Received: 7 December 2021 | Revised: 9 February 2022 | Accepted: 17 February 2022

DOI: 10.1002/emp2.12699

JACEP OPEN
JOURNAL OF THE AMERICAN COLLEGE OF EMERGENCY PHYSICIANS OPEN
A GLOBAL JOURNAL OF EMERGENCY MEDICINE
Open Access
WILEY

SYSTEMATIC REVIEW/META-ANALYSIS

Infectious Disease

Masking by health care and public safety workers in non-patient care areas to mitigate SARS-CoV-2 infection: A systematic review

P. Daniel Patterson PhD, NRP[1,2] | **Quentin S. Mcilvaine BS, NRP**[1,2] | **Lily Nong NRP**[1,2] | **Mary K. Liszka**[1] | **Rebekah S. Miller MLIS**[3] | **Francis X. Guyette MD, MPH**[1] | **Christian Martin-Gill MD, MPH**[1]

[1]School of Medicine, Department of Emergency Medicine, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

[2]School of Health and Rehabilitation Sciences, Emergency Medicine Program, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

[3]Health Sciences Library System, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

Correspondence
P. Daniel Patterson, PhD, NRP, University of Pittsburgh, School of Medicine, Department of Emergency Medicine, 3600 Forbes Ave., Iroquois Building, Suite 400A, Pittsburgh, PA 15261, USA.
Email: pdp3@pitt.edu

Abstract

Objectives: Wearing a mask is an important method for reducing severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission in health care and public safety settings. We assess the evidence regarding masking in the workplace during the initial months of the COVID-19 pandemic (PROSPERO CRD4202432097).

Methods: We performed a systematic review of published literature from 4 databases and evaluated the quality of evidence with the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) framework. We searched for observational and experimental research involving public safety and health care workers. We included articles evaluating the use of masks, versus no mask, on the outcome of SARS-CoV-2 infection.

Results: Our search yielded 15,013 records, of which 9 studies were included. Most studies (n = 8; 88.9%) involved infections or outbreaks among health care workers. The majority (88.9%) used in-depth interviews of cases and non-cases to obtain self-reported use of masks during periods of exposure. One of 9 studies quantitatively assessed differences in SARS-CoV-2 infection based on use of masks in non-patient care settings. Use of observational study designs, small sample sizes, inadequate control for confounding, and inadequate measurement of exposure and non-exposure periods with infected coworkers contributed to the quality of evidence being judged as very low.

Conclusions: The available evidence from the initial months of the pandemic suggests that the use of masks in congregate, non-patient care settings, such as breakrooms, helps to reduce risk of SARS-CoV-2 virus transmission. However, this evidence is limited and is of very low quality. Prospective studies incorporating active observation measures are warranted.

KEYWORDS
COVID, health care, masks, public safety, SARS-CoV-2

1 | INTRODUCTION

1.1 | Background

Since the COVID-19 pandemic began, numerous recommendations from the Centers for Disease Control and Prevention (CDC) and professional organizations suggest that workers in the health care and public safety sectors don personal protective equipment (PPE) to effectively mitigate exposure to severe acute respiratory syndrome coronavirus 2 SARS-CoV-2.[1] Most recommendations address use of facial coverings during encounters with patients, particularly with individuals suspected of or at higher risk of having COVID-19. The COVID-19 pandemic has made visible a unique body of research comparing different types of facial coverings based on laboratory and observational research.[2,3] In addition, there is a growing body of research investigating the impact of different types of PPE in relation to SARS-CoV-2 infection.[2,4] These data will guide future decisions for the remainder of the COVID-19 pandemic as well as future pandemics. We aim to address the impact of facial coverings (hereafter referred to as masks) in health care and public safety on SARS-CoV-2 infection in non-patient care settings like breakrooms.

1.2 | Importance

Health care workers (HCWs) and public safety workers (PSWs) have been at the front lines addressing the COVID-19 pandemic and are an ideal target for risk mitigation efforts. These groups are comparable, and therefore, how one group responded to exposure risk in the workplace will add to the lessons learned from the pandemic and guide future decisions. Both HCWs and PSWs are often in close proximity and exposed to one another for prolonged periods of time when not caring for or otherwise around patients. Both interact in breakrooms, conference rooms, education venues, and other common areas designated for employees. In these environments, infection prevention activities, such as masking, physical distancing, and hand hygiene, may be less rigorous. High-risk behaviors, such as eating, smoking, and public speaking, may be more common in these settings. Furthermore, HCWs and PSWs are also similar in the following ways: (1) they care for acute illness and injury during emergency situations; (2) their work-related tasks (ie, patient care) are often unpredictable, especially when comparing public safety to HCWs in the emergency department and other acute care settings; (3) PSWs and HCWs are similar in how their work is organized– in both settings, most work in shifts, including rotating shifts, night shifts, and long duration shifts;[5] and (4) both occupational groups are exposed to pathogens associated with human illness, and, therefore, must adopt strategies and protocols that mitigate exposure and infection risk.[6–8] The key difference between HCWs and PSWs is the environment where most of the work is done. Those in public safety perform most work outside of the hospital, clinic, or other stationary health care facility. They face exposure to hazards and threats that many HCWs do not. Still, considering the many similarities between these occupational groups, information about risk assessment and work restrictions for emergency medical services (EMS) and fire personnel are presented collectively with that for HCWs.[1,9]

Similarly, seroprevalence of SARS-Co-V-2 infection has been evaluated jointly for these groups of workers.[10] Illness among HCWs during a pandemic threatens the capabilities of already strained health systems. Exposure of PSWs and the subsequent need to quarantine multiple individuals at an individual public safety agency further compromises the availability and operational readiness of essential emergency medical and fire services within a community.

1.3 | Goals of this investigation

During the initial months of the pandemic, wearing masks was believed to be an important method of reducing the risk of transmission of SARS-CoV-2 in the workplace. However, there was great uncertainty regarding the need for masking in potentially low-risk settings such as breakrooms.[11–14] Given this uncertainty, we assessed use of masking in the workplace, specifically in non-patient care settings while around coworkers.

2 | METHODS

2.1 | Study design and setting

Although we describe our study as a rapid systematic review,[15,16] we adopted a systematic review study design to identify peer-reviewed, published literature as well as preprint literature. Rapid reviews and rapid systematic reviews share similar design characteristics to systematic reviews, yet they differ in the amount of time required to complete the review and a reduction in the number of databases searched.[15–18] Narrative reviews, scoping reviews, and other non-systematically focused searches are less rigorous, often guided by opinion, and may include a limited number of databases searched.[19] Similar to systematic reviews, we prospectively registered our research question and methods in advance, searched multiple databases, screened the literature using standard inclusion/exclusion criteria, evaluated agreement between screeners, reviewed bibliographies for additional relevant literature, abstracted key information from the retained literature, listed reasons for exclusion, and followed the Grading of

Recommendations Assessment, Development and Evaluation (GRADE) approach to assess bias.[20]

2.2 | Selection of participants

We searched select databases for observational and experimental research studies focused on adults (18 years or older) identified as PSWs, including EMS, fire services, and law enforcement (corrections officers were not included in searches). To capture additional relevant literature, our search included studies involving HCWs of any type. We considered additional HCW literature given that (1) the number of studies germane to PSWs was believed to be limited; (2) PSWs are similar with respect to potential exposures to SARS-CoV-2 both in patient-care and non-patient care settings; and (3) the organization of literature across multiple HCW groups improves generalizability to different public safety environments and strengthens our ability to assess the collective impact of mask use as a risk mitigation strategy.

2.3 | Intervention of interest

The intervention of interest was wearing a "mask" in work-related environments outside of a clinical or public environment. For this literature review we define the term "mask" as including facemasks, respirators, or cloth face coverings. The CDC defines facemasks as "surgical masks or procedure masks."[1] A respirator is described by the CDC as "a personal protective device worn on the face, covering the nose and mouth, and used to reduce inhalation of hazardous airborne particles, gases, or vapors."[1] Different types of respirators often used in public safety and health care settings include disposable N95 filtering facepiece respirators, powered air purifying respirators, and elastomeric respirators.[1] In contrast to facemasks and respirators, the CDC emphasizes that "cloth face coverings are not considered personal protective equipment" and that cloth face coverings should not be worn instead of a respirator or surgical facemask if more than source control is needed.[1] However, because PSWs in the workplace may use a cloth face covering for the primary purpose of source control when around coworkers, we retained articles that reported use of facemasks, respirators, or cloth face coverings.

2.4 | Comparisons of interest

Our primary comparison of interest was wearing a mask versus no mask.

2.5 | Outcomes

The primary outcome of interest was the incidence of SARS-CoV-2 infection.

2.6 | Literature search methods

Our study team's research librarian searched 4 databases (Medline via PubMed, EMBASE, Preprint Europe PMC, and the World Health Organization COVID-19 database) from December 1, 2019, to January 29, 2021. Database-specific subject headings and keywords covering the concepts of COVID-19, HCWs, and masks were used to identify records relevant to our population, intervention, control, and outcomes (PICO)-structured research question. The PICO research question that we sought to answer through this review is: *In public safety personnel or related workers, does wearing a mask (face covering) at the workplace (or work vehicle) when around coworkers, versus not wearing a mask, lower the incidence of COVID-19 infection?* (PROSPERO CRD4202432097; registered January 21, 2021). For purposes of our search, the PubMed COVID-19 search strategy was adapted from a search developed in April 2020 by the Medical Library Association Clinical Librarians Caucus; the Europe PMC COVID-19 search was an altered version of that database's filter. Results were downloaded in to EndNote software and de-duplicated following the Bramer Method.[21] See online Supplement Appendix A for full details of our search strategies for each database.

2.7 | Screening records

We trained co-investigators comprising 3 unique dyads to independently screen records. Screeners used the DistillerSR software program (Evidence Partners; Ottawa, Ontario, Canada) to review study titles and abstracts, when available. Our screeners flagged records for inclusion or exclusion based on elements of the PICO research question. We retained all records flagged for inclusion and used input from co-investigators to adjudicate conflicts or differences in opinion regarding inclusion or exclusion.

2.8 | Full-text review

Three co-investigators independently reviewed the full-text version of records retained during screening as an inclusion or conflict. Co-investigators judged each record as relevant or irrelevant against our study PICO question. We searched the bibliographies of all articles examined in full-text form to identify potentially relevant research not identified during the database searches. We then abstracted key information into tables from all retained full-text articles. The information abstracted from each of the retained articles included the full citation, study participants/subjects, study aims/hypotheses, study design, intervention, comparisons, outcome measures, and key findings. Three co-investigators verified data abstractions for accuracy (See online Supplement Appendix B). Online Supplement Appendix C reports the reasons given for excluding an article after full-text review.

2.9 | Data analysis

Pooled analyses were not feasible given the lack of consistency in measurement and reporting across studies. In light of this limitation, we summarized and synthesized the findings in narrative format. Agreement between reviewers during the screening process was determined by the Kappa statistic.

2.10 | Risk of bias assessment

We assessed for potential biases of the retained research using a template prescribed by the GRADE Working Group.[20] Given that none of the retained studies identified used an experimental research design, we did not assess for limitations with allocation concealment, blinding of participants or investigators, incomplete outcome data, flawed measurement, lack of controlling for confounding, or incomplete follow-up.[22,23] Following the GRADE approach, we assessed for (1) application of appropriate eligibility criteria; (2) flaws in measurement of exposure and outcome; (3) adequacy of controls for confounding; and (4) completeness of follow-up.[20]

2.11 | Quality of evidence assessment

The GRADE framework prescribes that the assessment of evidence quality, for each outcome, be measured across multiple factors, and in summary, judge evidence quality as very low, low, moderate, or high.[24] The factors included in this judgment include the study design, risk of bias, inconsistency, indirectness, imprecision, and other considerations (eg, publication bias and magnitude of effect).[24] We identified wide variability and substantial limitations in the data reported in the retained research. Given these limitations, we report an aggregate assessment of evidence quality.

3 | RESULTS

3.1 | Characteristics of participants

Much of the data reported in the retained research originates from HCWs based in the hospital setting. One of the retained studies reported including case data from public safety workers,[25] yet these data were reported in combination with data from other health care personnel. In total, 27,361 HCWs were screened or surveilled as part of the studies examined in this systematic review.

3.2 | Main results

Our search yielded 15,013 records (titles and abstracts), of which 41 were retained after co-investigators completed screening and conflict adjudication (Figure 1). Interrater agreement across 3 dyads was moderate (Kappa = 0.46, 0.28, 0.50), and similar to a number of previous systematic reviews focused on PSWs.[19] Forty-one records were retained for review and examined in full-text by multiple co-investigators. Concurrent with full-text review, investigators searched bibliographies and identified 25 potentially relevant publications, which were also examined in full-text format. In total, 65 full-text publications were examined against PICO criteria. Among these publications, 9 publications describing 9 unique studies were retained (See Table 1 and online Supplement Appendix B), whereas 56 publications were excluded (See online Supplement Appendix C). During the initial searches, 2 of the 9 publications retained were identified as preprint articles.[26,27] Later in the review process, we discovered that both preprint publications were published in 2 separate peer-reviewed journals.[28,29] We therefore identified multiple publications for 2 unique studies. Key findings from the 9 studies, and their respective publications (n = 11 total publications), were abstracted into tables (See online Supplement Appendix B). All exclusions (n = 56) with reasons for exclusion, as determined by multiple co-investigators, appear in online Supplement Appendix C.

Four of 9 studies used a case report/case study/outbreak investigation type design.[25,30–32] One study, initially published as a preprint,[27] used a cross-sectional study design,[27,29] 1 used a case-control study design,[33] and 3 studies (1 initially published as a preprint)[26] used a cohort study design or were otherwise characterized having prospectively collected observational data.[28,31,32,34,35] Although the time frame of investigations varied, most studies launched and concluded during the months of March and June 2020. The majority of studies (n = 8; 88.9%) involved infections or outbreaks among physicians, nurses, and other HCWs in the hospital setting.[29,30,33–35]

Few of the retained studies provided detailed, quantitative data on the incidence of infection with SARS-CoV-2 and only 1 reported infections resulting from exposure to a colleague while wearing or not wearing a mask. In univariate analysis, Celebi et al reported a significant association ($P < 0.05$) between exposure to colleagues in a non-patient care setting without a mask (ie, breakroom), while consuming food within 1 m of a colleague, and failing to keep a safe physical distance from a colleague.[33] Modeling with logistic regression, using a backward stepwise method for variable elimination, revealed that the odds of infection was 7.4 times higher (95% confidence interval 1.898-29.020) among HCWs who reported staying in the breakroom when around colleagues not wearing a mask for more than 15 minutes compared to non-cases.[33] A separate study by Piapan et al reported that 27 of 115 (23.5%) HCWs in public hospitals infected with SARS-CoV-2 reported exposure to colleagues, not infected patients.[32] Piapan et al also reported that whereas most HCWs (71.3%) reported using PPE during working hours, use was not "appropriate" during HCW meetings.[32] Other studies retained in this review reported SARS-CoV-2 infections relative to mask wearing, describe a lack of masking in non-patient areas (eg, a breakroom or a meeting room), yet provide no or limited quantitative data.

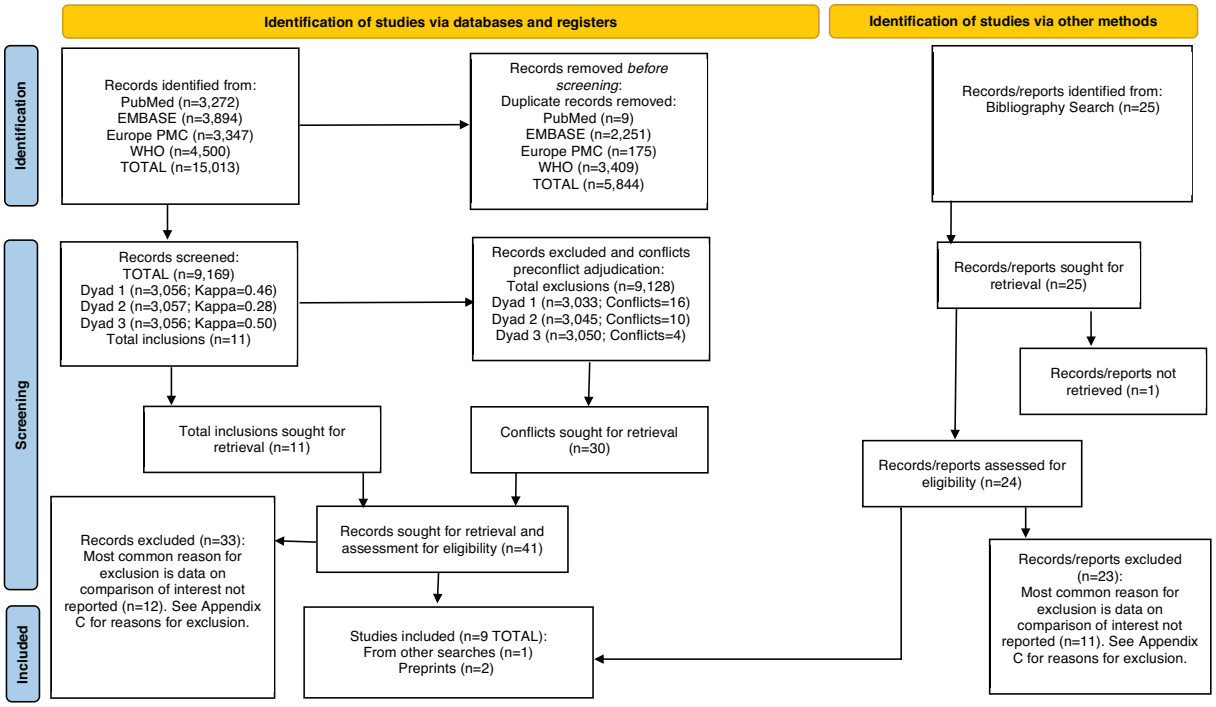

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart of the literature search

3.3 | Description of interventions

Although all 9 of the retained studies reported on use of masks as an intervention of interest, the details of mask use were limited. Most studies (n = 8; 88.9%) reported use of in depth interviews of cases and non-cases and obtaining self-reported use of masks during specific periods of exposure.[28–30,32–35] The method of measurement for mask wearing was unclear in a study by Gao et al.[31] None of the retained studies reported the exact timing of mask use, adherence to proper mask placement, or use of masks for source control among cases.

3.4 | Description of comparisons

Only 1 of 9 studies quantitatively assessed differences in SARS-CoV-2 infection (cases of COVID-19) based on use or inappropriate use of masks.[33] One additional study compared rates of contact with colleagues and/or patients by HCWs with or without diagnosis of COVID-19.[32] The remainder of studies (1) compared risk of exposure based on numerous factors (eg, cohort, location, or other), (2) aggregated masking with other measures of PPE, and (3) showed variation in how the outcomes were quantified. This variation prevented aggregation of the data for pooled estimates of effect.

3.5 | Description of outcome measures

One study assessed infections reported directly to the health department, which originated from various health care settings.[25] Six of 9 studies (66.7%) identified cases with the reverse transcriptase polymerase chain reaction test,[28–30,32–34] whereas 3 studies did not report the exact method used to identify cases or referenced a resource that was not immediately available for this review.[25,31,35]

3.6 | Quality of evidence assessment

Lack of detailed reporting prevented use of the GRADE-specific evidence profile tables to formally assess evidence quality.[24] However, we used the GRADE approach to evaluate the overall quality of the retained observational research.[20] We identified several factors that generally downgraded the quality of the retained research as described by GRADE, including the observational study designs, small sample sizes, inadequate control for confounding, lack of adequate data on adherence to masking, and inadequate measurement of exposure and non-exposure periods with infected coworkers. Combined, these characteristics resulted in the retained evidence to be judged of very low quality based on the GRADE approach.

4 | LIMITATIONS

This systematic review was generated using databases relevant to our PICO question. Our search may not have identified relevant literature indexed in other databases, gray literature, or unindexed works published in trade journals. We examined the interrater agreement between screeners to mitigate bias during the initial screening. Similar to previous research, interrater agreement was moderate.[19] We reduced the likelihood of overlooking or missing relevant research

TABLE 1 Summary of findings

Author, year	Population studied and sample size screened and/or infected	Study design and time period	Comparisons presented	Outcomes assessed
Celebi et al., 2020	HCW N = 703 (screened)	Case-control March 20, 2020 to May 20, 2020	Wearing mask vs not wearing mask for 15+ min in breakroom	SARS-CoV-2 infection
Fell et al., 2020	HCW N = 17,330 (exposed)	Case report/case study March 6, 2020 to July 11, 2020	Exposure to infected persons in different settings	SARS-CoV-2 infection
Gao et al., 2020	HCW N = 20 (infected)	Outbreak investigation	Contact tracing investigation to identify exposure time, location, and use of masks during exposure period	SARS-CoV-2 infection
Gordon et al., 2020 (preprint) Gordon et al., 2021 (final publication)	HCW N = 49 (infected)	Surveillance study of population January 25, 2020 to November 25, 2020	Work factors associated with infection vs no infection with contact tracing to identify exposure location	SARS-CoV-2 infection
Oksanen et al., 2020 (preprint) and Oksanen et al., 2021 (final publication)	HCW N = 1072 (volunteered for study)	Cross-sectional survey of population June 12, 2020 to July 15, 2020	Mask wearing by type of exposure (ie, colleague to colleague) by setting (workplace or outside of work)	SARS-CoV-2 infection
Piapan et al., 2020	HCW N = 903 (screened)	Surveillance study of population March 1, 2020 to April 6, 2020	Contact tracing with in-depth interviews to identify exposure location and use of PPE during exposure	SARS-CoV-2 infection
Seidelman et al., 2020	HCW N = not reported	Prospective observational study March 15, 2020 to June 6, 2020	Exposure to suspected case and use of masking during exposure for 10 min less than 6 feet apart	SARS-CoV-2 infection
Vimercati et al., 2021	HCW N = 5750 (screened)	Prospective cohort March 11, 2020 to April 29, 2020	Adequacy of PPE stratified into high vs low risk of exposure in presence of infected persons	SARS-CoV-2 infection
Zabarsky et al., 2021	HCW N = 1534 (screened)	Surveillance study March 15, 2020 to July 15, 2020	Use of PPE during select time periods (ie, when universal masking not required) and exposure in different settings	SARS-CoV-2 infection

Abbreviations: HCW, health care worker; PPE, personal protective equipment.

by conducting an extensive bibliography search of retained literature. This additional step yielded 25 potentially relevant articles (studies), of which 1 article (n = 1 study) was retained in the final pool of inclusions.[32]

Data extraction from retained research is a key step in systematic reviews that often suffers from error.[36] As recommended, we reduced extraction error by involving multiple coinvestigators in data extraction.[37] Our review is further limited in the ability to assess evidence quality for individual studies. The assessment of bias and quality in retained research encompasses use of templates, like those provided by GRADE and the Cochrane collaboration.[20,22,23] Although we were able to assess the bias with a framework prescribed by GRADE,[20] the lack of consistency in reporting prevented us from using GRADE evidence profile tables, which permit an itemized assessment and determination on evidence quality.[24] Absent this template, we assessed the quality based on the protocolized foundations prescribed by GRADE and judged the quality as very low. Our judgment is subject to bias, which means that future investigations that include the research assessed in this review may judge the quality of evidence differently. Finally, most studies did not report outcome data in a format that could be assessed in pooled analyses. Such incomplete reporting is a common limitation that impedes meta-analyses and often leads to narrative synthesis of evidence.

5 | DISCUSSION

5.1 | Summary of key findings

In this systematic review, we identified limited evidence that directly addresses our research question, comparison, and outcome of interest. In total, 9 studies met our criteria for inclusion. These studies were limited by small sample sizes, limited descriptions of exposure and outcomes of interest, and limited quantitative data on the comparison of

interest. Despite these limitations, each of the retained studies suggests mask use in workplace settings mitigates the risk of SARS-CoV-2 infection. Although more robust research is needed, the findings across multiple studies provide evidence supporting the use of masks by HCWs and PSWs in non-patient care areas of the workplace.

Given the described limitations of existing studies, we judged the overall body of evidence assessing the effectiveness of masks during the early days and months of the COVID-19 pandemic as very low quality based on the GRADE methodology. This finding is not surprising, given the evolution of pandemic-related research during the early months, comprised largely of case reports and locally led outbreak investigations. Robust study designs and thorough reporting require time and resources that may not have been available in select locations, especially at the beginning of the pandemic.

5.2 | Inclusion/exclusion of published studies

We sought to include peer-reviewed published articles, as well as preprint literature, of original research studies that assessed the association between the risk of SARS-CoV-2 infection and use of masks while proximal to coworkers in non-patient care areas. Of the 65 articles reviewed in full-text, only 9 were retained. Several studies reported on multiple factors that were of interest, however, we excluded these studies due to limited reporting of the comparison or outcome of interest. For example, the study by Schwierzeck et al reported on 52 positive cases of SARS-CoV-2 infection among employees in a tertiary care hospital located in Germany.[38] Authors reported that 39 reported close contact with a positive case while at work and 20 of the 39 involved close contact with coworkers who may have been the source of transmission. Although these data were informative, Schwierzeck et al did not report on use of masks and did not report on the details of exposure with potential worker-to-worker infection.[38]

5.3 | Agreement and disagreement with other systematic and rapid reviews

Our systematic review differs from other recent reviews that aim to explore the impact of mask use among HCWs and PSWs. Griswold et al completed an "umbrella review" focused on informing recommendations for use of different types of PPE by hospital staff while performing surgery.[4] Our review differed given our focus on using masks in non-patient care settings. A separate review by Chu et al sought to assess the effects of physical distancing, masks, and eye protection on virus transmission in health care and non-health care settings.[2] Important differences in methodology compared to our review include the use of different databases of published studies, a narrower date range ending on March 26, 2020, and differences in the outcome of interest, such as transmission of viruses other than SARS-CoV-2.

Another rapid review by Chou et al similarly evaluated the incidence of SARS-CoV-2 infection in relation to use of PPE (ie, masks). This review also differs from ours in that Chou et al sought to address 3 different research questions, attempting to (1) describe the differences in disease burden based on age, sex, and comorbidity, (2) identify the risk factors for transmission to HWCs and (3) identify risk factors for household transmission of SARS-CoV-2, SARS-CoV-1 and Middle East respiratory syndrome. Our review focused on a singular question of transmission of SARS-CoV-2 among HCWs and PSWs in non-patient settings, with and without masks. Additional differences include differences in publication date ranges and the lack of a formal risk of bias assessment of the studies retained by Chou et al, whereas we used a template prescribed by the GRADE working group for purposes of assessing bias (study limitations) in observational research.[20]

5.4 | Lessons learned

We identified important gaps in evidence related to mitigation of HCW and PSW exposure to SARS-CoV-2 infection in non-patient care settings. Most of the studies examined in this review did not provide quantitative reporting of infection or exposure. None provided meticulous data on mask wearing adherence, mask type, or presence of other modifying conditions during the periods of exposure in non-patient care settings. Futhermore, all the data were collected during the early period of the pandemic; the impact of later variants on transmission and mitigation is unclear.

The limitations in previous research, in relation to our PICO question, point to possible strategies that may be useful in new studies. First, future investigations should make every effort to focus on non-patient care settings, where many workers may perceive the setting as "safer" than patient areas and where respite from patient-related duties, including eating without a mask on, may be expected. Second, investigators may need to reconsider the best measurement of outcomes. Our review reveals a fair amount of inconsistency and reliance on subject recall and self-report. Direct observation is expensive, but for higher quality studies, directly observing behavior in select environments may be necessary to quantify exposure and adherence reliably and accurately. Obtaining these data may be achievable with a combination of innovative technology and randomly selected periods of surveillance.

In conclusion, the existing evidence collected during the early months of the COVID-19 pandemic suggests that the use of masks by health care and public safety workers in congregate, non-patient care settings, such as breakrooms, meeting spaces, and in public safety vehicles, helps to reduce risk of SARS-CoV-2 virus transmission. Reported data are of low quality limited by primarily retrospective observational study designs and would benefit from additional prospective studies incorporating active observation measures.

GRANTS/OTHER FINANCIAL SUPPORT

This work is supported by the following Intergovernmental Personnel ACT (IAP) agreements from the National Institute for Occupational Safety and Health (NIOSH): 20IPA2014138 (FXG), 20IPA2014139 (CMG), and 20IPA2014141 (PDP). Co-authors QSM, LIN, and MKL acknowledge support from the University of Pittsburgh, Office of

the Provost, Office of Undergraduate Studies (Office of Vice Provost Joseph McCarthy), School of Health and Rehabilitation Sciences, Emergency Medicine Program. The findings and conclusions in this document are those of the authors and do not necessarily represent the official position of NIOSH or the Centers for Disease Control and Prevention.

INSTITUTION AND ETHICS APPROVAL/INFORMED CONSENT

Not applicable.

CONFLICTS OF INTEREST

The authors report no conflicts of interest.

AUTHOR CONTRIBUTIONS

Authors P. Daniel Patterson, Francis X. Guyette, Rebekah S. Miller, and Christian Martin-Gill contributed to the conception of the design of this work. All authors contributed to the acquisition of study data, analysis, interpretation, drafting of the manuscript, and providing critically important intellectual content. All authors reviewed and approved the final version and agree to be accountable for all aspects of this work.

ORCID

P. Daniel Patterson PhD, NRP https://orcid.org/0000-0002-8189-0919

REFERENCES

1. CDC. *Interim Recommendations for Emergency Medical Services (EMS) Systems and 911 Public Safety Answering Points/Emergency Communication Centers (PSAP/ECCs) in the United States During the Coronavirus Disease (COVID-19) Pandemic*. National Center for Immunization and Respiratory Diseases (NCIRD). 2020. https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-for-ems.html. Division of Viral Diseases, Centers for Disease Control and Prevention. Last Updated: July 15, 2020. Accessed August 19, 2021, 2021.
2. Chu DK, Akl EA, Duda S, et al. Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. *Lancet*. 2020;395(10242):1973-1987.
3. MacIntyre CR, Wang Q, Cauchemez S, et al. A cluster randomized clinical trial comparing fit-tested and non-fit-tested N95 respirators to medical masks to prevent respiratory virus infection in health care workers. *Influenza Other Respir Viruses*. 2011;5(3):170-179.
4. Griswold DP, Gempeler A, Kolias A, Hutchinson PJ, Rubiano AM. Personal protective equipment for reducing the risk of COVID-19 infection among health care workers involved in emergency trauma surgery during the pandemic: an umbrella review. *J Trauma Acute Care Surg*. 2021;90(4):e72-e80.
5. Patterson PD, Runyon MS, Higgins JS, et al. Shorter versus longer shift duration to mitigate fatigue and fatigue related risks in Emergency Medical Services: a systematic review. *Prehosp Emerg Care*. 2018;22(Suppl 1):28-36.
6. Boal WL, Leiss JK, Ratcliffe JM, et al. The national study to prevent blood exposure in paramedics: rates of exposure to blood. *Int Arch Occup Environ Health*. 2010;83(2):191-199.
7. Boal WL, Hales T, Ross CS. Blood-borne pathogens among firefighters and emergency medical technicians. *Prehosp Emerg Care*. 2005;9(2):236-247.
8. Behrman AJ, Shofer FS, Green-McKenzie J. Trends in bloodborne pathogen exposure and follow-up at an urban teaching hospital: 1987 to 1997. *J Occup Environ Med*. 2001;43(4):370-376.
9. *CDC. Interim guidance for managing healthcare personnel with SARS-CoV-2 infection or exposure to SARS-CoV-2*. 2021; https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-risk-assesment-hcp.html. Centers for Disease Control and Prevention. Last Updated: September 10, 2021. Accessed October 1, 2021, 2021.
10. Akinbami LJ, Vuong N, Petersen LR, et al. SARS-CoV-2 seroprevalence among healthcare, first response, and public safety personnel, detroit metropolitan area, Michigan, USA, May-June 2020. *Emerg Infect Dis*. 2020;26(12):2863-2871.
11. Igielnik R, *Most Americans Say They Regularly Wore A Mask In Stores In The Past Month; Fewer See Others Doing It*. 2020; https://www.pewresearch.org/fact-tank/2020/06/23/most-americans-say-they-regularly-wore-a-mask-in-stores-in-the-past-month-fewer-see-others-doing-it/ Pew Research Center. Washington, DC. Last Updated: June 23, 2020. Accessed September 27, 2021, 2021.
12. Stanley-Becker I, *Mask or No Mask? Face Coverings Become Tool In Partisan Combat*. 2020; https://www.washingtonpost.com/politics/in-virus-response-riven-by-politics-masks-are-latest-rorschach-test/2020/05/12/698477d4-93e6-11ea-91d7-cf4423d47683_story.html. The Washington Post. Washington, DC. Last Updated: May 12, 2020. Accessed September 27, 2021, 2021.
13. Kortepeter M, Why you'll still need to wear a mask even after COVID-19 vaccines arrive. 2020; https://www.forbes.com/sites/coronavirusfrontlines/2020/10/20/why-youll-still-need-to-wear-a-mask-even-after-covid-19-vaccines-arrive/?sh=6846aa545a42 Forbes. Last Updated: October 20, 2020. Accessed September 27, 2021.
14. Silberner J. *Why You Should Still Wear A Mask And Avoid Crowds After Getting The COVID-19 Vaccine*. National Public Radio. Last Updated; 2021. https://www.npr.org/sections/health-shots/2021/01/12/956051995/why-you-should-still-wear-a-mask-and-avoid-crowds-after-getting-the-covid-19-vac.. January 12, 2021. Accessed September 27, 2021, 2021.
15. Khangura S, Konnyu K, Cushman R, Grimshaw J, Moher D. Evidence summaries: the evolution of a rapid review approach. *Syst Rev*. 2012;1:10.
16. Schunemann HJ, Moja L. Reviews: rapid! Rapid! Rapid! …and systematic. *Syst Rev*. 2015;4(1):4.
17. Tricco AC, Antony J, Zarin W, et al. A scoping review of rapid review methods. *BMC Med*. 2015;13:224.
18. Garritty C, Gartlehner G, Nussbaumer-Streit B, et al. Cochrane rapid reviews methods group offers evidence-informed guidance to conduct rapid reviews. *J Clin Epidemiol*. 2021;130:13-22.
19. Patterson PD, Higgins JS, Weiss PM, Lang E, Martin-Gill C. Systematic review methodology for the fatigue in emergency medical services project. *Prehosp Emerg Care*. 2018;22(Suppl 1):9-16.
20. Guyatt GH, Oxman AD, Vist G, et al. GRADE guidelines: 4. Rating the quality of evidence–study limitations (risk of bias). *J Clin Epidemiol*. 2011;64(4):407-415.
21. Bramer WM, Giustini D, de Jonge GB, Holland L, Bekhuis T. De-duplication of database search results for systematic reviews in endnote. *J Med Libr Assoc*. 2016;104(3):240-243.
22. Balshem H, Helfand M, Schunemann HJ, et al. GRADE guidelines: 3. Rating the quality of evidence. *J Clin Epidemiol*. 2011;64(4):401-406.
23. Higgins JS, Altman DG, Gotzsche PC, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ*. 2011;343:d5928.
24. Guyatt GH, Oxman AD, Akl EA, et al. GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol*. 2011;64(4):383-394.

25. Fell A, Beaudoin A, D'Heilly P, et al. SARS-CoV-2 Exposure and infection among health care personnel - Minnesota, March 6 - July 11, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(43):1605-1610.
26. Gordon CL, Trubiano JA, Holmes NE, et al. Staff to staff transmission as a driver of healthcare worker infections with COVID-19. *medRxiv*. 2020.
27. Oksanen L-MAH, Sanmark E, Oksanen SA, et al. Healthcare workers' high COVID-19 infection rate: the source of infections and potential for respirators and surgical masks to reduce occupational infections. *medRxiv*. 2020.
28. Gordon CL, Trubiano JA, Holmes NE, et al. Staff to staff transmission as a driver of healthcare worker infections with COVID-19. *Infect Dis Health*. 2021.
29. Oksanen L-MAH, Sanmark E, Oksanen SA, et al. Sources of healthcare workers' COVID-19 infections and related safety guidelines. *Int J Occup Med Environ Health*. 2021;34(2):239-249.
30. Zabarsky TF, Bhullar D, Silva SY, et al. What are the sources of exposure in healthcare personnel with coronovirus disease 2019 infection?. *Am J Infect Control*. 2021;49(3):392-395.
31. Gao S, Yuan Y, Xiong Y, et al. Two outbreaks of SARS-CoV-2 in department of surgery in a Wuhan hospital. *Infect Prev Pract*. 2020;2(3):100065.
32. Piapan L, Michieli PD, Ronchese F, et al. COVID-19 outbreak in healthcare workers in hospitals in Trieste, North-east Italy. *J Hosp Infect*. 2020;106(3):626-628.
33. Celebi G, Piskin N, Beklevic AC, et al. Specific risk factors for SARS-CoV-2 transmission among health care workers in a University hospital. *Am J Infect Control*. 2020;48(10):1225-1230.
34. Vimercati L, De Maria L, Quarato M, et al. COVID-19 hospital outbreaks: protecting healthcare workers to protect frail patients. An Italian observational cohort study. *Int J Infect Dis*. 2021;102:532-537.
35. Seidelman JL, Lewis SS, Advani SD, et al. Universal masking is an effective strategy to flatten the severe acute respiratory coronavirus virus 2 (SARS-CoV-2) healthcare worker epidemiologic curve. *Infect Control Hosp Epidemiol*. 2020;41(12):1466-1467.
36. Horton J, Vandermeer B, Hartling L, et al. Systematic review data extraction: cross-sectional study showed that experience did not increase accuracy. *J Clin Epidemiol*. 2010;63(3):289-298.
37. Buscemi N, Hartling L, Vandermeer B, Tjosvold L, Klassen TP. Single data extraction generated more errors than double data extraction in systematic reviews. *J Clin Epidemiol*. 2006;59(7):697-703.
38. Schwierzeck V, Correa-Martinez CL, Schneider KN, et al. SARS-CoV-2 in the employees of a large university hospital. *Dtsch Arztebl Int*. 2020;117(19):344-345.
39. Chou R, Dana T, Buckley DI, et al. Epidemiology of and risk factors for Coronovirus infection in health care workers: a living rapid review. *Ann Intern Med*. 2020;173(2):120-136.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Patterson PD, Mcilvaine QS, Nong L, et al. Masking by health care and public safety workers in non-patient care areas to mitigate SARS-CoV-2 infection: A systematic review. *JACEP Open*. 2022;3:e12699. https://doi.org/10.1002/emp2.12699