reduction factor. If log10</p>

		<p>reductions are not reported by the study, we will calculate them using the study data provided (e.g., colony counts), where possible. For studies reporting a pathogen load “below minimum detectable limits,” we will calculate a log₁₀ reduction factor using half of the limit of detection, as previously described (23) and used in other studies (20, 24). Consistent with our previous approach, for studies that report a final pathogen load of “zero” and no limit of detection, it will be assumed that all pathogen was inactivated (20). Similarly, if studies report a pathogen load “below minimum detectable limits” and no limit of detection, it will be assumed that all pathogen was inactivated (20).</p> <p>A random effects model will be used to present either the pooled absolute value pre-/post-decontamination intervention or relative change (from control or no intervention arm). The Mantel-Haenszel method will be used to estimate study weights. We will calculate pooled risk ratios for dichotomous outcomes and mean differences for continuous outcomes, with a corresponding 95% CI. A two-sided p-value <0.05 will be considered significant.</p> <p>The degree of statistical heterogeneity will be evaluated from forest plots, using chi-square tests (p <0.10 representing significant heterogeneity) and the I² statistic (I² >50% representing moderate to substantial heterogeneity).</p>
15c	Describe any proposed additional analyses (e.g., sensitivity or subgroup analyses, meta-regression)	<p>Additional analyses are as follows:</p> <ol style="list-style-type: none"> 1. For the synthesis and presentation of decontamination results we will perform a separate analysis limiting to studies that evaluate specific pathogen types (e.g., viruses, bacteria), where possible. 2. For the synthesis and presentation of mask performance results (airflow resistance and FE) we will perform separate analyses evaluating specific mask types (by model and/or performance standard [e.g., ASTM level], where possible. 3. For the synthesis and presentation of mask performance and decontamination results, separate analysis limited to studies that evaluated used masks (i.e., those already worn in the healthcare setting), where possible. Recent data relating to decontamination of N95 FFRs has demonstrated that used facemasks may perform differently to decontamination interventions than unused masks (25). 4. If sufficient data permits (at least three studies) we will describe and quantitatively synthesize the data for low risk of bias studies.
15d	If quantitative synthesis is not appropriate, describe the type of summary planned	If there is insufficient quantity or quality of data or the methods are sufficiently heterogenous the study findings will be presented descriptively in tables and text.

Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (e.g., publication bias across studies, selective reporting within studies)	Based on the anticipated small size of the available literature (approximately 10 studies per decontamination intervention) and limited variability in study sample sizes generally observed in laboratory studies, no statistical test of publication bias are planned.
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (e.g., GRADE)	The cumulative body of evidence regarding the reuse and decontamination of surgical mask PPE will be evaluated using the following domains: 1) Study quality, 2) Risk of bias, 3) Precision, 4) Consistency, and 5) Indirectness. A final overall quality of evidence will be summarized in a summary of findings table.

References:

1. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev*. 2015;**4**(1). doi: 10.1186/2046-4053-4-1
2. Zorko DJ, Gertsman S, O'Hearn K, Timmerman N, Ambu-Ali N, Dinh T, et al. Decontamination interventions for the reuse of surgical mask personal protective equipment: a systematic review. *J Hosp Infect*. 2020;**106**(2):283-94. doi: 10.1016/j.jhin.2020.07.007
3. Centers for Disease Control and Prevention. Strategies for Optimizing the Supply of Facemasks 2020, <https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/face-masks.html> [accessed February 11, 2021]
4. Balazy A, Toivola M, Adhikari A, Sivasubramani SK, Reponen T, Grinshpun SA. Do N95 respirators provide 95% protection level against airborne viruses, and how adequate are surgical masks? *Am J Infect Control*. 2006;**34**(2):51-57. doi: 10.1016/j.ajic.2005.08.018
5. Lin T-H, Chen C-C, Huang S-H, Kuo C-W, Lai C-Y, Lin W-Y. Filter quality of electret masks in filtering 14.6–594 nm aerosol particles: Effects of five decontamination methods. *PloS One*. 2017;**12**(10). doi: 10.1371/journal.pone.0186217
6. Tseng C-C, Pan Z-M, Chang C-H. Application of a quaternary ammonium agent on surgical face masks before use for pre-decontamination of nosocomial infection-related bioaerosols. *Aerosol Sci Tech*. 2016;**50**(3):199-210. doi: 10.1080/02786826.2016.1140895
7. Shen H, Leonas KK. Study of Repellent Finish Of Filtration Ability Of Surgical Face Masks. *International Nonwovens Journal*. 2005(4):1558925005os-1551400403. doi: 10.1177/1558925005os-1400403
8. Quan F-S, Rubino I, Lee S-H, Koch B, Choi H-J. Universal and reusable virus deactivation system for respiratory protection. *Sci Rep*. 2017;**7**(1):1-10. doi: 10.1038/srep39956
9. Li Y, Wong T, Chung, Guo YP, Hu JY, Guan YT, et al. In vivo protective performance of N95 respirator and surgical facemask. *Am J Ind Med*. 2006;**49**(12):1056-1065. doi: 10.1002/ajim.20395
10. Li Y, Leung P, Yao L, Song Q, Newton E. Antimicrobial effect of surgical masks coated with nanoparticles. *J Hosp Infect*. 2006;**62**(1):58-63. doi: 10.1016/j.jhin.2005.04.015
11. Demir B, Cerkez I, Worley S, Broughton R, Huang T-S. N-halamine-modified antimicrobial polypropylene nonwoven fabrics for use against airborne bacteria. *ACS Appl Mater Interfaces*. 2015;**7**(3):1752-1757. doi: 10.1021/am507329m
12. MacIntyre CR, Chughtai AA. Facemasks for the prevention of infection in healthcare and community settings. *BMJ*. 2015;**350**:h694. doi: 10.1136/bmj.h694
13. World Health Organization. Rational use of personal protective equipment for coronavirus disease (COVID-19) and considerations during severe shortages: interim guidance, 6 April 2020. Geneva: World Health Organization; 2020.
14. World Health Organization. Advice on the use of masks in the context of COVID-19: interim guidance, 6 April 2020. Geneva: World Health Organization; 2020.
15. Klompas M, Morris CA, Sinclair J, Pearson M, Shenoy ES. Universal masking in hospitals in the Covid-19 era. *N Eng J Med*. 2020. doi: 10.1056/NEJMp2006372
16. Mackintosh, Eliza. European countries mandate medical-grade masks over homemade cloth face coverings. CNN [newspaper on the Internet]. January 22, 2021 [accessed February 11, 2021]. Available at: <https://www.cnn.com/2021/01/22/europe/europe-covid-medical-masks-intl/index.html>
17. O'Hearn K, Agarwal A, Choong K, Gertsman S, Nama N, Sampson M, et al. Live Scoping Review of N95 and Surgical Facemask Decontamination and Reuse: A Scoping Review Protocol. *OSF Preprints*. 2020. doi: 10.31219/osf.io/rpc27
18. Rengasamy S, Shaffer R, Williams B, Smit S. A comparison of facemask and respirator filtration test methods. *J Occup Environ Hyg*. 2017;**14**(2):92-103. doi: 10.1080/15459624.2016.1225157

19. Fisher EM, Noti JD, Lindsley WG, Blachere FM, Shaffer RE. Validation and application of models to predict facemask influenza contamination in healthcare settings. *Risk Anal.* 2014;**34**(8):1423-1434. doi: 10.1111/risa.12185
20. Gertsman S, Agarwal A, O'Hearn K, Webster R, Tsampalieros A, Barrowman N, et al. Microwave- and heat-based decontamination of N95 filtering facepiece respirators: a systematic review. *J Hosp Infect.* 2020;**106**(3):536-553. doi: 10.1016/j.jhin.2020.08.016
21. O'Hearn K, Gertsman S, Sampson M, Webster R, Tsampalieros A, Ng R, et al. Decontaminating N95 and SN95 masks with ultraviolet germicidal irradiation does not impair mask efficacy and safety. *J Hosp Infect.* 2020;**106**(1):163-75. doi: 10.1016/j.jhin.2020.07.014
22. O'Hearn K, Gertsman S, Webster R, Tsampalieros A, Ng R, Gibson J, et al. Efficacy and safety of disinfectants for decontamination of N95 and SN95 filtering facepiece respirators: a systematic review. *J Hosp Infect.* 2020;**106**(3):504-521. doi: 10.1016/j.jhin.2020.08.005.
23. Singh A, Nocerino J. Robust estimation of mean and variance using environmental data sets with below detection limit observations. *Chemometrics and Intelligent Laboratory Systems.* 2002;**60**(1-2):69-86. doi: 10.1016/S0169-7439(01)00186-1.
24. Heimbuch BK, Wallace WH, Kinney K, Lumley AE, Wu C-Y, Woo M-H, et al. A pandemic influenza preparedness study: Use of energetic methods to decontaminate filtering facepiece respirators contaminated with H1N1 aerosols and droplets. *Am J Infect Control.* 2011;**39**(1):e1-e9. doi: 10.1016/j.ajic.2010.07.004
25. Czubyt MP, Stecy T, Popke E, Aitken R, Jabusch K, Pound R, et al. N95 mask reuse in a major urban hospital: COVID-19 response process and procedure. *J Hosp Infect.* 2020;**106**(2):277-82. doi: 10.1016/j.jhin.2020.07.035

Appendix A. Risk of bias assessment criteria and scoring

Domain	Study Outcome	Low Risk (0 points)	Moderate Risk (1 point)	High Risk (2 points)	Unclear ^a
Study Design	All	Controlled study or pre-post design	Partially controlled, quasi-experimental, or case-control design	Uncontrolled and no pre-post design	Insufficient information
Methodology Consistency	Filtration efficiency	Particle diameter, size distribution, charge, and airflow rate are consistent across arms	Some of the stated criteria not reported	None of the stated criteria reported	Insufficient information
	Airflow Resistance	Airflow rate is consistent across arms	Some of the stated criteria not reported	None of the stated criteria reported	Insufficient information
	Germicidal Effect	Detailed description of pathogen inoculation procedure (including inoculation medium and transmission mode) and assay procedure (including times/temperatures where applicable); procedures consistent across arms unless they are experimental variables	Some of the stated criteria not reported	None of the stated criteria reported	Insufficient information
	Infection Prevention	Detailed description of infection apparatus; ambient temperature and aerosol pressure are consistent across arms	Some of the stated criteria not reported	None of the stated criteria reported	Insufficient information
	Physical Characteristics	Description of how masks were evaluated, and all arms evaluated the same way	Some of the stated criteria not reported	None of the stated criteria reported	Insufficient information
	Adverse Effects	Description of how masks were evaluated, and all arms evaluated the same way	Some of the stated criteria not reported	None of the stated criteria reported	Insufficient information
Population Heterogeneity	All	Masks or mask components derived from the same batch/lot, and each different model analyzed separately	Some of the stated criteria not reported (e.g. mask models analyzed separately but lots not specified)	None of the stated criteria reported	Insufficient information
	Adverse Effects ^b Infection Prevention ^b	Homogenous subjects (<i>Animal</i> —same age, breed, and sex; <i>Humans</i> —same age and sex distribution)	Some of the stated criteria not reported	None of the stated criteria reported	Insufficient information
Sampling Bias	All	No indication that any masks were excluded from tests, or clear indication of exclusion with analyses accounting for the missing information	Data missing for some samples and not accounted for in analysis or conclusions	Samples replaced by new masks (e.g. if untestable due to degradation) and exclusion of original samples is not accounted for in analysis or conclusions	Insufficient information
Outcome Evaluation	All	Results determined by blinded evaluators or a machine (i.e. objective)	Partially-machine measured and/or partially-blinded evaluation	Unblinded evaluator or other subjective manner	Insufficient information
Selective Reporting	All	Results for all specified objectives and tests are reported, and/or missing data is clearly accounted for in analysis; all reported results were mentioned in the methods/objectives	Results of all objectives/tests are included or accounted for but results that were not specified in the methods/objective are also reported	Results for some objectives/tests are missing and not accounted for	Insufficient information
Overall Study Risk of Bias (Sum Score)		Low Risk of Bias (sum score 0-1)	Moderate Risk of Bias (sum score 2-6)	High Risk of Bias (sum score 7-12)	

^a For studies with unclear risk of bias in a domain, a range of overall risk of bias was provided assuming low and high risk of bias scores in these domains, respectively.

^b Two risk of bias scores were assessed for the population heterogeneity domain—one risk of bias score for the mask population and one for the population in which infection/adverse effects were assessed. The average domain score was used in the calculation of overall risk of bias.