



Topic Brief: Reusable versus Disposable PPE

Date: 6/15/2020

Nomination Number: 0903

Purpose:

This document summarizes the information addressing a nomination submitted on April 27, 2020 through the Effective Health Care (EHC) Website. This information was used to inform the Evidence-based Practice Center (EPC) Program decisions about whether to produce an evidence report on the topic, and if so, what type of evidence report would be most suitable.

Issue:

Personal protective equipment (PPE) is a specialized clothing or equipment, such as medical masks, respirators, gloves, gowns, and eye protection worn by healthcare personnel to prevent infection^{1, 2}. The Coronavirus Disease 2019 (COVID-19) pandemic created a shift from reusable to disposable PPE due to its perceived greater effectiveness at preventing infection³. Also, global shortages of PPE supplies called for alternative solutions involving extended use and reprocessing of PPE⁴⁻⁶. There is limited evidence regarding the comparative effectiveness of disposable versus reusable PPE, as well as the efficacy and safety of different methods of PPE reprocessing. Additionally, recent studies^{7, 8} have raised concerns regarding a greater environmental and public health burden associated with less sustainable forms of PPE.

Program Decision:

Key Questions (KQs) 1, 2, and 2a pertaining to the effectiveness of disposable, reusable and reprocessed PPE were adequately addressed by a total of 24 published and in-progress evidence reviews. Three of these reviews also partially covered a part of KQ 1a pertaining to strategies for optimizing the use of limited PPE supply during the pandemic. The remainder of KQ 1a pertaining to broader aspects of PPE supply chain management and the nominator's concerns related to environmental and public health impacts of different forms of PPE are outside the scope of the AHRQ EHC Program which focuses on developing evidence reviews to inform decision-making about healthcare interventions or care delivery. Because the nomination questions are either sufficiently addressed by the existing reviews or are outside the scope of the EHC Program, AHRQ will not develop a new evidence review.

Key Findings

We found eight systematic reviews⁹⁻¹⁶, including one Cochrane review¹¹, and eight rapid reviews¹⁷⁻²⁴ (including one rapid review update²⁴) which assessed the effectiveness and comparative effectiveness of reusable and disposable PPE in preventing infection transmission within healthcare settings (KQ 1). Two systematic reviews^{15, 16} and one rapid review¹⁹ assessed strategies to optimize the limited supplies of PPE (KQ 1a).

Three systematic reviews^{9, 14, 25} and five rapid reviews^{19, 23, 26-28} assessed the effectiveness of extended use and reprocessing/reuse of PPE compared to standard use (KQ 2). Five published systematic^{9, 25, 29-31} and two rapid reviews^{27, 32} in addition to five protocols³³⁻³⁷ for in-development systematic reviews, examined the safety and efficacy of different methods of PPE reprocessing and reuse (KQ2a).

Background

PPE is a critical component of infection prevention and control strategies in healthcare and community settings. Safe and effective use of PPE is essential to protect healthcare workers and transmission within healthcare settings and in the community. Effective use of PPE is particularly important during the COVID-19 pandemic because of the high prevalence of the coronavirus disease (SARS-CoV-2) (3,296,599 confirmed SARS-CoV-2 cases reported in the U.S. according to July 13, 2020 CDC report³⁸) and high rates of asymptomatic infection transmission³⁹.

PPE can be effective only if the equipment can form a barrier between healthcare workers and infectious pathogens. All manufactured PPE must meet strict technical standards, and its use in healthcare settings is regulated by infection prevention and control guidelines. Recent widespread shortages of PPE and the need to conserve limited reserves necessitated temporary solutions involving extended use, reuse and reprocessing of PPE. The World Health Organization (WHO)², the Centers for Disease Control and Prevention (CDC)¹ and other authorities issued guidelines on rational use of PPE and recommendations for alternative methods of PPE use. However, there is uncertainty regarding the effectiveness, comparative effectiveness and risks associated with PPE reprocessing and reuse resulting in inconsistent recommendations across different guidelines. Additionally, the recent shift towards a greater use of disposable and less reusable PPE raised additional concerns regarding environmental, economic, and public health impacts⁴⁰ associated with manufacturing, use and disposal of less environmentally sustainable healthcare equipment⁸.

Nomination Summary

This research topic was nominated by a group of Harvard and Yale physician climate leaders interested in the environmental sustainability of healthcare services. They are interested in a comprehensive evidence review assessing (1) the benefits and harms of reusable compared to disposable compared to reprocessed PPE for infection control and prevention in healthcare settings and (2) the environmental and public health impacts associated with the manufacturing, use, and disposal of different types of PPE by the healthcare industry. Though assessment of environmental impacts is outside the scope of AHRQ and the EHC Program, in the course of our evidence literature search we identified a few relevant studies that may be of interest to the nominator. These are included under Related Resources.

Scope

1. What is the effectiveness and comparative effectiveness of different types of disposable and reusable PPE (in addition to standard precautions) for infection prevention and control in healthcare settings?
 - (a) What are the costs of acquisition, utilization, disposal, and supply-availability related considerations of disposable and reusable PPE?

2. What is the effectiveness and comparative effectiveness of extended use and the reprocessing followed by reuse of PPE compared to standard use (i.e. guideline mandated frequency and duration) for infection prevention and control in healthcare settings?
 (a) What is the efficacy and safety of different methods for PPE reprocessing?

Table 1. Questions and PICOS (population, intervention, comparator, outcome, and setting)

Questions	1. Effectiveness and comparative effectiveness of reusable and disposable PPE to prevent infection transmission (a) Costs and supply availability considerations for reusable and disposable PPE	2. Effectiveness and comparative effectiveness of extended use and reuse of PPE compared to standard use (a) Efficacy and safety of different methods of PPE reprocessing
Population	Healthcare workers (physicians, nurses, other healthcare staff), other healthcare services personal (environmental services employees, janitorial staff, etc.)	Healthcare workers (physicians, nurses, other healthcare staff), other healthcare services personal (environmental services employees, janitorial staff, etc.)
Interventions	Below PPE types, used individually or in combination: Disposable PPE Facial/Respiratory protection <ul style="list-style-type: none"> • Medical/surgical facemasks • N-95 and FFP2 respirators Eye protection <ul style="list-style-type: none"> • Face shields Contact isolation equipment <ul style="list-style-type: none"> • Isolation gowns • Surgical gowns • Isolation aprons • Lab coats • Protective full body suits Gloves (nonsterile) Reusable PPE <ul style="list-style-type: none"> • Powered air purifying respirators (PAPR) • Elastomeric facepiece respirators (EFR) • Goggles • Fabric isolation gowns 	Extended use (i.e. wearing the same facemask for repeated close contact encounters with several different patients, without removing the facemask between patient encounters.) Reprocessing/reuse (i.e. repeat use after decontamination, disinfection and/or sterilization process) using one or more of the following (or other) methods: <ul style="list-style-type: none"> • Ultraviolet germicidal irradiation • Microwave and heat-based decontamination • Dry heat inactivation • Autoclave sterilization • Chemical disinfection (i.e. chlorine dioxide, hydrogen perchloride, ethylene oxide, etc.)
Comparators	One type of PPE (used individually or in combination) compared to other type	Standard use (duration and frequency) compared to extended use compared to reprocessing (i.e. use following decontamination)
Outcomes	KQ1: Effectiveness at preventing infection: <ul style="list-style-type: none"> • Transmission to healthcare workers • Transmission to patients KQ 1a: Supply availability: <ul style="list-style-type: none"> • Risk of supply-chain interruptions • Supply shortages KQ 1a: Costs: <ul style="list-style-type: none"> • Acquisition per unit cost • Storage, reprocessing and disposal related costs 	KQ 2: Effectiveness at preventing infection: <ul style="list-style-type: none"> • Transmission to healthcare workers • Transmission to patients KQ 2a: Efficacy of reprocessing methods: <ul style="list-style-type: none"> • Reduction in viral/bacterial load KQ 2-2a: Performance post-reprocessing: <ul style="list-style-type: none"> • Aerosol penetration • Airflow resistance • Fit/structural integrity • Physical appearance • Residual odor/chemical residues KQ 2-2a: Usability and comfort:

		<ul style="list-style-type: none"> • Donning and doffing ease • Wearing comfort
Setting	Inpatient and outpatient healthcare settings, nursing homes, long-term care facilities, etc.	Inpatient and outpatient healthcare settings, nursing homes, long-term care facilities, etc.

Abbreviations: NA=not applicable; PPE=personal protective equipment; PAPR=Powered Air Purifying Respirator. EFR= Elastomeric Faceplates Respirator

Assessment Methods

See Appendix A.

Summary of Literature Findings

Our search identified eight systematic reviews⁹⁻¹⁶ and eight rapid reviews¹⁷⁻²⁴ pertaining to KQ1 (effectiveness of reusable and disposable PPE). Fifteen of the sixteen reviews have been published since March 2020 in response to the COVID-19 pandemic, and thus have overlapping questions and evidence. Fifteen reviews, including seven systematic reviews^{9, 10, 12-16} and eight rapid reviews^{18-21, 23, 24, 26, 28} compared the effectiveness of medical and surgical facemasks and N95 respirators. Three systematic reviews^{9, 10, 13} and one living rapid review¹⁹ (including a rapid review update²⁴) evaluated the effectiveness of cloth facemasks. One systematic review¹¹ and one preprint rapid review²³ directly compared reusable and disposable facepiece respirators (N95 versus elastomeric facepiece respirators (EFRs) and powered air purifying respirators (PAPRs)). Four systematic reviews^{9, 11, 15, 16} and two rapid reviews^{20, 23} (one preprint) included studies of eye protection (goggles, face shields and eye protection integrated with PAPRs). One additional Cochrane review¹¹ assessed the effectiveness of full body suits, isolation gowns and aprons at preventing contact-based infection transmission; they found one study comparing reusable fabric gowns to disposable gowns.

Two systematic reviews^{15, 16} and one rapid review¹⁹ considered methods to optimize the use of limited PPE supplies in the context of the COVID-19 pandemic (KQ1a). No evidence reviews and only one primary economic modeling study⁴¹ addressed the remainder of KQ1a, pertaining to costs associated with the acquisition, storage, use and disposal of reusable, disposable, and reprocessed respiratory PPE (i.e. filtering facemasks and powered air purifying respirators)

We found three systematic reviews^{9, 14, 25}, five rapid reviews^{19, 23, 26-28} (two pre-prints) pertaining to KQ2. These reviews assessed the comparative effectiveness of extended use and reuse/reprocessing of PPE compared to standard use. Four published systematic^{9, 25, 29, 31} and two rapid reviews^{27, 32} in addition to five protocols³³⁻³⁷ for upcoming systematic reviews assessed the efficacy and safety of different reprocessing methods (decontamination, disinfection and sterilization) for facemasks and N95 respirators (KQ2a). One systematic review²⁵ compared the efficacy of different reprocessing methods for surgical facemasks. One rapid review²⁶ synthesized the existing evidence for extended use of N95 respirators. Four upcoming reviews^{33-35, 37} will assess the comparative efficacy and safety of different methods of reprocessing for medical facemasks and N95 respirators. One upcoming living systematic review³⁶ will specifically examine how different methods of reprocessing of N95 respirators impact their function and performance.

See Appendix Tables C1 and C2 for descriptions of the evidence reviews.

Table 2. Literature identified for the nomination question

Question	Systematic reviews (6/2017-6/2020)
1. Effectiveness and comparative effectiveness of reusable and disposable PPE	Total reviews: 16 ^{9-24, 42, 43} Total systematic reviews – 8 ⁹⁻¹⁶ <ul style="list-style-type: none"> • Cochrane – 1¹¹ Total rapid reviews – 8 ¹⁷⁻²⁴ <ul style="list-style-type: none"> • Pre-print – 1²³ • Rapid review update – 1²⁴
1(a). Costs and supply availability factors	Total reviews: 3 ^{15, 16, 19} Total systematic reviews – 2 ^{15, 16} Total rapid reviews – 1 ¹⁹
2. Effectiveness and comparative effectiveness of extended use, reprocessing/reuse vs standard use of PPE	Total reviews: 8 ^{9, 14, 19, 23, 25-28} Total systematic reviews – 3 ^{9, 14, 25} Total rapid reviews – 5 ^{19, 23, 26-28} <ul style="list-style-type: none"> • Pre-print – 2^{23, 27}
2(a). Efficacy and safety of PPE reprocessing methods	Total reviews: 8 ^{9, 25, 27, 29-32} Total systematic reviews – 5 ^{9, 25, 29-31} <ul style="list-style-type: none"> • Pre-print – 3^{30, 31} Total rapid reviews – 2 ^{27, 32} <ul style="list-style-type: none"> • Pre-print – 1²⁷ • In-progress – 1³² Systematic review protocols – 5 ³³⁻³⁷

Abbreviations: NA=not applicable; PPE=personal protective equipment.

See Appendix B for detailed assessments of all EPC selection criteria.

Summary of Selection Criteria Assessment

For this nomination, KQs 1, 2 and 2a were sufficiently addressed by existing reviews. For KQ1a, we found two systematic reviews^{15, 16} and one rapid review²³ that considered certain aspects of optimizing the use of limited PPE supply but did not address the entire question.

Please see Appendix B for detailed assessments of individual EPC Program selection criteria.

Related Resources

We identified additional information in the course of our assessment that may be useful to the nominator. One economic modeling study⁴¹ examined the financial expenditures associated with utilization of different types of PPE (an assessment relevant to KQ 1a). Another primary study provided an environmental lifecycle assessment of reusable and disposable medical isolation gowns, addressing the environmental and public health impacts of reusable, disposable, and reprocessed PPE.

In addition, the Emergency Care Research Institute (ECRI) has produced reviews of environmental footprints of the healthcare industry. ECRI's recent guidance report developed in conjunction with the U.S. Environmental Protection Agency that discusses environmentally preferable purchasing and other methods of reducing energy consumption by the healthcare industry can be found on their website⁴⁴.

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Appendix A: Methods

We assessed nomination for priority for a systematic review or other AHRQ Effective Health Care report with a hierarchical process using established selection criteria. Assessment of each criteria determined the need to evaluate the next one. See Appendix B for detailed description of the criteria.

Appropriateness and Importance

We assessed the nomination for appropriateness and importance.

Desirability of New Review/Absence of Duplication

We searched for high-quality, completed or in-process evidence reviews published in the last three years on May 8, 2020 followed by a repeat search on June 12, 2020 on the questions of the nomination from these sources:

- AHRQ: Evidence reports and technology assessments
 - AHRQ Evidence Reports <https://www.ahrq.gov/research/findings/evidence-based-reports/index.html>
 - EHC Program <https://effectivehealthcare.ahrq.gov/>
 - US Preventive Services Task Force <https://www.uspreventiveservicestaskforce.org/>
 - AHRQ Technology Assessment Program <https://www.ahrq.gov/research/findings/ta/index.html>
- US Department of Veterans Affairs Products publications
 - Evidence Synthesis Program <https://www.hsrd.research.va.gov/publications/esp/>
 - VA/Department of Defense Evidence-Based Clinical Practice Guideline Program <https://www.healthquality.va.gov/>
- Cochrane Systematic Reviews <https://www.cochranelibrary.com/>
- Cochrane COVID Rapid Reviews: <https://covidrapidreviews.cochrane.org/>
- CEBM Oxford COVID-19 Evidence Service <https://www.cebm.net/oxford-covid-19-evidence-service/>
- University of York Centre for Reviews and Dissemination database <https://www.crd.york.ac.uk/CRDWeb/>
- PROSPERO Database (international prospective register of systematic reviews and protocols) <http://www.crd.york.ac.uk/prospéro/>
- PubMed <https://www.ncbi.nlm.nih.gov/pubmed/>
- Campbell Collaboration <http://www.campbellcollaboration.org/>
- McMaster Health System Evidence <https://www.healthsystemsevidence.org/>
- WHO Health Evidence Network <http://www.euro.who.int/en/data-and-evidence/evidence-informed-policy-making/health-evidence-network-hen>

Impact of a New Evidence Review

The impact of a new evidence review was qualitatively assessed by analyzing the current standard of care, the existence of potential knowledge gaps, and practice variation. We considered whether it was possible for this review to influence the current state of practice through various dissemination pathways (practice recommendation, clinical guidelines, etc.).

Feasibility of New Evidence Review

We conducted a limited literature search in Ovid MEDLINE for the last five years from 7/12/2015 to 7/12/2020. We reviewed all titles and abstracts of the identified studies for inclusion. We classified identified studies by question and study design to estimate the size and scope of a potential evidence review.

Search strategy

Ovid MEDLINE(R) ALL 1946 to June 11, 2020
Date searched: June 12, 2020
1 Personal Protective Equipment/ or Protective Clothing/ or Masks/ or Respiratory Protective Devices/ (12335)
2 ("personal protective equipment" or PPE or cap or caps or aprons or capes or coveralls or "elastomeric respirator*" or facemask* or facepiece* or gowns or hat or hats or headwear or masks or N95 or "protective clothing" or (respiratory adj2 (device* or protect*)) or wrap or wraps).ti,ab,kf. (83857)
3 or/1-2 (91868)
4 Equipment Reuse/ (2868)
5 (reusab* or reuse or reusing or sustainability).ti,ab,kf. (44320)
6 or/4-5 (46032)
7 and/3,6 (455)
8 limit 7 to english language (426)
9 limit 8 to yr="2015 -Current" (206)
10 randomized controlled trials as topic/ or random allocation/ or double-blind method/ or single-blind method/ or exp clinical trial as topic/ or placebos/ or research design/ or comparative study/ or exp evaluation studies/ or follow up studies/ or prospective studies/ (3444646)
11 ("randomized controlled trial" or "controlled clinical trial" or "clinical trial").pt. (837812)
12 ((clin* adj25 trial*) or ((single* or doubl* or trebl* or tripl*) adj25 (blind* or mask*)) or control* or placebo* or prospective* or random* or volunteer*).ti,ab. (5248803)
13 or/10-12 (7526603)
14 animals/ not humans/ (4673354)
15 13 not 14 (6247396)
16 and/9,15 (67)
17 exp cohort studies/ or exp epidemiologic studies/ or exp clinical trial/ or exp evaluation studies as topic/ or exp statistics as topic/ (5533571)
18 ((control and (group* or study)) or (time and factors) or program or survey* or ci or cohort or comparative stud* or evaluation studies or follow-up*).mp. (7280615)
19 or/17-18 (9574715)
20 (animals/ not humans/) or comment/ or editorial/ or exp review/ or meta analysis/ or consensus/ or exp guideline/ (8427530)
21 hi.fs. or case report.mp. (610364)
22 or/20-21 (8957471)
23 19 not 22 (7390151)
24 and/9,23 (73)

25 or/16,24 (102)

26 9 not 25 (104)

EBM Reviews - Cochrane Central Register of Controlled Trials May 2020

Date searched: June 12, 2020

Date searched: June 12, 2020

1 ("personal protective equipment" or PPE or cap or caps or aprons or capes or coveralls or "elastomeric respirator*" or facemask* or facepiece* or gloves or gowns or hat or hats or headwear or masks or N95 or "protective clothing" or (respiratory adj2 (device* or protect*)) or tyvek or wrap or wraps).ti,ab. (8261)

2 (reusab* or reuse or reusing or sustainability).ti,ab. (2643)

3 and/1-2 (55)

4 limit 3 to yr="2015 -Current" (27)

Appendix B. Selection Criteria Assessment

Selection Criteria	Assessment
1. Appropriateness	
1a. Does the nomination represent a health care drug, intervention, device, technology, or health care system/setting available (or soon to be available) in the United States?	Yes. The CDC requires disposable and reusable PPE in all healthcare settings in the U.S. for infection control and prevention re. KQs 1, 2 and 2a pertain to comparative effectiveness of different types of PPE. KQs 1a relates to PPE costs and supply chain management.
1b. Is the nomination a request for an evidence report?	Yes.
1c. Is the focus on effectiveness or comparative effectiveness?	Yes.
1d. Is the nomination focus supported by a logic model or biologic plausibility? Is it consistent or coherent with what is known about the topic?	Yes.
2. Importance	
2a. Represents a significant disease burden; large proportion of the population	Yes as of July 13, 2020, the CDC reported over 3 million of confirmed COVID-19 cases in the U.S. ³⁸ . Healthcare workers are at increased risk for contracting COVID-19 and care organizations are required to protect them by providing guideline mandated PPE Recent review ⁴⁵ revealed high prevalence rates of confirmed COVID-19 infection in healthcare workers (between 1.12% and 18.6%) and noted a strong association between PPE use and decreased infection risk. As such, effective use of PPE is important to protect people in healthcare and community settings.
2b. Is of high public interest; affects health care decision making, outcomes, or costs for a large proportion of the U.S. population or for a vulnerable population	According to the July 2, 2020 Congressional Budget Office report, the COVID-19 pandemic will cost the U.S. economy an estimated \$7.9 trillion ⁴⁶ over the next decade. This includes an estimated 56 billion to 556 billion in healthcare costs over the next two years. High costs of care will disproportionately affect over 30 million of uninsured Americans who may be expected to cover an expected average of \$73,300 for a COVID-19 related hospital stay compared to approximately a half of that amount (an estimated \$38,221) when it is covered by insurance ⁴⁷ .
2c. Incorporates issues around both clinical benefits and potential clinical harms	Yes. This topic concerns comparative effectiveness of different forms of PPE and efficacy and safety of procedures for PPE reprocessing.
2d. Represents high costs due to common use, high unit costs, or high associated costs to consumers, to patients, to health care systems, or to payers	Yes. The April 7, 2020 report by the Society for Healthcare Organization Procurement Professionals (SHOPP) ⁴⁸ calculated the daily costs of PPE for healthcare worker according to the current CDC guidelines. The SHOPP reported a 1084% increase in PPE costs per one healthcare worker from pre-COVID-19 pricing.
3. Desirability of a New Evidence Review/Absence of Duplication	
3. A recent high-quality systematic review or other evidence review is not available on this topic	KQs 1, 2 and 2a were sufficiently addressed by published reviews. We found 16 reviews ^{9-24, 42, 43}

	<p>relevant to KQ1, eight reviews^{9, 14, 19, 23, 25-28} for KQ2 and eight reviews^{9, 25, 27, 29-32} and five protocols³³⁻³⁷ for upcoming systematic reviews for KQ2a.</p> <p>Three reviews^{15, 16, 19} partially addressed a part of KQ1a regarding the supply availability of different PPE types.</p>
4. Impact of a New Evidence Review	
4a. Is the standard of care unclear (guidelines not available or guidelines inconsistent, indicating an information gap that may be addressed by a new evidence review)?	<p>Yes. The CDC⁴⁹, FDA⁵⁰, and other regulatory agencies issued recent guidance on optimizing the use of PPE. However, this guidance focuses mainly on compliance with hospital infection control standards and does not consider environmental harms of healthcare services. There is little guidance regarding the environmental and public health impacts⁷ of different types of PPE to help healthcare organizations make environmentally conscious supply purchasing decisions.</p>
4b. Is there practice variation (guideline inconsistent with current practice, indicating a potential implementation gap and not best addressed by a new evidence review)?	<p>Yes. Most healthcare organizations purchase their supplies, including PPE based on cost and patient and employee safety considerations and without considering their environmental sustainability.</p>
5. Primary Research	
<p>5. Effectively utilizes existing research and knowledge by considering:</p> <ul style="list-style-type: none"> - Adequacy (type and volume) of research for conducting a systematic review - Newly available evidence (particularly for updates or new technologies) 	<p>We found only one primary study⁴¹ that addressed a part of KQ1a related to costs of stockpiling of PPE.</p>

Abbreviations: AHRQ=Agency for Healthcare Research and Quality; CDC=Centers for Disease Control and Prevention; COVID-19=coronavirus disease 2019; FDA=Food and Drug Administration; KQ=key question; PPE=personal protective equipment.

Appendix C. Summary of Included Systematic Reviews

Table C1. Published Systematic Reviews

Author, Year, Country, Study Type, n of included studies	Population and Setting	Intervention vs Comparator	Relevant Outcomes	Results
<p>Garcia Godoy et al.⁹, 2020</p> <p>USA</p> <p>Scoping Review</p> <p>n=67 (48 peer-reviewed studies and 19 gray literature articles)</p>	<p>Healthcare workers (nurses, doctors, co-medical personnel), healthy volunteers (for laboratory/ controlled studies)</p> <p>Patient care settings (inpatient and outpatient), experimental/laboratory settings</p>	<p>The following PPE types, used alone or in combination were compared to one another:</p> <ul style="list-style-type: none"> • Medical facemasks • Surgical facemasks • Fabric (non-medical grade) facemasks • N-95 respirators • Other respirators (KF94, KF80) • Face shields <p>Continuous vs targeted use of medical and surgical facemasks and N95 respirators</p> <p>Efficacy of PPE preprocessing strategies, including but not limited to the following decontamination methods:</p> <ul style="list-style-type: none"> • Ultraviolet germicidal irradiation (UVGI) • Microwave irradiation • Microwave generated steam and moist heat incubation • Chemical decontamination (i.e. hydrogen peroxide gas plasma, 70% isopropyl alcohol etc.) 	<p>Self-reported (based on symptoms) or laboratory confirmed viral (e.g., SARS-CoV-2, influenza A/B etc.) or bacterial (E. Coli etc.) upper respiratory infection</p> <p>Efficacy of different PPE decontamination methods:</p> <ul style="list-style-type: none"> • Fractional penetration by viral particles • Resistance of SARS coronavirus to temperature and UV irradiation • Face fit • Changes in physical appearance, odor, and filtration performance 	<p>Compared to surgical facemasks, N95 respirators performed better in laboratory settings, may provide superior protection in inpatient settings and are equivocal in outpatient settings.</p> <p>Conserving surgical mask and N95 respirator supplies through extended use, reuse, or decontamination may result in inferior protection.</p> <p>Alternative forms of facial protection (non-medical grade facemasks) offer inferior protection.</p>

Author, Year, Country, Study Type, n of included studies	Population and Setting	Intervention vs Comparator	Relevant Outcomes	Results
<p>Liang et al., 2020¹⁰</p> <p>China</p> <p>Systematic Review and Meta-Analysis</p> <p>n=21 (13 case control, 6 cluster RCTs, 2 cohort)</p>	<p>Healthcare workers (12 studies) Nonhealthcare professional populations (8 studies) Healthcare workers and patient contacts (1 study)</p> <p>Patient care and community settings</p>	<p>The following PPE types, used alone or in combination, compared to one another:</p> <ul style="list-style-type: none"> • Medical facemasks • Surgical facemasks • Fabric (paper or cotton) facemasks • N-95 respirators 	<p>Self-reported (based on symptoms) or laboratory confirmed viral respiratory infection.</p> <p>Prevention of respiratory viral infection transmission.</p>	<p>Wearing facemasks and N95 respirators was effective for protecting healthcare workers from SARS infection in a hospital setting. However, gowns and gloves did not show a measurable protective effect.</p> <p>Fit tested and non-fit tested N95 respirators were not significantly different in their performance.</p>
<p>Verbeek et al., 2020¹¹</p> <p>Finland</p> <p>Cochrane Systematic Review</p> <p>n=24 (14 RCT, 1 quasi-RCT, 9 nonrandomized trials)</p>	<p>Healthcare workers and ancillary hospital staff, non-healthcare laboratory staff</p> <p>Patient care settings, experimental/laboratory settings</p>	<p>Powered air purifying respirator (PAPR) plus coverall vs N95 respirator plus isolation gown</p> <p>Modified (more protective) PPE vs standard PPE:</p> <ul style="list-style-type: none"> • Gowns with sealed gown-glove interface • Gowns with improved fit around the neck, wrists, and hands • Added grab tabs to facilitate doffing of masks or gloves <p>Gowns vs aprons for preventing infectious exposures from contact with contaminated body fluids</p> <p>Different types of full body PPE compared to another PPE type for preventing infectious exposures from contact with contaminated body fluids.</p>	<p>Contamination of body sites (skin surface and PPE) using visible fluorescence marker</p> <p>Contamination with viral or bacterial pathogen, quantity of viral or bacterial contamination</p> <p>PPE usability as assessed by the users (comfort, ease of donning and doffing, satisfaction with use etc.)</p> <p>Donning and doffing compliance; donning and doffing time.</p>	<p>Covering more of the body leads to better protection but is associated with increased difficulty related to putting on and removing PPE.</p> <p>Respirators worn with coveralls may protect better than a mask worn with a gown but are more difficult to put on.</p> <p>More breathable types of PPE may have similar surface contamination rates but are associated with greater user satisfaction.</p>

Author, Year, Country, Study Type, n of included studies	Population and Setting	Intervention vs Comparator	Relevant Outcomes	Results
		<p>Different types of methods of PPE donning and doffing compared to one another</p> <p>Water repellent vs breathable PPE fabric (1 study)</p>		
<p>Bartoszko et al, 2020¹²</p> <p>Canada</p> <p>Systematic Review and Meta-Analysis</p> <p>n=4 RCTs</p>	<p>Healthcare workers</p> <p>Patient care settings, including inpatient (emergency department, wards) and outpatient (outpatient primary care and dental clinics etc.)</p>	<p>Medical and surgical facemasks compared to N95 respirators and FFP2 respirators</p>	<p>Laboratory confirmed viral respiratory infection</p> <p>Serology confirmed viral infection</p> <p>Laboratory confirmed coronavirus infection</p> <p>Laboratory confirmed influenza</p> <p>Influenza -like illness</p> <p>Clinical respiratory illness</p> <p>Workplace absenteeism.</p>	<p>Low certainty evidence suggests that medical masks and N95 respirators offer similar protection against respiratory viral infections (including with coronavirus) to healthcare workers engaged in direct patient care (without performing aerosol generating procedures).</p>
<p>Offeddu et al., 2017¹³</p> <p>UK</p> <p>Systematic Review and Meta-Analysis</p> <p>n=29 (6 RCT and 23 observational studies)</p>	<p>Healthcare workers</p> <p>Healthcare settings, including inpatient and outpatient settings</p>	<p>Medical facemasks vs N95 respirators (fit tested or non-fit tested)</p> <p>Continuous or targeted use of N95 respirators versus medical facemasks</p> <p>Surgical facemasks vs N95 respirators (including continuous vs targeted use of each)</p> <p>Nonmedical grade cotton facemasks: double layered versus single layered</p> <p>Any surgical facemask compared to another compared to N95 respirator</p>	<p>Self-reported (based on symptoms) or laboratory confirmed upper respiratory while or bacterial infection</p>	<p>Compared to medical and surgical facemasks, N95 respirators conferred superior protection against clinical respiratory illness and laboratory confirmed bacterial, but not viral infections.</p> <p>Wearing multilayered cotton masks is not associated with protection from SARS infection</p>

Author, Year, Country, Study Type, n of included studies	Population and Setting	Intervention vs Comparator	Relevant Outcomes	Results
<p>Long et al., 2020¹⁴</p> <p>China</p> <p>Systematic Review and Meta-Analysis</p> <p>n=6 RCTs</p>	<p>Healthcare workers (5 studies), household members of a laboratory confirmed SARS infected case (1 study)</p> <p>Healthcare settings (inpatient and outpatient) (5 studies), community setting (1 study)</p>	<p>Targeted use of surgical facemasks vs fit-tested N95 respirators</p> <p>Continual use of surgical facemasks vs non-fit tested N95 respirators</p> <p>Continual use of fit tested vs non-fit tested N95 respirators compared to continual use of surgical facemasks</p> <p>Continual use of fit tested N95 respirators vs targeted use of fit test N95 respirators compared to continual use of surgical facemasks</p> <p>Targeted use of fit tested N95 respirators compared to targeted use of medical facemasks</p>	<p>Self-reported (based on symptoms) or laboratory confirmed respiratory viral infection (Influenza A/B, RSV, coronavirus)</p> <p>Workplace absenteeism</p>	<p>The use of N95 respirators compared to surgical facemasks is not associated with lower rates of laboratory confirmed influenza. This suggests that N95 respirators should not be recommended for general public and healthcare workers without direct contact with patients with confirmed or suspected influenza infection.</p>
<p>Chu et al., 2020¹⁵</p> <p>Canada</p> <p>Systematic Review and Meta-Analysis</p> <p>n=172 observational studies included in SR, 44 studies in meta-analysis)</p>	<p>Healthcare workers, non-healthcare workers</p> <p>Healthcare (inpatient and outpatient) settings and community settings</p>	<p>Medical or surgical facemasks or 12-16-layer cotton masks compared to no facemasks</p> <p>Medical or surgical facemasks compared to N95 respirators</p> <p>Eye protection (eye goggles or face shields) compared to no eye protection</p> <p>2 qualitative and 2 cross-sectional studies reported on data related to the cost PPE</p>	<p>Risk of transmission (defined confirmed or probable COVID-19, SARS, or MERS) from noninfected to infected individuals</p> <p>COVID-19, SARS, or MERS infection related hospitalizations</p> <p>COVID-19, SARS, or MERS infection related intensive care unit admissions</p>	<p>The use of medical or surgical facemasks could lead to a larger reduction in infection risk. N95 and similar facepiece respirators showed stronger associations with reduced infection compared to disposable surgical or similar facemasks (i.e. reusable 12-16-layer cotton masks).</p> <p>Using eye protection was also associated with less infection</p>

Author, Year, Country, Study Type, n of included studies	Population and Setting	Intervention vs Comparator	Relevant Outcomes	Results
		and resource use in the management of SARS (2 studies), MERS (1 study) and SARS-CoV-2 (1 study)		compared with not using eye protection.
Jessop et al., 2020¹⁶ UK Systematic Review n=95 studies	Healthcare (surgical wards and operating room) settings	Types of PPE reviewed: <ul style="list-style-type: none"> • Surgical facemasks • FFP2 and FFP3 masks • N95 respirators • Eye protection • Surgical gowns • Disposable aprons • Gloves <p>The review also considered ethical aspects of rationing PPE due to supply shortages and touched on a number of innovative solutions to meeting the PPE demand during the times of pandemic.</p>	Risk of infection transmission during surgical procedures with different types of PPE Sources of transmission of infection during surgical procedures	The review provides practical advice on all aspects of PPE use in surgical practice
Iannone et al., 2020¹⁸ Italy Rapid Review n=5 studies (1 RCT and 4 cluster studies)	Healthcare workers (4 studies) and community dwelling adults (1 study) Healthcare (inpatient wards, emergency departments, outpatient clinics) setting (4 studies) and community setting (1 study)	Surgical facemasks vs N95 respirators Surgical facemasks vs FFP-2 masks Medical facemasks vs N95 respirators Medical facemasks vs fit-tested and non-fit-tested N95 respirators	Laboratory confirmed respiratory viral infections Laboratory confirmed bacterial colonization Clinical respiratory infection Influenza -like illness	Wearing N95 respirators can prevent approx. 75 more respiratory viral infections per 1000 healthcare workers compared to surgical facemasks. N95 respirators were more effective than surgical facemasks at protecting against laboratory confirmed respiratory bacterial and viral infections. There was no direct high-quality evidence to show whether N95 respirators were also superior to surgical facemasks for

Author, Year, Country, Study Type, n of included studies	Population and Setting	Intervention vs Comparator	Relevant Outcomes	Results
				protecting against SARS-CoV-2 infection.
Chou et al, 2020¹⁹ USA Living Rapid Review n=39	Healthcare workers and healthcare workers, community dwelling adults Healthcare settings, community settings	N95 respirators or equivalent, medical and surgical facemasks, cloth masks, surgical paper masks and P2 masks One type of mask versus another type of mask, mask single use versus reuse, mask use versus non-use.	Laboratory confirmed infection Clinical respiratory illness Influenza -like illness Infection with SARS-CoV-2, SARS-CoV-1, or MERS-CoV-1 Harms of mask usage	Evidence for the effectiveness of masks to prevent respiratory infections is stronger in healthcare compared to community settings. N95 respirators may result in greater reduction of SARS-CoV-1 infection risk in healthcare settings compared to surgical masks, but the applicability to SARS-CoV-2 is uncertain.
Chou et al., 2020²⁴ USA Living Rapid Review Update n=1	Household contacts of laboratory confirmed COVID-19 cases Healthcare and community settings	N95 respirator vs surgical facemask N95 respirator vs surgical facemask vs cloth mask Surgical facemask vs cloth mask N95 respirator or surgical facemask vs cloth mask	SARS-CoV-2 infection SARS-CoV-1 or MERS-CoV infection Influenza infection influenza -like illness Other respiratory illness (excluding pandemic coronaviruses)	There was no association between mask use after illness onset in the index case and risk for SARS-CoV-2 infection among family members. Although the new study provides evidence for effectiveness of mask use in community settings to prevent SARS-CoV-2 infection, the strength of evidence is insufficient.
Greenhalgh et al., 2020²¹ UK Rapid Review n=1	Healthcare workers Healthcare setting	Shoe protective equipment (shoe covers) as a component of healthcare worker PPE	Outcomes related to reducing infection transmission	The review found no relevant trials and only one observational study related to the use of protective shoe covers by healthcare workers. More research is needed to determine whether shoe covers should be included as a part of PPE.
Greenhalgh et al., 2020²² UK	Healthcare workers Healthcare setting	N95 respirators compared to fluid resistant surgical facemasks (FRSM)	Laboratory confirmed influenza Laboratory confirmed respiratory infection Influenza like illness	Included studies provide cautious support for the use of surgical facemasks to protect from respiratory viral infections

Author, Year, Country, Study Type, n of included studies	Population and Setting	Intervention vs Comparator	Relevant Outcomes	Results
Rapid Review n=17			Confirmed bacterial colonization	when providing patient care (without performing aerosol generating procedures)
NSW Health. COVID-19 Critical Intelligence Unit, 2020²⁰ Australia Rapid Review	Healthcare workers Healthcare setting	This review examined current guidelines on the use of PPE and the evidence behind the guidelines. The following PPE types reviewed: Medical/surgical facemasks Eye protection N95/FFP2 or equivalent respirators Gloves and gowns	Respiratory virus transmission Functional respirator performance characteristics	The review evaluated contemporary guidance on the use of PPE in healthcare settings to prevent SARS-CoV-2 infection and examined the evidence base underlying the guidelines' recommendations.
Zorko et al., 2020²⁵ Canada Systematic Review n=7	Experimental/laboratory settings	Surgical facemasks Reprocessing methods for surgical facemasks including the following: <ul style="list-style-type: none"> • Dry heat • Moist heat (autoclave) • Chemical disinfection (70% ethanol, isopropyl, sodium hypochlorite) 	Mask performance (i.e. filtration efficiency and airflow resistance) Reduction in pathogen load In-vivo infection rates following use of the contaminated masks Changes in physical appearance (i.e. mask appearance or physical degradation) User experience (i.e. skin irritation) Feasibility of the intervention (i.e. time, cost, resource utilization)	Mask performance was best preserved with using dry heat-based decontamination. There is limited evidence on the safety or efficacy of other techniques to decontaminate surgical facemasks.
NSW Health. COVID-19 Critical Intelligence Unit, 2020²⁶ Australia Rapid Review	Healthcare workers Healthcare settings	Surgical facemasks compared to N95 respirators	Laboratory confirmed influenza Laboratory confirmed respiratory viral infection Laboratory confirmed respiratory infection Influenza like illness	The review found one meta-analysis based on six RCTs and no primary studies comparing the effectiveness of surgical facemasks and N95 respirators. The meta-analysis showed no statistically significant difference

Author, Year, Country, Study Type, n of included studies	Population and Setting	Intervention vs Comparator	Relevant Outcomes	Results
				in efficacy of surgical facemasks and N95 respirators to prevent laboratory confirmed viral illness
MacIntyre et al., 2020²⁸ Australia Rapid Review n=19 RCTs	Healthcare workers, community dwelling adults Healthcare settings, community settings	Medical facemasks, P2 masks Medical facemasks vs targeted use of N95 respirators Medical facemasks vs fit tested N95 respirators vs non-fit tested N95 respirators Medical facemasks vs continuous use of N95 respirators vs targeted use of N95 respirators	Respiratory infection transmission related outcomes	RCT data supports continuous use of facepiece respirators during patient care shifts to prevent infection in healthcare workers. The same data suggests that community mask use by well people would also be beneficial, particularly to prevent COVID-19 transmission from pre-symptomatic individuals.
O’Hearn et al., 2020³⁵ Canada Systematic Review n=5	Experimental/laboratory setting	Effectiveness of ultraviolet germicidal irradiation to decontaminate N95 and SN95 respirators	Particle penetration and airflow resistance Germicidal impact (reduction of viral/bacterial pathogens) Physical characteristics (physical appearance, odor, fit, texture, chemical residues)	Ultraviolet germicidal irradiation was effective at decontaminating N95 respirators as they consistently maintained certification standards following UVGI.

Table 4. Pre-published and in-progress systematic reviews

Author, Year, Country, Study Type, n of included studies	Population and Setting	Intervention vs Comparator	Relevant Outcomes	Results
Burton et al, 2020²³ UK Rapid Review n=38 studies	Healthcare workers and experimental/laboratory setting	Filtering facepiece respirator (FFP) vs elastomeric facepiece respirator (EFR) vs fluid resistance surgical mask (FRSM) Filtering facepiece respirator (FFP) vs powered air purifying	Respirator fit User comfort/usability Ease-of-use during clinical activities Intubation time Speech intelligibility Headaches associated with mask use	Training on proper respirator use and ensuring adequate fit are essential for safe respirator use and failures result in reduced protection. All types of respirators may cause discomfort and interfere with users’ communication, which

Author, Year, Country, Study Type, n of included studies	Population and Setting	Intervention vs Comparator	Relevant Outcomes	Results
		respirator (PAPR) vs elastomeric facepiece respirator (EFR) Powered air purifying respirator (PAPR) vs elastomeric facepiece respirator (EFR) Filtering facepiece respirator (FFP) vs powered air purifying respirator (PAPR)		may limit their safe use if worn for prolonged periods of time. Studies suggest that respirator use has little negative impact on healthcare providers' work performance in the short term.
Gertsman et al., 2020³¹ Canada Systematic Review	Experimental/laboratory setting	Reprocessing strategies for N95 respirators, including: <ul style="list-style-type: none"> • Microwave irradiation and heat • Autoclaving 	Reduction in viral/bacterial load after decontamination interventions Aerosol penetration Airflow resistance Physical changes (fit, odor, degradation)	Microwave irradiation coupled with heat was safe and effective for decontaminating N95 respirators. However, autoclave-based disinfection had negative effect on fit and functional parameters of respirators and is not recommended.
O'Hearn et al., 2020³⁰ Canada Systematic Review n=13 studies	Experimental/laboratory setting	Different decontamination strategies for the processing of N95 and SN95 respirators: chemical disinfectants (sodium hypochlorite, ethanol, isopropyl alcohol)	Viral/bacterial load reduction following disinfection Aerosol penetration Airflow resistance Fit/comfort Physical appearance Residual odor User safety/skin irritation	N95 respirator sterilization using vaporized hydrogen peroxide was successful to ensure adequate decontamination. However, chemical decontamination with other disinfectants negatively affected respirator function and fit and is not recommended.
Toomey et al., 2020²⁷ Ireland Rapid Review n=4 SRs	Experimental/laboratory setting	Re-use, extended use or reprocessing of medical and surgical facemasks and N95 respirators <ul style="list-style-type: none"> • Microwave and heat-based disinfection • Decontamination using chemical disinfectants 	Decontamination effectiveness Respirator performance and appearance: <ul style="list-style-type: none"> • filtration efficiency • airflow resistance • physical integrity • fit • user comfort and safety 	There is limited evidence regarding the impact of extended use and reuse of surgical facemasks and respirators on their effectiveness for infection prevention.

Author, Year, Country, Study Type, n of included studies	Population and Setting	Intervention vs Comparator	Relevant Outcomes	Results
		<ul style="list-style-type: none"> • Ultraviolet germicidal irradiation • Disinfectant wipes • Gamma irradiation 		
Gupta et al., 2020³³ India Systematic Review Protocol	Review of laboratory-based experimental studies assessing different methods of reprocessing or decontamination of PPE	Reprocessing methods for N95 respirators, including but not limited to: <ul style="list-style-type: none"> • Ultraviolet germicidal irradiation • Steam exposure • Dry heat exposure • Gaseous or liquid chemical disinfectants 	Effectiveness of reprocessed N95 respirators, including: <ul style="list-style-type: none"> • Physical durability • User acceptability • Filter efficiency • Respirator fit • Microbicidal efficacy • Presence of chemical residues 	This in-development systematic review will assess the efficacy of different methods of reprocessing of N95 respirators
McNally et al., 2020²⁹ Canada Systematic Review Protocol	Healthcare workers Healthcare setting, experimental/laboratory settings	Reprocessing methods for N95 respirators, including but not limited to: <ul style="list-style-type: none"> • Microwave radiation • Microwave generated steam • Microwave radiation plus extraneous water • Dry heat • Moist heat • Autoclave serialization 	Percent filter aerosol penetration following microwave radiation/heat treatment Airflow resistance Viral or bacterial contamination on mask surface Fit/ wearability post disinfection Physical degradation Residual odor	This in-development systematic review will answer the question of whether various decontamination strategies can be safely and effectively used to reprocess N95 respirators.
McNally et al., 2020 Canada Systematic Review Protocol	Experimental/laboratory settings	Methods of reprocessing of N95 respirators, including decontamination with the following types of disinfectants: <ul style="list-style-type: none"> • Hydrogen peroxide • Bleach (sodium hypochlorite) • Ethanol • Isopropyl alcohol • Ethylene oxide 	N95 mask performance after disinfection, including: <ul style="list-style-type: none"> Filter aerosol penetration airflow resistance Fit Safety Residual odor Chemical skin irritation User comfort Bacterial decontamination 	This in-development systematic review will assess efficacy and safety of using different chemical disinfectants to decontaminate N95 and SN95 facepiece respirators
Rajaei et al., 2020³⁶ USA	Experimental/laboratory settings	Any methods of sterilization of N95 respirators and their	Reduction of bacterial/viral load Gross changes including changes in texture, pliability,	This in-development systematic review will assess different sterilizations methods for N95

Author, Year, Country, Study Type, n of included studies	Population and Setting	Intervention vs Comparator	Relevant Outcomes	Results
Living Systematic Review Protocol		analogues (FFP2 or KN95, PS2, DS)	order, structural integrity etc. compared to baseline Filter aerosol penetration after decontamination compared to baseline Filter aerosol resistance after decontamination compared to baseline Fit testing	respirators and how they affect respirator fit and functional performance
Said Abbas et al., 2020³⁷ Egypt Systematic Review and Meta-Analysis Protocol	Healthcare and experimental/laboratory settings	Different methods of disinfection and sterilization of medical facemasks and N95 respirators	The following outcomes after disinfection: <ul style="list-style-type: none"> • Biocidal efficacy • Filtration performance • Residual toxicity • Maintenance of fit 	This in-development systematic review will assess the efficacy of different disinfection and sterilization techniques used to reprocess medical facemasks and N95 respirators.
Carr et al., 2020³² Canada Rapid Review	Healthcare workers Healthcare setting (community health clinics, emergency department, inpatient wards, long-term care)	Methods of reprocessing N95 respirators	Outcome metrics related to germicidal efficiency and effectiveness of use after decontamination	This in-development rapid review will assess the efficacy of different disinfection techniques procedures for reprocessing of N95 respirators.