Technical Brief
Number 42

Infection Prevention and Control for the Emergency Medical Services and 911 Workforce

Agency for Healthcare Research and Quality

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This report is based on research conducted by the Johns Hopkins University Evidence-based Practice Center (EPC) under contract to the Agency for Healthcare Research and Quality (AHRQ), Rockville, MD (Contract No. 75Q80120D00003). The findings and conclusions in this document are those of the authors, who are responsible for its contents; the findings and conclusions do not necessarily represent the views of AHRQ. Therefore, no statement in this report should be construed as an official position of AHRQ or of the U.S. Department of Health and Human Services.

None of the investigators have any affiliations or financial involvement that conflicts with the material presented in this report.

The information in this report is intended to help healthcare decision makers—patients and clinicians, health system leaders, and policymakers, among others—make well-informed decisions and thereby improve the quality of healthcare services. This report is not intended to be a substitute for the application of clinical judgment. Anyone who makes decisions concerning the provision of clinical care should consider this report in the same way as any medical reference and in conjunction with all other pertinent information, i.e., in the context of available resources and circumstances presented by individual patients.

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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-based Practice Centers (EPCs), sponsors the development of evidence reports and technology assessments to assist public- and private-sector organizations in their efforts to improve the quality of healthcare in the United States. The reports and assessments provide organizations with comprehensive, science-based information on common, costly medical conditions and new healthcare technologies and strategies. The EPCs systematically review the relevant scientific literature on topics assigned to them by AHRQ and conduct additional analyses when appropriate prior to developing their reports and assessments.

This EPC evidence report is a Technical Brief. A Technical Brief is a rapid report, typically on an emerging medical technology, strategy, or intervention. It provides an overview of key issues related to the intervention—for example, current indications, relevant patient populations and subgroups of interest, outcomes measured, and contextual factors that may affect decisions regarding the intervention. Although Technical Briefs generally focus on interventions for which there are limited published data and too few completed protocol-driven studies to support definitive conclusions, the decision to request a Technical Brief is not solely based on the availability of clinical studies. The goals of the Technical Brief are to provide an early objective description of the state of the science, a potential framework for assessing the applications and implications of the intervention, a summary of ongoing research, and information on future research needs. In particular, through the Technical Brief, AHRQ hopes to gain insight on the appropriate conceptual framework and critical issues that will inform future research.

AHRQ expects that the EPC evidence reports and technology assessments will inform individual health plans, providers, and purchasers as well as the healthcare system as a whole by providing important information to help improve healthcare quality.

If you have comments on this Technical Brief, they may be sent by mail to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 5600 Fishers Lane, Rockville, MD 20857, or by email to epc@ahrq.hhs.gov.

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Key Informants

In designing the study questions, the EPC consulted a panel of Key Informants who represent subject experts and end-users of research. Key Informant input can inform key issues related to the topic of the Technical Brief. Key Informants are not involved in the analysis of the evidence or the writing of the report. Therefore, in the end, study questions, design, methodological approaches, and/or conclusions do not necessarily represent the views of individual Key Informants.

Key Informants must disclose any financial conflicts of interest greater than $5,000 and any other relevant business or professional conflicts of interest. Because of their role as end-users, individuals with potential conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any conflicts of interest.

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Peer Reviewers

Prior to publication of the final Technical Brief, the EPC sought input from independent Peer Reviewers without financial conflicts of interest. However, the conclusions and synthesis of the scientific literature presented in this report do not necessarily represent the views of individual reviewers.

Peer Reviewers must disclose any financial conflicts of interest greater than $5,000 and any other relevant business or professional conflicts of interest. Because of their unique clinical or content expertise, individuals with potential nonfinancial conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential nonfinancial conflicts of interest identified.

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Infection Prevention and Control Issues for the Emergency Medical Services and 911 Workforce

Structured Abstract

Objectives. To summarize current evidence on exposures to infectious pathogens in the emergency medical services (EMS) and 911 workforce, and on practices for preventing, recognizing, and controlling occupationally acquired infectious diseases and related exposures in that workforce.

Review methods. We obtained advice on how to answer four Guiding Questions by recruiting a panel of external experts on EMS clinicians, State-level EMS leadership, and programs relevant to EMS personnel, and by engaging representatives of professional societies in infectious diseases and emergency medicine. We searched PubMed®, Embase®, CINAHL®, and SCOPUS from January 2006 to March 2022 for relevant studies. We also searched for reports from State and Federal Government agencies or nongovernmental organizations interested in infection prevention and control in the EMS and 911 workforce.

Results. Twenty-five observational studies reported on the epidemiology of infections in the EMS and 911 workforce. They did not report demographic differences except for a higher risk of hepatitis C in older workers and severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in minorities. EMS clinicians certified/licensed in Advanced Life Support have a high risk for blood and fluid exposure, and EMS clinicians had a higher risk of hospitalization or death from SARS-CoV-2 than firefighters whose roles were not primarily related to medical care. Eleven observational studies reported on infection prevention and control practices (IPC), providing some evidence that hand hygiene, standard precautions, mandatory vaccine policies, and on-site vaccine clinics are effective. Research on IPC in EMS and 911 workers has increased significantly since the SARS-CoV-2 pandemic.

Conclusions. Moderate evidence exists on the epidemiology of infections and effectiveness of IPC practices in EMS and 911 workers, including hand hygiene, standard precautions, mandatory vaccine policies, and vaccine clinics. Most evidence is observational, with widely varying methods, outcomes, and reporting. More research is needed on personal protective equipment effectiveness and vaccine acceptance, and better guidance is needed for research methods in the EMS and 911 worker setting.

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Executive Summary

Key Points

- Emergency medical service (EMS) workers appear to be at higher risk of infection when compared to firefighters and other frontline emergency personnel.
- Little research exists on infectious diseases in 911 dispatchers and telecommunicators.
- Research studies on infectious diseases in the EMS and 911 workforce have increased significantly since the beginning of the coronavirus disease 2019 (COVID-19) pandemic.
- Most research since 2006 has concentrated on the epidemiology of infections and infection risk.
- Research into the field effectiveness of N95 respirator and surgical face mask personal protective equipment (PPE) is limited, especially in the arena of airborne diseases.
- Regular hand hygiene decreases the spread of methicillin-resistant *Staphylococcus aureus* (MRSA).
- Standard precautions, such as gloves, decrease the chance of needlestick exposures.
- Vaccine uptake increases with the application of on-site directed clinics in the workforce, especially when combined with an active, targeted educational program with supervisor and peer support.
- Mandatory influenza vaccine programs increase the likelihood of vaccine uptake.
- Research into EMS and 911 infectious disease issues would be strengthened by a national research agenda including improved data uniformity, use of appropriate comparison groups, and comparable outcome measures.

Background and Purpose

The COVID-19 pandemic has highlighted the need for an improved understanding of infectious diseases in the EMS and 911 workforce. Public facing EMS clinicians have contact with multiple patients per day as they move through varying work environments in the field and hospital setting. Although PPE has been studied in controlled settings, research in EMS settings is more challenging. The transition of patients throughout these environments and the challenges of hand washing and PPE in the field provide opportunities for pathogens to spread from patients or co-workers to EMS clinicians. In addition, first responders, including 911 telecommunicators, are often in a communal work environment with shared eating and sleeping spaces. EMS clinicians are also at risk for needlestick injuries and blood-borne exposures to viruses such as human immunodeficiency virus (HIV) and hepatitis C, and droplet/airborne exposures to viruses such as influenza and the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).

This Technical Brief aims to summarize current evidence on exposures to infectious pathogens in the EMS and 911 workforces and on interventions or practices for preventing, recognizing, and controlling occupationally acquired infectious diseases in these workforces. The Technical Brief also seeks to identify future research needs in this area. The Guiding Questions are:

1. What are the **characteristics, incidence, prevalence, and severity of occupationally acquired infectious diseases and related exposures** for the EMS and 911 workforces?

2. What are the characteristics and reported effectiveness (i.e., benefits and harms) of practices to **prevent** infectious diseases?
3. What are the characteristics and reported effectiveness (i.e., benefits and harms) of practices examined in studies of the EMS and 911 workforces to **recognize and control** (e.g., chemoprophylaxis, but excluding treatment) infectious diseases?
4. What are the context and implementation factors of studies with effective EMS and 911 workforce practices to prevent, recognize, and treat occupationally acquired infectious diseases? This description might include distinguishing factors such as workforce training, surveillance, protective equipment, pre- and post-exposure prophylaxis, occupational health services, preparedness for emerging infectious diseases, and program funding.
5. What future research is needed to close existing evidence gaps regarding preventing, recognizing, and treating occupationally acquired infectious diseases in the EMS and 911 workforces?

Methods

We employed methods consistent with those outlined in the Evidence-based Practice Center Program Methods Guidance (https://effectivehealthcare.ahrq.gov/topics/cer-methods-guide/overview), and we describe these in the full report. Our searches covered publication dates from January 1, 2006, to March 15, 2022. We included studies of the EMS and 911 workforces conducted in the United States. We included studies that evaluated the effectiveness of EMS and 911 workforce practices that had a comparison group. We did not include studies that evaluated firefighters or police personnel whose roles were not primarily related to medical care.

Results

In the published literature, we found 32 studies that met our inclusion criteria. Twenty-five were observational studies examining the characteristics, incidence, prevalence, and/or severity of occupationally acquired infectious diseases and related exposures in the EMS and 911 workforces. Eleven observational studies reported on the characteristics and effectiveness of infection prevention and control (IPC) practices in the EMS and 911 workforces. Some studies examined both the epidemiology of occupational infections and the interventions or practices to mitigate or prevent them. None of the studies used an experimental design.

Research into infectious diseases in the EMS and 911 workforces has increased significantly since the COVID-19 pandemic, and most of the evidence on how occupationally acquired infections differ by demographics is limited to SARS-CoV-2. The incidence, prevalence, and severity of infections generally did not differ according to demographic differences in the EMS and 911 workforces, except for an increase in hepatitis C in older workers and an increase in SARS-CoV-2 in Black non-Hispanic and other Hispanic workers when compared with white non-Hispanic workers. Compared with single-role firefighters (firefighters whose role was not primarily related to medical care), EMS workers had an increased risk of hospitalization or death from COVID-19 and a mildly increased prevalence of hepatitis C. In addition, EMS workers

certified/licensed in Advanced Life Support (ALS) had an increased risk of blood exposure, fluids exposure, and needlesticks when compared to workers certified/licensed in Basic Life Support (BLS). One study found no differences in years of experience, population density, or level of care for nasal colonization with MRSA.

In the 11 observational studies on characteristics and effectiveness of IPC practices in the EMS and 911 workforces, several workforce practices were examined, including hand hygiene, standard precautions, and on-site vaccine clinics. Both daily and post-glove use hand hygiene were negatively correlated with nasal colonization of MRSA. The increased use of standard precautions such as face masks, gloves, and protective devices for resuscitation were associated with a decreased likelihood of a needlestick.

One study demonstrated that the lack of PPE and PPE breach or failure were correlated with higher SARS-CoV-2 seropositivity. Another study demonstrated that aerosol-generating procedures (AGPs), with full PPE, were not associated with SARS-CoV-2 diagnosis. Only one EMS clinician developed COVID-19 infection during the study period. No included study examined the protectiveness of N95 respirators or Powered Air-Purifying Respirators during AGPs in comparison with use of surgical masks alone or when paired with a face shield.

On-site vaccine clinics were found to be effective at improving vaccine acceptance and uptake for H1N1 influenza and seasonal influenza, especially when paired with an active program of education, social influence, and advice from supervisors. Vaccine uptake and acceptance were enhanced not only by the presence of a vaccination program, but also by accompanying educational modules and buy-in from supervisors and trusted peers. Mandatory vaccination policies for seasonal influenza and H1N1 influenza also were shown to be effective at increasing vaccine uptake amongst EMS and 911 workers. No studies on mandatory vaccination policies for SARS-CoV-2 fit within our inclusion criteria.

Limitations

The available data exhibits considerable heterogeneity in research design, methodology, and outcomes studied. Most studies in our review were observational cohort studies with a comparison group. The studies of IPC practices included in this review are limited to those having a comparison group because effectiveness of a public health intervention cannot be reliably determined without a comparison group. Although the observational studies of IPC practices generally included EMS and 911 workers representative of the target population of interest, most of the studies did not provide enough information to assess potential selection bias and confounding factors. These studies also did not provide separate information about the effectiveness of IPC practices in 911 telecommunicators and emergency dispatchers.

Implications and Conclusions

A moderate amount of evidence exists on the incidence, prevalence, and severity of occupationally acquired infections in the EMS and 911 workforce, but most of that evidence has been published in the last 2 years and mostly focuses on SARS-CoV-2. This evidence reinforces concerns about the substantial risks of numerous types of infection in the EMS and 911 workforces. A moderate amount of evidence also exists on the characteristics and effectiveness of IPC practices in the EMS and 911 workforces, offering some support for the effectiveness of hand hygiene, standard precautions, mandatory vaccination policies, and on-site vaccine clinics. However, many evidence gaps remain. More research is needed on the effectiveness of different types of IPC interventions for the full range of occupationally acquired infections in the EMS

and 911 workforces. The evidence is limited by lack of experimental study designs in the EMS setting and insufficient attention to potential selection bias and confounding in observational studies. Future research could benefit from a national research agenda including the above elements and incorporating practical guidance on how to conduct studies in the highly challenging mobile environments typical of EMS work.

Introduction

Background

Historical themes of infection prevention and control (IPC) in emergency medical services (EMS) have classically centered around hand hygiene, disinfection of surfaces, sharps safety, personal protective equipment (PPE), and the disinfection of equipment. EMS clinicians often have contact with multiple patients per day, in home, ambulance, and hospital environments, while 911 telecommunicators have varying degrees of contact with EMS clinicians. The transition of patients throughout these environments and the challenges of hand washing and personal protection in the field provide opportunities for pathogens to spread among EMS clinicians and 911 telecommunicators.[1] For the purposes of this Technical Brief, the EMS and 911 workforce is defined as the personnel primarily involved in medical care, including telecommunicators who support delivery of care,

Many infectious agents can be transmitted via contact with the skin or mucous membranes; despite this, compliance with hand hygiene measures has been less than optimal.[2] Viruses such as norovirus can be spread by contact and possibly through airborne exposure after emesis. In Nevada, EMS clinicians wore gloves during 56 percent of activations, washed hands after 27 percent of patient encounters, and disinfected equipment 31 percent of the time.[3] In Maine, one study suggested that half of ambulances tested positive for methicillin-resistant *Staphylococcus aureus* (MRSA) in high action areas.[4] Another study showed that 57 percent of reusable ambulance equipment tested positive for blood.[5] Yet another study reported that current decontamination practices may not reduce viral load on ambulance surfaces.[6]

Other infectious agents, such as the human immunodeficiency virus (HIV) and hepatitis C, can spread to EMS clinicians via blood-borne exposure. EMS clinicians have an increased risk of injury from needle sticks or other sharp instruments because of the difficulty of performing procedures in a mobile environment.[7] Hepatitis B can be spread via blood-borne exposure, and many EMS clinicians are required to be vaccinated against it. Yet, studies have shown that EMS clinicians frequently do not follow recommendations for minimizing the risk of needle stick injuries.[8]

The EMS and 911 workforces are also at risk for airborne exposure to infectious diseases, such as tuberculosis, influenza, and the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The risk of airborne exposure is increased by not consistently using appropriate respiratory and eye/face protection.[7]

The coronavirus disease 2019 (COVID-19) pandemic has highlighted the importance of IPC practices. However, adherence to IPC guidance involves structural determinants such as public health policy and budgetary support as well as individual knowledge, attitudes, education, skills, and behaviors. The resulting decisional dilemmas that emerge include addressing reasons for decreased adherence to IPC standards by EMS clinicians and 911 telecommunicators, and implementing effective IPC at the individual and system levels.

Barriers to research in the prehospital field contribute to the limitations of the science in EMS today. Study design and data collection challenges arise from the mobile work environment and multiple care sites such as homes, streets, outdoor settings, and the hospital. Previous research into IPC for EMS clinicians has been heterogenous and often qualitative in nature given these barriers to experimental design and quantitative data collection in the field environment. Some previous PPE research may be relevant to EMS clinicians, but this is subject to the limitations related to changes in work environment, movement, exertion, and safety concerns.

The Office of Emergency Medical Services at the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) requested this Technical Brief for the purpose of summarizing the evidence on: exposures to and incidence/prevalence/severity of infectious diseases in the EMS and 911 workforces; and interventions for preventing, recognizing, and controlling occupationally acquired infectious diseases in the EMS and 911 workforces. This brief should be useful to policy makers, researchers, and managers in the EMS and 911 field in making decisions about how to minimize the risk of infectious diseases in the EMS and 911 workforces. The Technical Brief should help to identify future research needs by identifying research questions that have not been addressed in the literature.

Guiding Questions

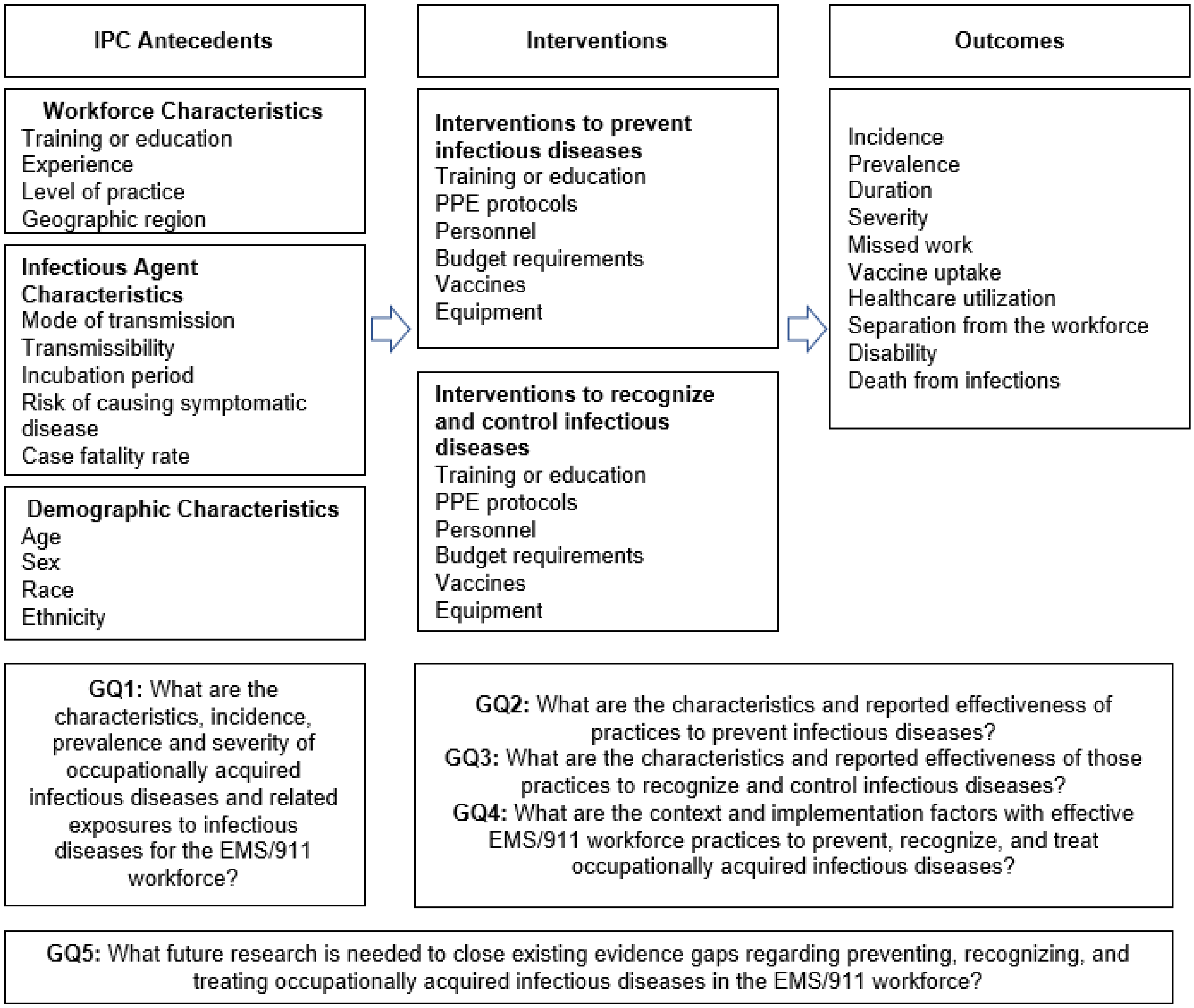
1. What are the **characteristics, incidence, prevalence, and severity of occupationally acquired infectious diseases and related exposures** for the EMS and 911 workforces?
    a. How do the incidence, prevalence, and severity of infectious diseases and related exposures vary by *demographic characteristics* (e.g., age, sex, race, ethnicity) of the workforce?
    b. How do the incidence, prevalence, and severity of infectious diseases and related exposures vary by *workforce characteristics* (e.g., training, experience, level of practice, geographic region)?
2. What are the characteristics and reported effectiveness (i.e., benefits and harms) of practices to **prevent** infectious diseases?
    a. How do workforce practices to prevent infectious diseases vary by *demographic characteristics* (e.g., age, sex, race, ethnicity)?
    b. How do workforce practices to prevent infectious diseases vary by *workforce characteristics* (e.g., level of training, experience, geographic region)?
    c. How do workforce practices to prevent infectious diseases *vary by practice characteristics* (e.g., specific types of training incorporated into practice, PPE, personnel, and budget requirements)?
    d. What is the *reported effectiveness* (i.e., benefits and harms) in studies of EMS and 911 workforce practices to prevent infectious diseases? (Outcomes of interest include but are not limited to, incidence, prevalence, duration, severity, missed work, healthcare utilization, separation from the workforce, disability, and death from infections.)
3. What are the characteristics and reported effectiveness (i.e., benefits and harms) of practices examined in studies of the EMS and 911 workforces to **recognize and control** (e.g., chemoprophylaxis, but excluding treatment) infectious diseases?
    a. How do workforce practices to recognize and control infectious diseases vary by *demographic characteristics* (e.g., age, sex, race, ethnicity) of the EMS and 911 workforces?
    b. How do workforce practices to recognize and control infectious diseases vary by *workforce characteristics* (e.g., level of training, experience, level of practice, geographic region)?
    c. How do workforce practices to recognize and control infectious diseases vary by *infection recognition and control practice characteristics* (e.g., specific types of training incorporated into practice, PPE, personnel, and budget requirements)?
    d. What is the *reported effectiveness* (i.e., benefits and harms) in studies of EMS and 911 workforce practices to recognize and control infectious disease?

(Outcomes of interest include but are not limited to, incidence, prevalence, duration, severity, missed work, healthcare utilization, separation from the workforce, disability, and death from infections.)

4. What are the context and implementation factors of studies with effective EMS and 911 workforce practices to prevent, recognize, and treat occupationally acquired infectious diseases? This description might include distinguishing factors such as workforce training, surveillance, protective equipment, pre- and post-exposure prophylaxis, occupational health services, preparedness for emerging infectious diseases, and program funding.
5. What future research is needed to close existing evidence gaps regarding preventing, recognizing, and treating occupationally acquired infectious diseases in the EMS and 911 workforces?

For Guiding Question 1, we defined occupationally acquired exposures to infectious diseases as contact exposure (intact skin), respiratory exposure (inhaled and aerosolized), and blood-borne exposure (needle sticks, blood to non-intact skin, etc.). Organisms of interest included but are not limited to MRSA, SARS-CoV-2, influenza, tuberculosis, HIV, and hepatitis B and C. We considered the 911 workforce to include the 911 telecommunicators who are fielding the calls and interacting with EMS clinicians. The EMS workforce includes the responding healthcare personnel in field settings. We developed a conceptual framework to guide work on the Technical Brief (Figure 1).

Figure 1. Conceptual framework for infection prevention and control in EMS and 911 workers



EMS = emergency medical services; IPC = infection prevention and control; GQ = Guiding Question; PPE = personal protective equipment

Methods

Discussions With Key Informants

In consultation with representatives from the Agency for Healthcare Research and Quality (AHRQ) and National Highway Traffic Safety Administration (NHTSA), we recruited a panel of external experts on emergency medical services (EMS) clinicians, state-level EMS leadership, and programs relevant to EMS and 911 workers. We also engaged representatives of professional societies in infectious diseases and emergency medicine: National Registry of Emergency Medical Technicians (NREMT), National Association of EMS Physicians, National Association of State EMS Officials, National Association of State 911 Administrators, National Association for Public Safety Infection Control Officers, and the Centers for Disease Control and Prevention (including the CDC's National Institute for Occupational Safety and Health). The external experts provided advice on how we answered each of our Guiding Questions (GQs). Questions for the Key Informants included: (1) do they suggest any revision in our analytic framework? (2) do they suggest any revision in how we define the relevant scope of occupational exposures to infection? (3) do they suggest any change in the criteria we use to determine whether an intervention is effective? (4) do they suggest any change in how we define or describe relevant contextual factors? (5) what do they think is most important to know about the quality of the studies we identify? (6) how important is it to determine the seroprevalence or infection rates of EMS workers if there is no comparison group? and (7) what is the value of studies that assess the infectious state of equipment?

Published Literature Search

We conducted a systematic search for published evidence using PubMed®, Embase®, CINAHL®, and SCOPUS from January 1, 2006, to March 15, 2022. We limited the search to the last 15 years. A 15-year cut-off corresponds to passage of the landmark Pandemic and All-Hazards Preparedness Act (PAHPA) in 2006,[9] which focused on improving the nation's public health and medical preparedness and response capabilities for emergencies. Our search strategies are in Appendix A.

Two members from the team independently assessed each citation to determine whether it met inclusion criteria (Table 1). Team members had expertise in emergency medicine, emergency medical services, infection control, or evidence synthesis. We included studies regardless of study quality if they provided original data on the GQs.

Table 1. Inclusion and exclusion criteria

PICOTS	Inclusion Criteria	Exclusion Criteria
Population	• EMS workforce including 911 telecommunicators exposed to or at risk of exposure to an occupationally acquired infectious disease as contact exposure, respiratory exposure, or blood-borne exposure*	• Firefighters and police personnel in roles not primarily related to medical care
Intervention	• One or more of the following types of interventions: • Training or education • PPE protocols • Personnel policies • Budget allocations • Vaccines • Equipment	• NA

PICOTS	Inclusion Criteria	Exclusion Criteria
Comparison	• Any comparison group (for studies that evaluate the effectiveness of an EMS and 911 workforce practice)	• Studies without a comparison group (for studies that evaluate the effectiveness of an EMS and 911 workforce practice)
Outcomes	• Incidence • Prevalence • Duration • Severity • Missed work • Healthcare utilization • Separation from the workforce • Disability • Death from infections	• NA
Timing	• Published after 2006 and includes data after 2006	• Does not include data after 2006
Setting	• Conducted in the United States	• Military exercises and drills • Live evacuations from another country
Study design	• Experimental and non-experimental studies with comparison groups, including pre-post studies • Relevant systematic reviews	• No original data (narrative reviews, commentaries, simulation studies)

EMS = emergency medical services; NA = not applicable; PICOTS=Population, Intervention, Comparison, Outcome, Time, Setting; PPE = personal protective equipment

* Organisms of interest included but are not limited to methicillin-resistant *Staphylococcus aureus*, severe acute respiratory syndrome coronavirus 2, influenza, tuberculosis, human immunodeficiency virus, and hepatitis B and C.

Gray Literature Search

We searched the gray literature for reports from selected state and federal government agencies and nongovernmental organizations that have an interest in this topic (e.g., CDC, the National Institutes of Health, Infectious Diseases Society of America, the Assistant Secretary for Preparedness and Response (ASPR), Society for Healthcare Epidemiology of America, and Association for Professionals in Infection Control and Epidemiology). We searched for ongoing research by using the clinicaltrials.gov database and by querying our advisors. We reviewed any material that was submitted through the Supplemental Evidence and Data for Systematic Reviews portal.

Information Management

For each eligible study, a team member used an Excel spreadsheet to extract information about the epidemiologic characteristics of the infectious disease exposures (GQ 1), as well as characteristics, effectiveness, and context of interventions (GQs 2-3), following the framework in Figure 1. We used the metaprop command in Stata to calculate 95% confidence intervals (CIs) associated with reported incidence and prevalence rates (and rates of serious infections). To assess effectiveness, we abstracted data on the main outcomes of each study, whether there was a statistically significant effect, and the direction and magnitude of the effect with the corresponding 95% CIs. We also captured the sample size of studies, recognizing that some studies may fail to find a significant difference because of a small sample size. A second team member reviewed extracted information for accuracy. For GQ 4, we included a summary of national, state, or local infection prevention and control (IPC) protocols pertinent to the EMS and 911 workforces that were identified in the included studies.

Paired reviewers independently assessed the quality of each study by focusing primarily on classifying the study design according to the accepted hierarchy of study designs. For studies that addressed GQ 1, we also assessed the quality of studies in terms of representativeness,

completeness, and accuracy by asking three questions: (1) Are the targeted individuals likely to be representative of the target population? (2) What percentage of targeted individuals agreed to participate? and (3) Did the study report any data on the validity of the tests of interest? To assess the quality of studies that applied to GQs 2-3, we used three questions from the Effective Public Health Practice Project tool:[10] (1) Are the individuals selected to participate in the study likely to be representative of the targeted population? (2) What percentage of selected individuals agreed to participate? and (3) Were there important differences between groups prior to the intervention?

Data Presentation

We used tables and accompanying text to summarize information from the studies on each of the GQs. We created an evidence map with associated data visualization techniques to help describe the extent of the literature on each of the questions. We used the population, intervention, comparison, outcome, timing, setting, and study design (PICOTS) framework to identify and organize the research gaps.

Peer Review and Public Commentary

Experts in emergency medical services and infection control, and individuals representing stakeholder and user communities were invited to provide external peer review of this Technical Brief. AHRQ and an associate editor also provided comments. The draft report was posted on the AHRQ website for 4 weeks to elicit public comment. We addressed all reviewer comments, revising the text as appropriate, and documented everything in a disposition of comments report that will be made available 3 months after AHRQ posts the final Technical Brief on the Effective Health Care website.

Results

We first present the results from the Key Informant interviews. We then present the results of the published literature search, organized by Guiding Question (GQ). We then present the results from the Gray Literature search.

Results of the Key Informant Interviews

We organized and held a one-hour session on October 25, 2021, with eight Key Informants who were selected for their expertise on the topic, representing a broad range of national, state, and regional emergency medical services (EMS) and 911 agencies. Guided by a series of pre-determined questions, the purpose of the session was to obtain feedback and clarification regarding specific aspects of the protocol. Key Informants will be invited to review the draft report and will be acknowledged in the final report by name and affiliation with the disclaimer that all views expressed therein are strictly those of the report authors.

Modifications to the Analytic Framework

With respect to the analytic framework, several Key Informants indicated that "training" should be replaced by "training and education" to represent distinct concepts. Secondly, the Key Informants felt that protocols, guidelines, standard operating procedures, and procedures are needed to serve as the basis for the education and training. Furthermore, training and education should be competency-based with incorporation of requisite knowledge, skills, and attitudes, and methods for independent evaluation of competency. Regarding interventions of interest, the Key Informants perceived an overemphasis in infection control on personal protective equipment (PPE). They recommended an alternate approach for consideration - to look for evidence on diverse types of interventions across the hierarchy of controls: elimination, substitution, engineering, administration, and PPE, recognizing what has been learned with Ebola virus and Coronavirus disease 2019 (COVID-19). For example, the safety culture of an organization would represent an administrative control. The Key Informants also felt that the analytic framework should acknowledge that exposures may result from activities not involving direct contact with patients. Regarding workforce characteristics of interest, the Key Informants suggested examination of high-performing organizations. Funding levels could be used as a proxy measure, with the caveat that public and private providers may differ in their ability to receive governmental funds. The Key Informants also recommended consideration of organizational size, team response size, and vaccination status of the workforce. For outcomes of interest, the Key Informants advised considering "near misses" or "close calls."

Scope

When the Evidence-based Practice Center (EPC) team proposed to define the scope of the Technical Brief as covering the EMS and 911 workforce primarily involved in medical care, including telecommunicators who support delivery of care, some Key Informants mentioned other groups. For example, while police or firefighters may interact with patients, their primary role does not directly involve provision of medical care. We decided to keep the brief focused on studies of EMS and 911 workers whose primary role is delivery or support of medical care. The Key Informants also noted the difficulties of parsing occupationally acquired exposures from off-duty exposures to infectious agents. Most Key Informants agreed that inclusion of studies

assessing surface contamination would not be useful because contamination does not equate to infection. The presence of other important infectious particles might not be identified in such studies.

Criteria for Determining Effectiveness of Interventions

One of the Key Informants mentioned workforce mental health as a criterion for determining effectiveness of interventions, stressing the relationship between infection control and workforce mental health. To date, little is known about how PPE compliance in the EMS and 911 setting is impacted by stress or surge conditions. The EPC team explained that it was working on a separate topic development brief to address workforce mental health issues, though not specifically focusing on or examining linkages between workforce infection prevention and control (IPC) practices and mental health.

Relevant Contextual Factors

The Key Informants asked for clarification of whether the Technical Brief would include inter-facility transports and how to define such transports. Key Informants also wished to clarify if both ground and air transport would be considered. As indicated in Table 1, we only excluded evacuations from another country.

Quality of Studies

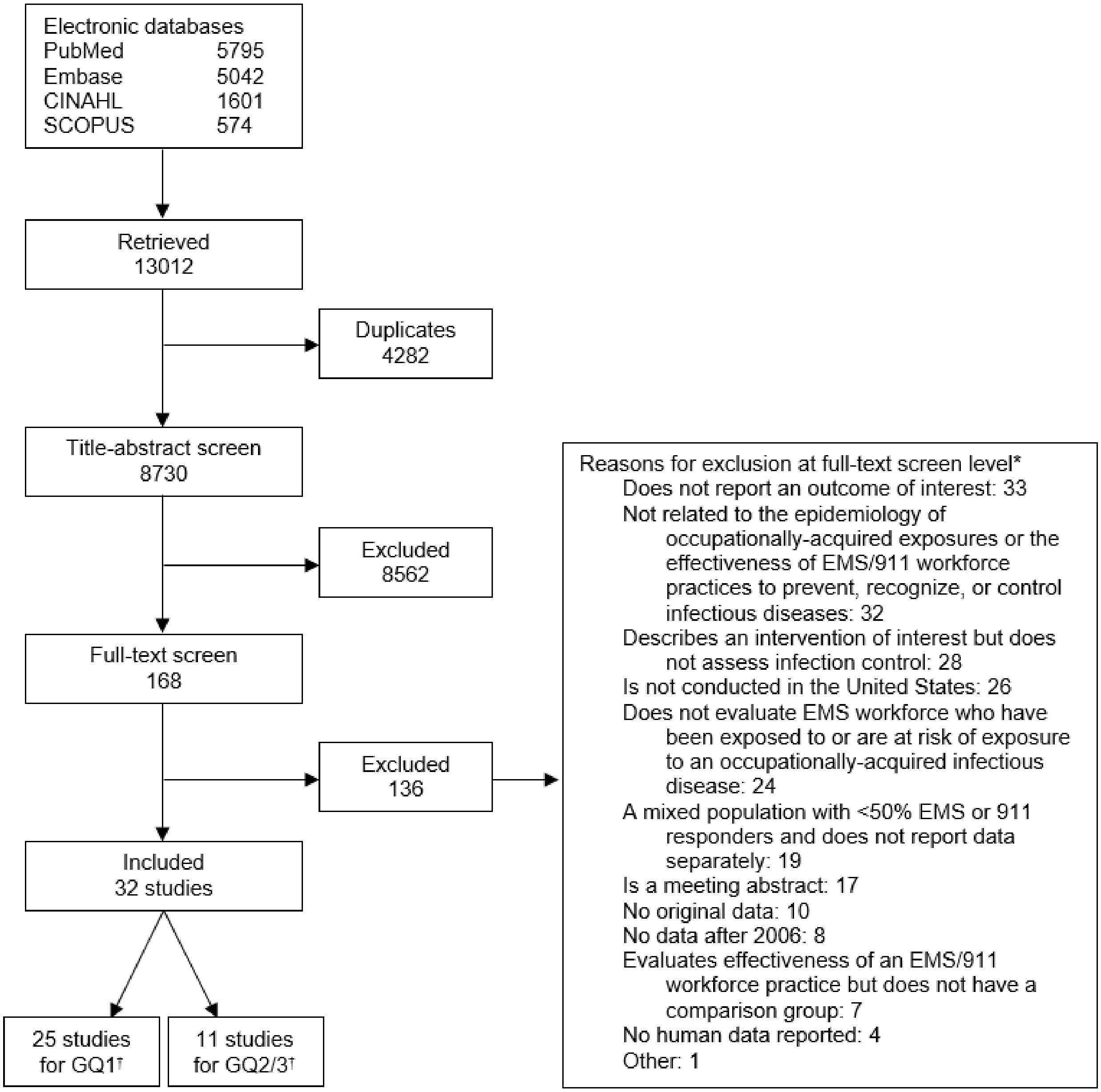
The Key Informants reported that studies on this topic used observational methods with serious limitations. Although they agreed with looking for studies of interventions using a comparison group, they noted that studies using the local community as a comparison group would require careful consideration of confounding factors.

Results of the Published Literature Search

We retrieved 8730 unique citations (Figure 2). After screening abstracts and full-text, we included 32 studies (N=88,658 participants).[8, 11-41] The list of excluded articles is in Appendix B. Evidence tables are provided in Appendix C.

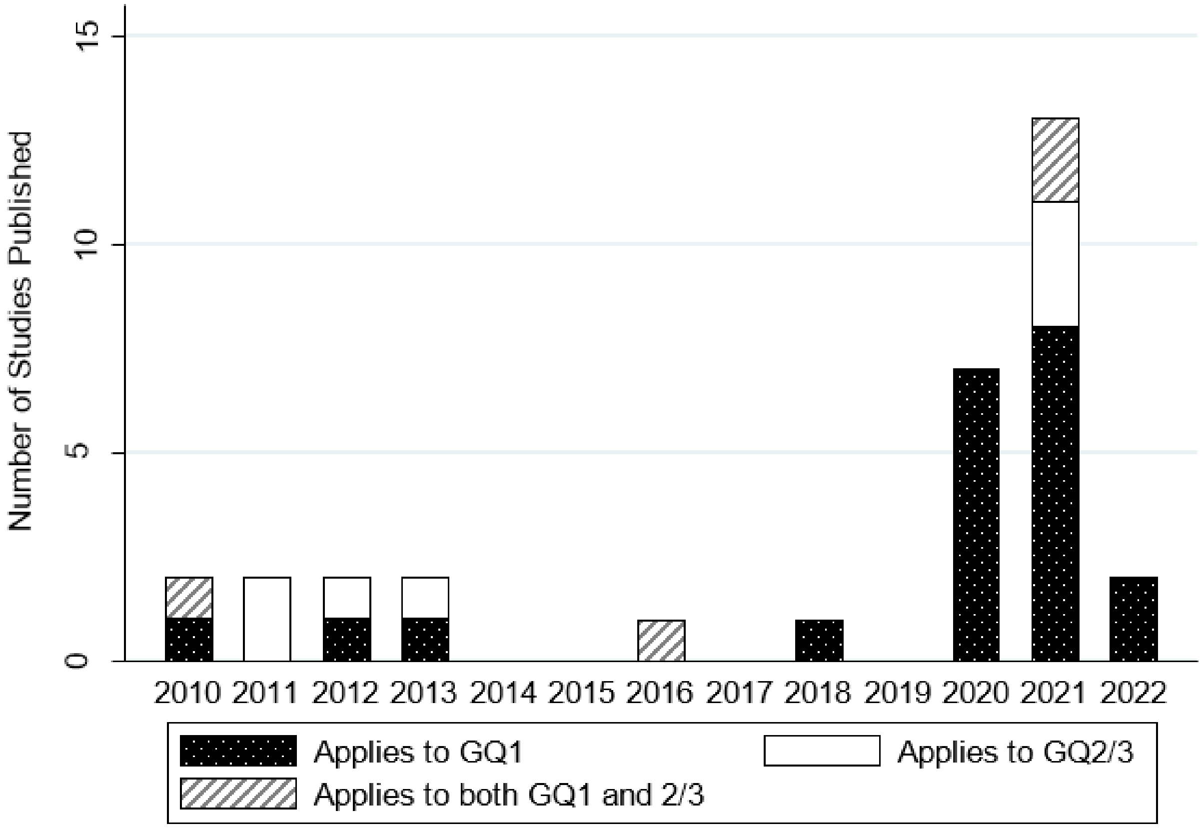
Twenty-one studies applied to GQ 1 only,[11-17, 19, 20, 23, 25, 29, 30, 32-39] seven studies applied to GQ 2/3 only,[18, 21, 22, 24, 27, 31, 40] and four studies applied to both GQ 1 and GQ 2/3.[8, 26, 28, 41] Twenty-two studies were published in 2020 or later (Figure 3). Many of the studies published in 2020 or later assessed the prevalence of COVID-19.

Figure 2. Results of literature search



* Articles could be excluded for more than one reason.
† Four studies applied to both GQ 1 and GQ 2/3.
CINAHL = Cumulative Index to Nursing and Allied Health Literature; EMS = emergency medical services; GQ = Guiding Question

Figure 3. Number of studies included for each Guiding Question by year of publication



GQ=Guiding Question

GQ 1: Characteristics, Incidence, Prevalence, and Severity of Occupationally Acquired Infectious Diseases and Related Exposures for the EMS and 911 Workforce

Characteristics of Studies

Of the 25 studies included for GQ 1, 16 were cross-sectional studies,[8, 11, 13-16, 20, 23, 25, 26, 28, 30, 32, 33, 38, 41] four were retrospective cohort studies,[12, 17, 19, 34] and five were a prospective cohort study.[29, 35-37, 39] The majority, 14, were set in urban areas,[13, 14, 17, 19, 20, 28-30, 32-34, 38, 41] with the remaining conducted in multiple settings (eight studies)[8, 11, 12, 23, 25, 26, 35, 39] and unclear settings three studies).[16, 36, 37] Studies were performed across the United States including six in the Northeast,[17, 19, 20, 29, 32, 33] three in the South,[8, 16, 25] four in the Midwest,[13-15, 26] six in the West,[12, 28, 30, 38, 39, 41] three in the Southwest,[11, 34, 35] and one was nationwide.[23] Studies were examined for any self-reported elements of high-performance systems, but very few systems were identified as such.

Study Quality

Most of the studies addressing GQ 1 used a cross-sectional design (16 of 25) and did not follow participants over time. As shown in Table 2, 76 percent of the studies on GQ 1 were somewhat or very likely to include individuals likely to be representative of the target

population. However, only 36 percent of the studies reported that 80 percent or more of the targeted individuals agreed to participate. Most of the studies reported on the validity of the tests or measures of interest, but six did not, and four relied on self-reported data that was not validated.

Table 2. Quality of studies that reported on the characteristics, incidence, prevalence, or severity of occupationally acquired infectious diseases and related exposures to infectious diseases among the EMS and 911 workforce

Quality Assessment Question	Quality Assessment Response	Cross-Sectional Studies n (%) N = 16	Prospective Cohorts n (%) N = 5	Retrospective Cohorts n (%) N = 4
Are the targeted individuals likely to be representative of the target population?	Very likely	11 (68.8%)	1 (20%)	4 (100%)
	Somewhat likely	3 (18.8%)	0	0
	Not likely	1 (6.3%)	0	0
	Can't tell	1 (6.3%)	4 (80%)	0
What percentage of targeted individuals agreed to participate?	80-100% agreement	5 (31.3%)	1 (20%)	3 (75%)
	60-79% agreement	2 (12.5%)	0	0
	Less than 60% agreement	4 (25%)	0	0
	Can't tell	5 (31.3%)	4 (80%)	1 (25%)
Did the study report any data on the validity of the tests of interest?	Yes	11 (68.8%)	1 (20%)	3 (75%)
	No/can't tell	2 (12.5%)	3 (60%)	1 (25%)
	Self-report	3 (18.8%)	1 (20%)	0

EMS=emergency medical services

Findings on Incidence, Prevalence, and Severity of Infections

Table 3 displays the incidence, prevalence, and severity of occupationally acquired infectious diseases and related exposures in the EMS and 911 workforce reported in all studies that met our inclusion criteria. Most of the studies reported prevalence rates, most frequently focusing on severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Few studies reported incidence rates, and no incidence rates were reported for infections other than SARS-CoV-2. Severity of disease was reported in a few studies in various terms such as death from infection, hospitalization, or separation from the workforce due to quarantine from exposure or symptoms. None of the studies reported on severity of infections other than SARS-CoV-2.

Table 3. Incidence, prevalence, and severity of occupationally acquired infectious diseases and related exposures among the EMS and 911 workforce

Author, Year	Outcome Category	Infectious Disease	Outcome	n/N	% with Outcome (95% CI)*
El Sayed, 2011[19]	Prevalence	Dermatologic (rash)	Confirmed case after reported work exposure	3/19	15.8 (5.5, 37.6)
Webber, 2018[29]	Prevalence	Hepatitis C	Positive tests from 2000-2012	151/11374	1.3 (1.1, 1.6)
Webber, 2018[29]	Prevalence	Hepatitis C	Positive tests from 2000-2012	151/11374	1.3 (1.1, 1.6)
El Sayed, 2011[19]	Prevalence	Mammalian bite (cat/human)	Confirmed case after reported work exposure	8/8	100 (67.6, 100)

Author, Year	Outcome Category	Infectious Disease	Outcome	n/N	% with Outcome (95% CI)*
El Sayed, 2011[19]	Prevalence	Meningitis	Confirmed case after reported work exposure	16/131	12.2 (7.7, 18.9)
Al Aminy, 2013[25]	Prevalence	MRSA	Nasal colonization of MRSA	7/110	6.4 (3.1, 12.6)
Al Aminy, 2013[25]	Prevalence	MRSA	Self-report history of MRSA infection	6/110	5.5 (2.5, 11.4)
Al Aminy, 2013[25]	Prevalence	MRSA	Nasal colonization of MRSA	7/110	6.4 (3.1, 12.6)
Al Aminy, 2013[25]	Prevalence	MRSA	Self-report history of MRSA infection	6/110	5.5 (2.5, 11.4)
Elie-Turenne, 2010[33]	Prevalence	MRSA	Cultured nasal swabs for s. aureus	1/52	1.9 (0.3, 10.1)
Elie-Turenne, 2010[33]	Prevalence	MRSA	Cultured nasal swabs for s. aureus	1/52	1.9 (0.3, 10.1)
Orellana, 2016[26]	Prevalence	MRSA	Nasal colonization of MRSA	13/280	4.6 (2.7, 7.8)
Orellana, 2016[26]	Prevalence	MRSA	Nasal colonization of MRSA	13/280	4.6 (2.7, 7.8)
Prezant, 2020[17]	Death	SARS-CoV-2	NA	4/5665	0.1 (0, 0.2)
Prezant, 2020[17]	Death	SARS-CoV-2	NA	4/5665	0.1 (0, 0.2)
Weiden, 2021[32]	Death	SARS-CoV-2	NA	4/14290	0 (0, 0.1)
Weiden, 2021[32]	Death	SARS-CoV-2	NA	4/14290	0 (0, 0.1)
Prezant, 2020[17]	Healthcare utilization	SARS-CoV-2	Hospitalization	66/5665	1.2 (0.9, 1.5)
Prezant, 2020[17]	Healthcare utilization	SARS-CoV-2	Hospitalization	66/5665	1.2 (0.9, 1.5)
Tarabichi, 2021[13]	Healthcare utilization	SARS-CoV-2	Hospitalization due to symptoms	1/16	6.3 (1.1, 28.3)
Tarabichi, 2021[13]	Healthcare utilization	SARS-CoV-2	Hospitalization due to symptoms	1/16	6.3 (1.1, 28.3)
Weiden, 2021[32]	Healthcare utilization	SARS-CoV-2	Hospitalization due to COVID-19	62/14290	0.4 (0.3, 0.6)
Weiden, 2021[32]	Healthcare utilization	SARS-CoV-2	Hospitalization due to COVID-19	62/14290	0.4 (0.3, 0.6)
Ellingson, 2021[35]	Incidence	SARS-CoV-2	RT-PCR assay (EMS)	13/86	15.1 (9.1, 24.2)
Ellingson, 2021[35]	Incidence	SARS-CoV-2	RT-PCR assay (Fire)	14/142	9.9 (6.0, 15.9)
Grant, 2021[41]	Incidence	SARS-CoV-2	Confirmed positive with anti-spike protein antibody test	3/1231 in 2 months	0.2 (0.1, 0.7)
Grant, 2021[41]	Incidence	SARS-CoV-2	Confirmed positive with anti-spike protein antibody test	3/1231 in 2 months	0.2 (0.1, 0.7)
Murphy, 2020[12]	Incidence	SARS-CoV-2	Diagnosis of COVID-19 after workforce exposure	3/700 in 6 weeks	0.4 (0.1, 1.3)
Murphy, 2020[12]	Incidence	SARS-CoV-2	Diagnosis of COVID-19 after workforce exposure	3/700 in 6 weeks	0.4 (0.1, 1.3)
Newberry, 2021[28]	Incidence	SARS-CoV-2	PCR test	9/983 in 3 months	0.9 (0.5, 1.7)
Newberry, 2021[28]	Incidence	SARS-CoV-2	PCR test	9/983 in 3 months	0.9 (0.5, 1.7)
Prezant, 2020[17]	Incidence	SARS-CoV-2	Incidence among firefighters	1198/11230 in 3 months	10.7 (10.1, 11.3)
Prezant, 2020[17]	Incidence	SARS-CoV-2	Incidence among EMS	573/4408 in 3 months	13.0 (12.0, 14.0)

Author, Year	Outcome Category	Infectious Disease	Outcome	n/N	% with Outcome (95% CI)*
Prezant, 2020[17]	Incidence	SARS-CoV-2	Incidence among firefighters	1198/11230 in 3 months	10.7 (10.1, 11.3)
Prezant, 2020[17]	Incidence	SARS-CoV-2	Incidence among EMS	573/4408 in 3 months	13.0 (12.0, 14.0)
McGuire, 2021[15]	Prevalence	SARS-CoV-2	IgG seroprevalence test	1/92	1.1 (0.2, 5.9)
Akinbami, 2020[14]	Prevalence	SARS-CoV-2	IgG seroprevalence test among firefighters	60/1158	6.7 (4.4, 9.9)
Akinbami, 2020[14]	Prevalence	SARS-CoV-2	IgG seroprevalence test among EMS	22/330	5.2 (4.0, 6.6)
Akinbami, 2020[14]	Prevalence	SARS-CoV-2	IgG seroprevalence test among firefighters	60/1158	6.7 (4.4, 9.9)
Akinbami, 2020[14]	Prevalence	SARS-CoV-2	IgG seroprevalence test among EMS	22/330	5.2 (4.0, 6.6)
Caban-Martinez, 2020[16]	Prevalence	SARS-CoV-2	IgG seroprevalence test	18/203	8.9 (5.7, 13.6)
Caban-Martinez, 2020[16]	Prevalence	SARS-CoV-2	IgG seroprevalence test	18/203	8.9 (5.7, 13.6)
Caban-Martinez, [37]2021[37]	Prevalence	SARS-CoV-2	Total COVID-19 illnesses among unvaccinated	160/586	27.3 (23.9, 31.1)
Caban-Martinez, [37]2021[37]	Prevalence	SARS-CoV-2	Total COVID-19 illnesses among vaccinated	24/829	2.9 (2.0, 4.3)
Caban-Martinez, [37]2021[37]	Prevalence	SARS-CoV-2	Total COVID-19 illnesses among unvaccinated	160/586	27.3 (23.9, 31.1)
Caban-Martinez, [37]2021[37]	Prevalence	SARS-CoV-2	Total COVID-19 illnesses among vaccinated	24/829	2.9 (2.0, 4.3)
Firew, 2020[23]	Prevalence	SARS-CoV-2	Self-report COVID-19 diagnosis	94/266	35.3 (29.8, 41.3)
Firew, 2020[23]	Prevalence	SARS-CoV-2	Self-report COVID-19 diagnosis	94/266	35.3 (29.8, 41.3)
McGuire, 2021[15]	Prevalence	SARS-CoV-2	IgG seroprevalence test	1/92	1.1 (0.2, 5.9)
Mohanty, 2020[36]	Prevalence	SARS-CoV-2	Viral RNA positive	5/224	2.2 (1.0, 5.1)
Mohanty, 2020[36]	Prevalence	SARS-CoV-2	Viral RNA positive	5/224	2.2 (1.0, 5.1)
Montague, 2022[39]	Prevalence	SARS-CoV-2	Diagnosis of COVID-19 – EMS	13/241	5.4 (2.5, 8.2)
Montague, 2022[39]	Prevalence	SARS-CoV-2	Diagnosis of COVID-19 – Fire	20/414	4.8 (2.8, 6.9)
Mulligan, 2022[38]	Prevalence	SARS-CoV-2	IgG or IgM seroprevalence test	61/686	8.9 (7.0, 11.3)
Mulligan, 2022[38]	Prevalence	SARS-CoV-2	IgG or IgM seroprevalence test	61/686	8.9 (7.0, 11.3)
Newberry, 2021[28]	Prevalence	SARS-CoV-2	IgG seroprevalence test	25/983	2.5 (1.7, 3.7)
Newberry, 2021[28]	Prevalence	SARS-CoV-2	IgG seroprevalence test	25/983	2.5 (1.7, 3.7)
Sami, 2021[20]	Prevalence	SARS-CoV-2	IgG seroprevalence test among dispatchers	87/292	29.8 (24.8, 35.3)
Sami, 2021[20]	Prevalence	SARS-CoV-2	IgG seroprevalence test among EMS	851/2418	35.2 (33.3, 37.1)

Author, Year	Outcome Category	Infectious Disease	Outcome	n/N	% with Outcome (95% CI)*
Sami, 2021[20]	Prevalence	SARS-CoV-2	IgG seroprevalence test among firefighters	1266/6087	20.8 (19.8, 21.8)
Sami, 2021[20]	Prevalence	SARS-CoV-2	IgG seroprevalence test among dispatchers	87/292	29.8 (24.8, 35.3)
Sami, 2021[20]	Prevalence	SARS-CoV-2	IgG seroprevalence test among EMS	851/2418	35.2 (33.3, 37.1)
Sami, 2021[20]	Prevalence	SARS-CoV-2	IgG seroprevalence test among firefighters	1266/6087	20.8 (19.8, 21.8)
Shukla, 2020[11]	Prevalence	SARS-CoV-2	IgG seroprevalence test	25/1713	1.5 (1.0, 2.1)
Shukla, 2020[11]	Prevalence	SARS-CoV-2	IgG seroprevalence test	25/1713	1.5 (1.0, 2.1)
Shukla, 2021[34]	Prevalence	SARS-CoV-2	Seroprevalence	45/201	22.4 (17.2, 28.6)
Shukla, 2021[34]	Prevalence	SARS-CoV-2	Seroprevalence	45/201	22.4 (17.2, 28.6)
Tarabichi, 2021[13]	Prevalence	SARS-CoV-2	Seroprevalence using IgG and IgM ELISA	16/296	5.4 (3.4, 8.6)
Tarabichi, 2021[13]	Prevalence	SARS-CoV-2	Seroprevalence using IgG and IgM ELISA	16/296	5.4 (3.4, 8.6)
Vieira, 2021[30]	Prevalence	SARS-CoV-2	IgG seroprevalence test	49/923	5.3 (4.0, 6.9)
Vieira, 2021[30]	Prevalence	SARS-CoV-2	IgG seroprevalence test	49/923	5.3 (4.0, 6.9)
Weiden, 2021[32]	Prevalence	SARS-CoV-2	Prevalence of COVID-19	5175/14290	36.2 (35.4, 37.0)
Weiden, 2021[32]	Prevalence	SARS-CoV-2	Prevalence of COVID-19	5175/14290	36.2 (35.4, 37.0)
Caban-Martinez, 2021[37]	Separation from workforce	SARS-CoV-2	Missed work due to COVID-19 illness among unvaccinated	Mean (SD) hours, 38.0 (46.0)	NA
Caban-Martinez, 2021[37]	Separation from workforce	SARS-CoV-2	Missed work due to COVID-19 illness among vaccinated	Mean (SD), hours, 11.9 (22.7)	NA
Caban-Martinez, 2021[37]	Separation from workforce	SARS-CoV-2	Missed work due to COVID-19 illness among unvaccinated	Mean (SD) hours, 38.0 (46.0)	NA
Caban-Martinez, 2021[37]	Separation from workforce	SARS-CoV-2	Missed work due to COVID-19 illness among vaccinated	Mean (SD), hours, 11.9 (22.7)	NA
Montague, 2022[39]	Separation from workforce	SARS-CoV-2	Episode of quarantine – EMS	14/241	5.8 (2.9, 8.8)
Montague, 2022[39]	Separation from workforce	SARS-CoV-2	Episode of quarantine – Fire	38/414	9.2 (6.4, 12)
Murphy, 2020[12]	Separation from workforce	SARS-CoV-2	Quarantine after exposure	129/700	18.4 (15.7, 21.5)
Murphy, 2020[12]	Separation from workforce	SARS-CoV-2	Quarantine after exposure	129/700	18.4 (15.7, 21.5)
Tarabichi, 2021[13]	Separation from workforce	SARS-CoV-2	Missed work or school due to symptoms	0/16	0 (0, 19.3)

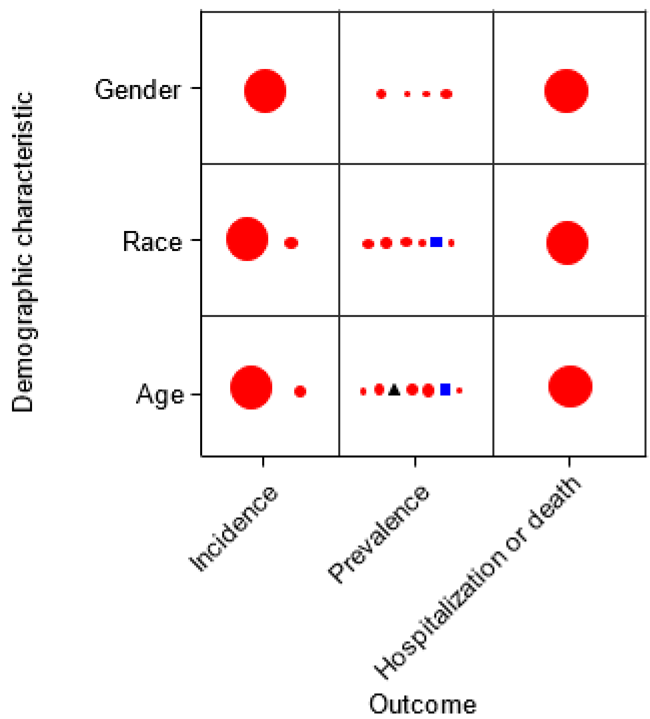
Author, Year	Outcome Category	Infectious Disease	Outcome	n/N	% with Outcome (95% CI)*
Tarabichi, 2021[13]	Separation from workforce	SARS-CoV-2	Missed work or school due to symptoms	0/16	0 (0, 19.3)
El Sayed, 2011[19]	Prevalence	Tuberculosis	Confirmed case after reported work exposure	31/68	45.6 (34.3, 57.3)
El Sayed, 2011[19]	Prevalence	Viral respiratory infection	Confirmed case after reported work exposure	38/61	62.3 (49.7, 73.4)

CI=confidence interval; COVID-19=coronavirus disease 2019; ELISA= enzyme-linked immunosorbent assay; EMS=emergency medical services; Ig=immunoglobin; MRSA=methicillin-resistant *Staphylococcus aureus*; n/N=number of people experiencing an event/number of people; NA=not applicable; RNA=ribonucleic acid; RT-PCR=real-time polymer chain reaction; SARS-CoV-2=severe acute respiratory syndrome coronavirus 2; SD=standard deviation
* Confidence intervals were computed using the Wilson method.

GQ 1a: Differences by Demographic Characteristics

Figure 4 displays the number of studies that reported on the outcomes of pathogen incidence, prevalence, and hospitalization or death by age, race, or gender. Most of the studies focused on SARS-CoV-2 exposures or COVID-19 hospitalizations, as shown in red circles in the figure. Many of the studies were small, as depicted by the small shapes in the figure.

Figure 4. Evidence map of studies that reported on incidence, prevalence, or severity of occupationally acquired infectious diseases and related exposures among the EMS and 911 workforce by demographic characteristics

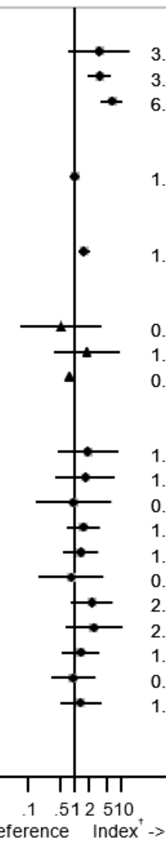


Each study is represented by a shape. The size of the shape is proportional to the sample size. Red circles represent studies of SARS-CoV-2 exposures; black triangles represent studies of MRSA exposures; blue squares represent studies of hepatitis C exposures. The placement of each shape within each cell does not signify anything.
EMS = emergency medical services; MRSA = methicillin-resistant *Staphylococcus aureus*; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2

Figure 5 displays data on differences in incidence, prevalence, and healthcare utilization for occupationally acquired infectious diseases and related exposures in the EMS and 911 workforce based on age. Most studies reported on SARS-CoV-2 prevalence, incidence, and hospitalization. The highest odds ratio (OR) was reported in the Newberry 2021 study for immunoglobulin G seroprevalence in workers 50 or more years old.[28]

Figure 5. Differences in incidence, prevalence, and healthcare utilization of occupationally acquired infectious diseases and related exposures among the EMS and 911 workforce based on age*†

Author, year	Comparison group	Reference group	Outcome	n/N comparison	n/N reference	OR (95% CI)
Hepatitis C Prevalence						
Webber, 2018	Age 30-39	Age 18-29	Positive test from 2000-2012	12/4561	0/947	3.35 (0.75, 15.05)
Webber, 2018	Age 40-49	Age 18-29	Positive test from 2000-2012	84/4578	0/947	3.41 (1.92, 6.03)
Webber, 2018	Age 50-59	Age 18-29	Positive test from 2000-2012	55/1193	0/947	6.30 (3.67, 10.80)
MRSA Prevalence						
Orellana, 2016	Age		Nasal colonization of MRSA	NR	NR	1.03 (0.98, 1.08)
SARS-CoV-2 Healthcare Utilization						
Weiden, 2021	Age per 10 yrs		Hospitalization or death from COVID	NR	NR	1.59 (1.20, 2.10)
SARS-CoV-2 Incidence						
Newberry, 2021	Age 35-49	Age 18-34	PCR test	3/556	2/206	0.52 (0.07, 3.74)
Newberry, 2021	Age 50+	Age 18-34	PCR test	4/221	2/206	1.83 (0.37, 9.16)
Weiden, 2021	Age per 10 yrs		COVID diagnosis	NR	NR	0.79 (0.74, 0.84)
SARS-CoV-2 Prevalence						
Caban-Martinez, 2020	Age 31-40	Age 21-30	IgG seroprevalence test	6/51	2/33	1.92 (0.44, 8.47)
Caban-Martinez, 2020	Age 41-50	Age 21-30	IgG seroprevalence test	7/67	2/33	1.70 (0.40, 7.24)
Caban-Martinez, 2020	Age 51+	Age 21-30	IgG seroprevalence test	3/52	2/33	0.95 (0.15, 6.00)
Mulligan, 2022	Age 30-44	Age 18-29	IgG or IgM seroprevalence test	29/287	6/93	1.55 (0.69, 3.47)
Mulligan, 2022	Age 45-60	Age 18-29	IgG or IgM seroprevalence test	24/270	6/93	1.38 (0.59, 3.24)
Mulligan, 2022	Age 60+	Age 18-29	IgG or IgM seroprevalence test	2/36	6/93	0.86 (0.18, 4.20)
Newberry, 2021	Age 35-49	Age 18-34	IgG seroprevalence test	17/556	2/206	2.36 (0.85, 6.56)
Newberry, 2021	Age 50+	Age 18-34	IgG seroprevalence test	6/221	2/206	2.58 (0.64, 10.43)
Vieira, 2021	Age 31-40	Age 21-30	IgG seroprevalence test	20/324	5/112	1.37 (0.54, 3.45)
Vieira, 2021	Age 41-50	Age 21-30	IgG seroprevalence test	12/286	5/112	0.94 (0.32, 2.76)
Vieira, 2021	Age 51+	Age 21-30	IgG seroprevalence test	12/201	5/112	1.34 (0.48, 3.71)



CI=confidence interval; EMS=emergency medical services; IgG=immunoglobulin; MRSA=methicillin-resistant *Staphylococcus aureus*; NR=not reported; PCR=polymerase chain reaction; OR=odds ratio; SARS-CoV-2=severe acute respiratory syndrome coronavirus 2; yrs=years

*Incidence outcomes designated with triangles.

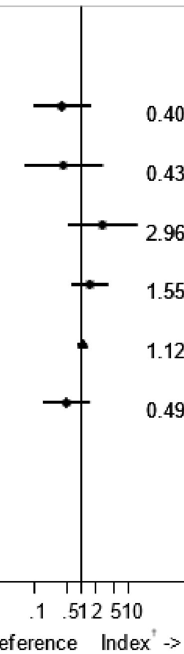
† Tarabichi 2021 is not included in the figure because it reported the mean age among those who were seropositive for SARS-CoV-2 (50.1 years) and the mean age among those who were negative (43.8 years).[13]

‡Numbers less than 1 indicate a higher rate among the reference group. Numbers greater than 1 indicate a higher rate among the comparison group.

Figure 6 shows gender-based differences in incidence, prevalence, and healthcare utilization for occupationally acquired infectious diseases. All data reviewed was for SARS-CoV-2. Of the studies that included an OR, all confidence intervals (CI) crossed one.

Figure 6. Differences in incidence, prevalence, and healthcare utilization for occupationally acquired infectious diseases and related exposures among the EMS and 911 workforce based on gender*

Author, Year	Index Group	Reference Group	Outcome Type	Outcome	n/N Comparison	n/N Reference	OR (95% CI)
SARS-CoV-2							
Tarabichi, 2021	Male	Female	Prevalence	IgG and IgM ELISA seroprevalence	12/253	4/42	0.40 (0.09, 1.67)
Caban-Martinez, 2020	Male	Female	Prevalence	IgG seroprevalence test	16/188	2/13	0.43 (0.06, 3.08)
Vieira, 2021	Male	Female	Prevalence	IgG seroprevalence test	49/897	0/26	2.96 (0.52, 16.84)
Weiden, 2021	Male	Female	Healthcare utilization	Hospitalization or death	NR	NR	1.55 (0.64, 4.02)
Weiden, 2021	Male	Female	Incidence	Positive diagnosis	NR	NR	1.12 (0.88, 1.44)
Mulligan, 2022	Male	Female	Prevalence	IgG or IgM seroprevalence test	57/601	4/83	0.49 (0.15, 1.58)



CI=confidence interval; ELISA=enzyme-linked immunosorbent assay; EMS=emergency medical services; IgG=immunoglobulinl; NR=not reported; OR=odds ratio; RT-PCR=real-time polymerase chain reaction; SARS-CoV-2=severe acute respiratory syndrome coronavirus 2

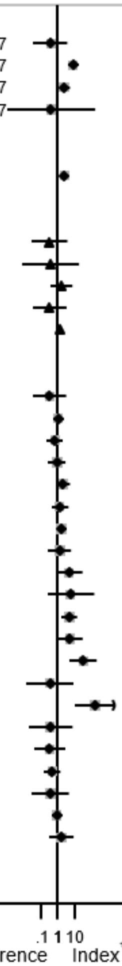
*Incidence outcomes designated with triangles.

† Numbers less than 1 indicate a higher rate among the reference group. Numbers greater than 1 indicate a higher rate among the comparison group.

Figure 7 highlights studies that reported on racial differences in incidence, prevalence, and healthcare utilization for occupationally acquired infectious diseases and related exposures. The majority of CIs cross one with the most prominent exceptions being for the Black non-Hispanic and other Hispanic groups in the Tarabichi study with ORs of 35.2 and 184 respectively.[13] The Newberry study reported ORs of 5.72 and 4.84 for Black and Hispanic groups, respectively, compared to White non-Hispanics, with relatively wide CIs.[28] One study, Webber 2018, examined differences based on race for hepatitis C and found an OR of 8.50 and 2.43 for Black and Hispanic groups when compared to their White co-workers.[29]

Figure 7. Differences in incidence, prevalence, and healthcare utilization of occupationally acquired infectious diseases and related exposures among the EMS and 911 workforce based on race*

Author, year	Comparison group	Reference group	Outcome	n/N comparison	n/N reference	OR (95% CI)
Hepatitis C Prevalence						
Webber, 2018	Asian	White	Positive test from 2000-2012	0/60	115/10077	0.36 (0.03, 3.97)
Webber, 2018	Black	White	Positive test from 2000-2012	21/546	115/10077	8.50 (3.95, 18.28)
Webber, 2018	Hisp	White	Positive test from 2000-2012	15/682	115/10077	2.43 (1.19, 4.93)
Webber, 2018	Other	White	Positive test from 2000-2012	0/9	115/10077	0.36 (0.00, 171.35)
SARS-CoV-2 Healthcare Utilization						
Weiden, 2021	Non-white	White	Hospitalization or death	NR	NR	2.46 (1.34, 4.51)
SARS-CoV-2 Incidence						
Newberry, 2021	Asian	White	PCR test	0/78	6/594	0.32 (0.03, 3.93)
Newberry, 2021	Black	White	PCR test	0/26	6/594	0.35 (0.01, 19.22)
Newberry, 2021	Hisp	White	PCR test	3/192	6/594	1.63 (0.35, 7.51)
Newberry, 2021	Other	White	PCR test	0/93	6/594	0.31 (0.03, 3.26)
Weiden, 2021	Non-white	White	Positive diagnosis	NR	NR	1.21 (1.06, 1.38)
SARS-CoV-2 Prevalence						
Caban-Martinez, 2020	Black	White	IgG seroprevalence test	0/9	15/154	0.31 (0.03, 3.19)
Caban-Martinez, 2020	Hisp	White	IgG seroprevalence test	15/149	15/154	1.04 (0.49, 2.20)
Caban-Martinez, 2020	Non-Hisp	White	IgG seroprevalence test	3/48	15/154	0.65 (0.21, 2.03)
Caban-Martinez, 2020	Other	White	IgG seroprevalence test	3/34	15/154	0.90 (0.26, 3.17)
Mulligan, 2022	Asian, Non-Hisp	White, Non-Hisp	IgG or IgM seroprevalence test	8/64	26/357	2.02 (0.76, 5.35)
Mulligan, 2022	Black, Non-Hisp	White, Non-Hisp	IgG or IgM seroprevalence test	4/46	26/357	1.23 (0.38, 3.95)
Mulligan, 2022	Hispanic	White, Non-Hisp	IgG or IgM seroprevalence test	21/197	26/357	1.54 (0.83, 2.88)
Mulligan, 2022	Other	White, Non-Hisp	IgG or IgM seroprevalence test	2/22	26/357	1.30 (0.25, 6.74)
Newberry, 2021	Asian	White	IgG seroprevalence test	3/78	8/594	4.71 (0.73, 30.23)
Newberry, 2021	Black	White	IgG seroprevalence test	1/26	8/594	5.72 (0.22, 152.17)
Newberry, 2021	Hisp	White	IgG seroprevalence test	9/192	8/594	4.84 (1.58, 14.80)
Newberry, 2021	Other	White	IgG seroprevalence test	4/93	8/594	5.58 (1.05, 29.55)
Tarabichi, 2021	Black, Non-Hisp	White, Non-Hisp	IgG & IgM ELISA seroprevalence	5/21	8/200	35.23 (5.24, 237.07)
Tarabichi, 2021	Other	White, Non-Hisp	IgG & IgM ELISA seroprevalence	0/10	8/200	0.34 (0.01, 9.24)
Tarabichi, 2021	Other, Hisp	White, Non-Hisp	IgG & IgM ELISA seroprevalence	3/10	8/200	183.66 (10.69, 3155.46)
Tarabichi, 2021	White, Hisp	White, Non-Hisp	IgG & IgM ELISA seroprevalence	0/12	8/200	0.33 (0.02, 7.05)
Tarabichi, 2021	White, Other	White, Non-Hisp	IgG & IgM ELISA seroprevalence	0/27	8/200	0.31 (0.04, 2.73)
Vieira, 2021	Asian	White	IgG seroprevalence test	1/60	46/827	0.46 (0.14, 1.48)
Vieira, 2021	Black	White	IgG seroprevalence test	0/11	46/827	0.34 (0.03, 4.66)
Vieira, 2021	Hisp	White	IgG seroprevalence test	8/174	46/827	0.83 (0.40, 1.71)
Vieira, 2021	Other	White	IgG seroprevalence test	2/25	46/827	1.58 (0.28, 8.87)



CI=confidence interval; ELISA=enzyme-linked immunosorbent assay; EMS=emergency medical services; Hisp=Hispanic; IgG=immunoglobulin; NR=not reported; PCR=polymerase chain reaction; OR=odds ratio; SARS-CoV-2=severe acute respiratory syndrome coronavirus 2

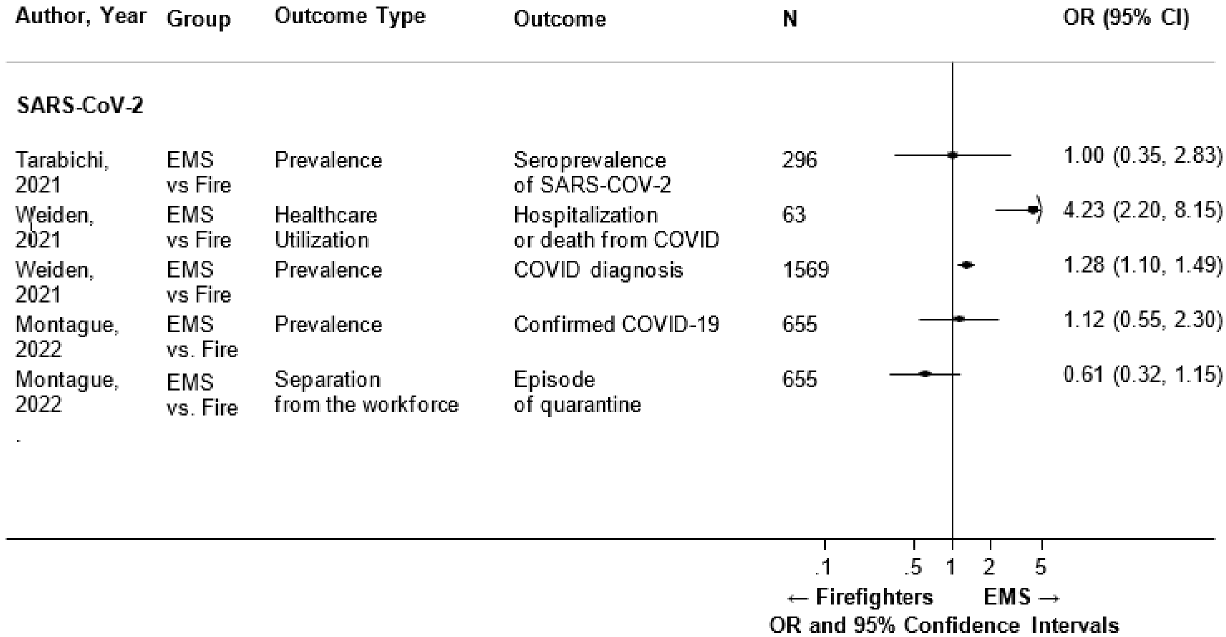
*Incidence outcomes designated with triangles.

† Numbers less than 1 indicate a higher rate among the reference group. Numbers greater than 1 indicate a higher rate among the comparison group.

GQ 1b: Differences by Workforce Characteristics

Three studies (Tarabichi 2021, Weiden 2021, and Montague 2022) compared firefighters versus EMS workers on the prevalence and healthcare utilization for SARS-CoV-2 (Figure 8).[13, 32, 39] The Weiden study reported a statistically significant 4.23 OR for EMS workers versus firefighters for hospitalization or death due to COVID-19.[32]

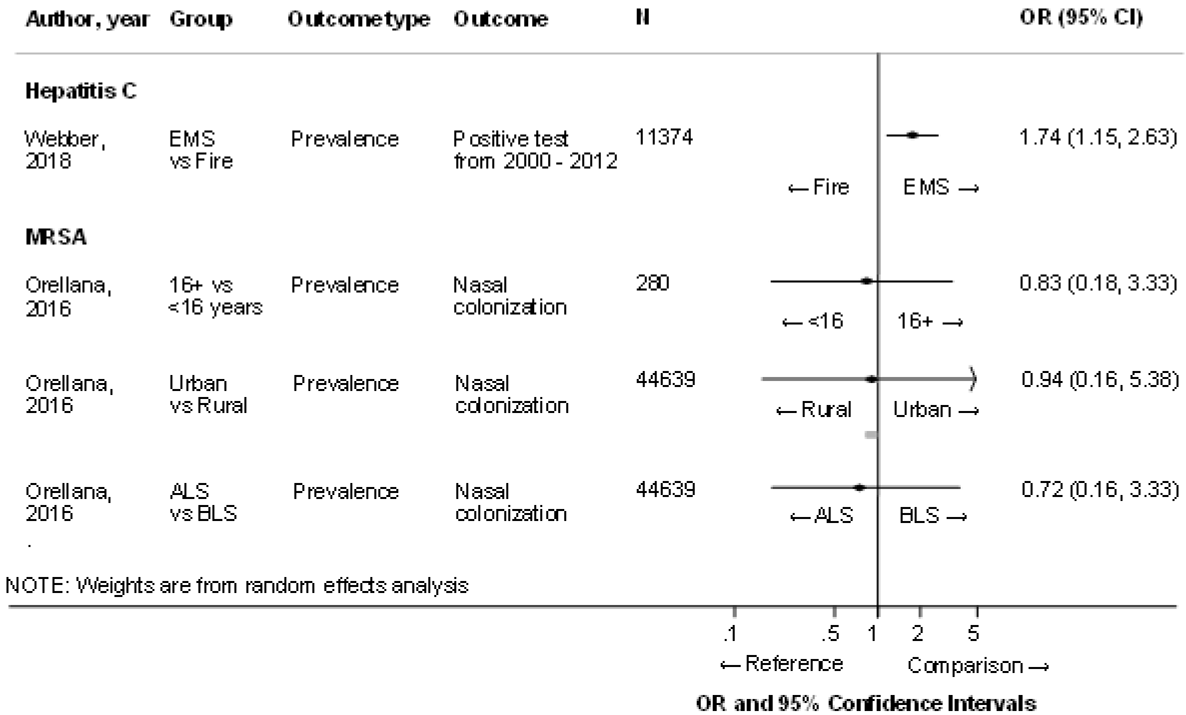
Figure 8. Differences in prevalence and healthcare utilization of occupationally acquired SARS-CoV-2 among the EMS and 911 workforce



CI=confidence interval; EMS=emergency medical services; N=sample size; OR=odds ratio; SARS-CoV-2=severe acute respiratory syndrome coronavirus 2

One study (Webber 2018) reported on hepatitis C prevalence for EMS workers versus firefighters and found an OR of 1.74 (Figure 9).[29] Another study (Orellana 2016) examined methicillin-resistant *Staphylococcus aureus* (MRSA) differences in workforce characteristics and found that for years of experience, population density, and level of care, each outcome had an OR with a wide 95% CI that included 1.[26]

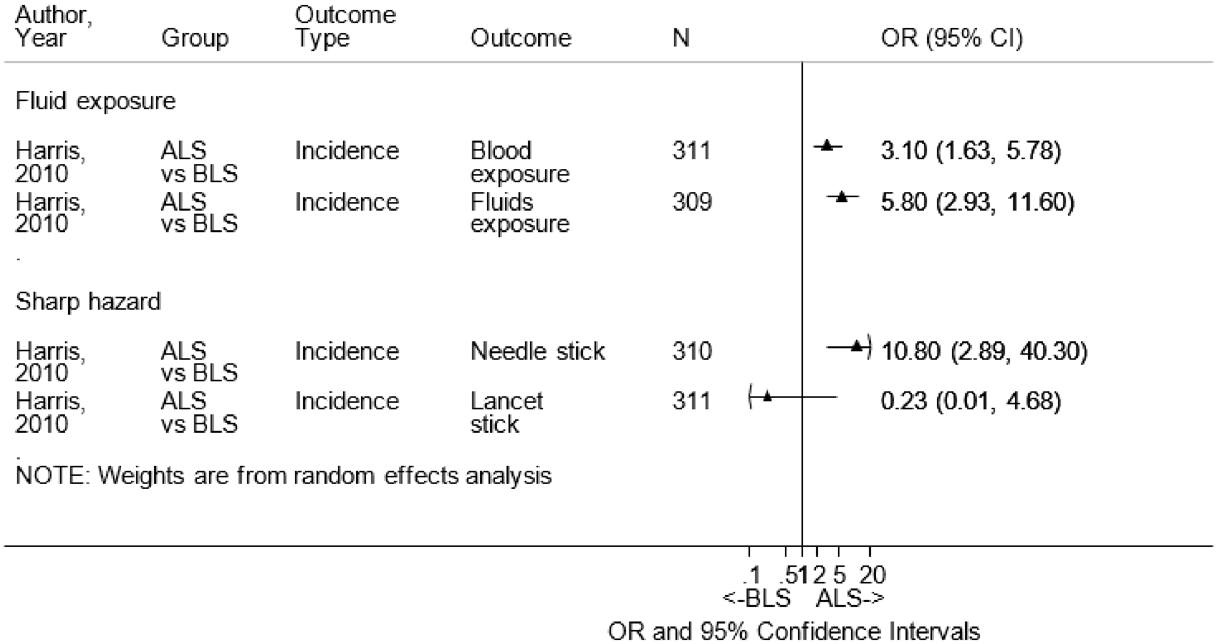
Figure 9. Differences in incidence, prevalence, and healthcare utilization of occupationally acquired MRSA and hepatitis C among the EMS and 911 workforce



ALS=workers with Advanced Life Support certification; BLS=workers with Basic Life Support certification; CI=confidence interval; EMS=emergency medical services; MRSA=methicillin-resistant *Staphylococcus aureus*; N=sample size; OR=odds ratio

When examining studies that met our inclusion criteria for occupational fluid and sharps exposures, one study was included (Harris 2010).[8] For blood and fluid exposure, the OR for workers with Advanced Life Support (ALS) certification versus Basic Life Support (BLS) certification was 3.10 and 5.80, respectively. For sharps exposures, needle sticks had a 10.8 OR for ALS versus BLS groups in comparison to lancet sticks, which had a 0.23 OR (with wide CI) for ALS versus BLS groups (Figure 10).

Figure 10. Differences in incidence, prevalence, and healthcare utilization of occupationally acquired risk exposures among the EMS and 911 workforce*



ALS=workers with Advanced Life Support certification; BLS=workers with Basic Life Support certification; CI=confidence interval; EMS=emergency medical services; N=sample size; OR=odds ratio
*Incidence outcomes designated with triangles

GQ 2/3: Characteristics and Reported Effectiveness of EMS and 911 Workforce Practices To Prevent, Recognize, and Control Infectious Diseases

Characteristics of Studies

Eleven studies were identified as being relevant to GQ 2/3.[8, 18, 21, 22, 24, 26-28, 31, 40, 41] All studies were observational studies with a concurrent comparison group; nine studies were prospective cohorts[8, 21, 22, 26-28, 31, 40, 41] and two were retrospective cohorts.[18, 24] Six were in urban settings[22, 24, 27, 28, 31, 41] and five were in multiple settings.[8, 18, 21, 26, 40] The studies took place in eight different states. Although few listed a jurisdictional funding description, a post-publication analysis of the jurisdictions suggests that studies were funded by a mixture of fire and third services (i.e., stand-alone ambulance) departments. Seven studies included both EMS workers and firefighters involved in medical care[8, 18, 22, 24, 28, 31, 41] and four studies only focused on EMS workers.[21, 26, 27, 40] The total study sample size ranged from 186 to 10,612 EMS and 911 workers.

In the review of studies that address GQ 2 and 3, we have combined these questions for purposes of presentation and discussion because the workforce practices to *prevent infectious disease* (GQ 2) and workforce practices to *recognize and control infectious disease* (GQ 3) often overlap and therefore address both. For example, PPE and vaccines could be viewed as workforce practices which both prevent and control infectious diseases.

Study Quality

None of the studies on GQ 2/3 used an experimental study design. According to the inclusion criteria for this review, all 11 of the included studies had a concurrent comparison group. Although all studies were somewhat or very likely to include workers representative of the target population, only 27 percent of the studies reported that 80 percent or more of workers selected to participate ultimately agreed to participate (see Table 4). Regarding potential selection bias, only 3 studies presented data indicating no important differences between those who participated and those who did not, while 1 study reported important differences between groups (Table 4). The other 6 studies did not present enough information to assess selection bias.

Table 4. Quality of studies that reported on the characteristics and effectiveness of EMS and 911 workforce practices to prevent, recognize, and control infectious diseases

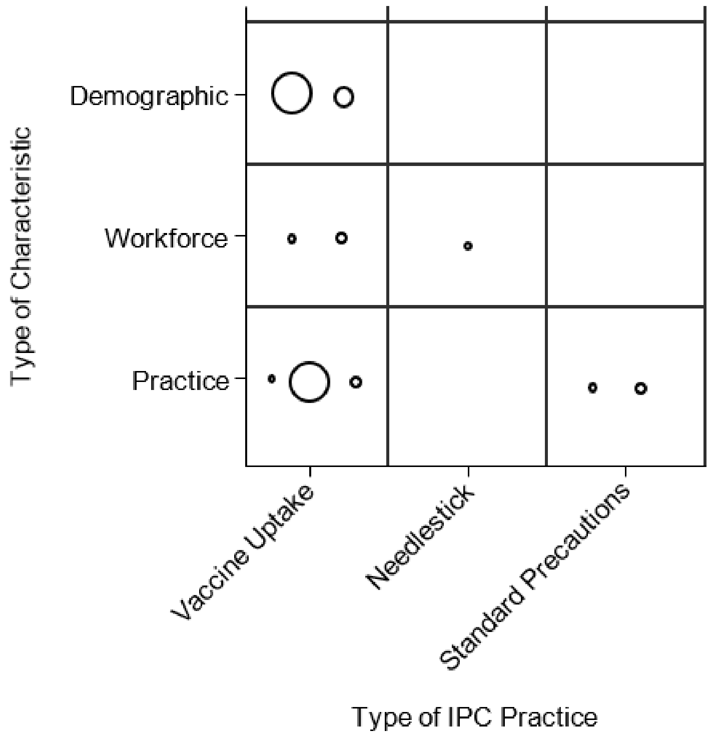
Quality Assessment Question	Quality Assessment Response	N (%) N=11
Are the individuals selected to participate in the study likely to be representative of the target population?	Very likely	7 (63.6%)
	Somewhat likely	4 (36.4%)
What percentage of selected individuals agreed to participate?	80-100% agreement	3 (27.3%)
	60-79% agreement	3 (27.3%)
	Less than 60% agreement	2 (18.2%)
	Can't tell	3 (27.3%)
Were there important differences between groups prior to the intervention?	Yes	1 (9.1%)
	No	3 (27.3%)
	Can't tell	7 (63.6%)

EMS=emergency medical services

Findings on Characteristics of IPC Practices

Figure 11 presents an evidence map of the main characteristics of the IPC practices that have been studied in the EMS and 911 worker population, and whether they reported on how practices vary by demographic, workforce, and practice characteristics. Each circle represents the number of studies, with vaccine uptake for influenza being the most frequently reported type of IPC practice. Only one study focused on prevention of needle stick injuries and only one study focused on standard precautions for IPC.

Figure 11. Evidence map of the studies that report on infection prevention and control practices and how they vary by demographic, workforce, and practice characteristics



Each study is represented by a circle. The size of the circle is proportional to the sample size. The placement of the circle within each cell does not signify anything.
IPC = infection practice and control

GQ 2/3a: Differences by Demographic Characteristics

Two studies reported on how an IPC practice varied by demographic characteristics.[24, 40] Glaser, in 2011, focused on H1N1 influenza vaccine uptake among EMS workers through utilization of a vaccine clinic.[24] The study found that vaccination was less likely in those younger than 30 years old (adjusted OR [aOR] 0.70; 95% CI 0.62 to 0.78), African Americans (aOR 0.46; 95% CI 0.40 to 0.50), and Hispanics (aOR 0.87; 95% CI 0.77 to 0.99) after adjusting for age, gender, race, class (EMS vs. firefighter), and smoking status. Gregory, in 2021, reported on odds of COVID vaccinations by associations with age (referent <28 years; 39 to 50 years: 1.56, 95% CI 1.17 to 2.08; >51 years: 2.22, 95% CI 1.64 to 3.01) and male sex (1.26, 95% CI 1.01 to 1.58).[40]

GQ 2/3b: Differences by Workforce Characteristics

Four studies addressed how IPC practices varied by workforce characteristics.[8, 21, 31, 40] Three studies evaluated vaccine uptake.[21, 31, 40] The third study evaluated needle stick exposures and standard precautions.[8]

Vaccine Uptake

Hubble, in 2011, found that EMS professionals in rural areas (35.5%) received the influenza vaccine at lower rates than urban (50.0%) or suburban (54.3%) EMS professionals (unadjusted p=0.01).[21] In 2021, Halbrook found that COVID-19 vaccine uptake was higher among in-hospital healthcare workers (96.0%) compared to EMS workers (87.5%) and that EMS workers

were significantly more likely to delay receiving a vaccine (aOR 2.94; 95% CI 1.71 to 5.04 after adjusting for age, sex, race, education, and patient contact).[31] Gregory, in 2021, found that increased COVID-19 vaccination uptake was associated with residing in an urban/suburban area (referent rural; 1.36, 95% CI 1.08 to 1.70), advanced education (referent General Educational Development or high school and below; bachelor's and above: 1.72, 95% CI 1.19 to 2.47).[40] In addition, vaccination odds were significantly higher with greater perceived risk of COVID-19 (2.05, 95% CI 1.68 to 2.50), and higher vaccine confidence (2.84, 95% CI 2.40 to 3.36) while lower with higher medical mistrust (0.54, 95% CI 0.46 to 0.63). In this study, despite availability of vaccine, just 69.8 percent of EMS professionals reported having received a COVID-19 vaccine while 30.2 percent indicated that they had not.[40]

Needlesticks

Harris, in 2010, found that volunteer EMS workers were less likely to be exposed via needle stick than paid EMS workers (unadjusted OR 0.74; 95% CI 0.23 to 2.30).[8] This mirrors Harris' other finding that BLS-certified/licensed EMS workers, who are more likely to be volunteers, were also at lower risk for needle stick than ALS-certified/licensed workers. BLS-certified/licensed workers do not perform intravenous cannulation, likely accounting for the difference in volunteer and paid worker risk.

Standard Precautions

Harris also found significant differences in protective practices among ALS- and BLS-certified/licensed EMS workers.[8] Specifically, ALS-certified/licensed EMS workers were more likely than BLS-certified/licensed EMS workers to wear gloves for all calls (unadjusted OR 1.75; 95% CI 0.81 to 3.79), use face masks (unadjusted OR 4.86; 95% CI 1.44 to 16.4), and use protective devices during resuscitation (unadjusted OR 17.3; 95% CI 1.04 to 28.8). Interestingly, ALS-certified/licensed EMS workers were also more likely to always recap needles (unadjusted OR 10.1; 95% CI 2.85 to 34.5), despite Centers for Disease Control and Prevention (CDC) and Occupational Health and Safety (OSHA) recommendations to not recap needles.

GQ 2/3c: Differences by Practice Characteristics

Four studies examined the association of vaccine uptake with practice characteristics, including the incorporation of training into practice, implementation of a vaccine clinic, presence of a mandatory vaccine policy, or a department of public health shelter-in-place order.[21, 22, 24, 40] No studies directly examined how use of IPC practices varied by available budget to support the practice.

Vaccine Uptake

Hubble in 2011 found that influenza vaccine uptake was greater when the practice provided influenza vaccination education and training (unadjusted OR 1.5; 95% CI 1.1 to 2.1) or hosted a vaccine clinic (unadjusted OR 3.3; 95% CI 1.3 to 8.3) compared to when the practice does not.[21] Glaser found that hosting a vaccine clinic in the workplace increased vaccine uptake (aOR 2.7; 95% CI 2.3 to 3.2) after adjusting for age, gender, race, class (EMS vs. firefighter), and smoking status.[24] Rebmann in 2012 found that mandatory vaccine policies for H1N1 and other strains of influenza increased the vaccine uptake rates; 100 percent of participants reporting mandatory vaccine policies also reported being vaccinated while those who did not have a mandatory vaccine policy reported a 66.8 percent vaccination rate for H1N1 influenza (unadjusted $p<0.01$)

and a 75.6 percent vaccination rate for seasonal influenza (unadjusted $p<0.001$).[22] Gregory found increased odds of COVID-19 vaccination were associated with working at a hospital (referent fire-based agency; 1.53, 95% CI 1.04 to 2.24).[40]

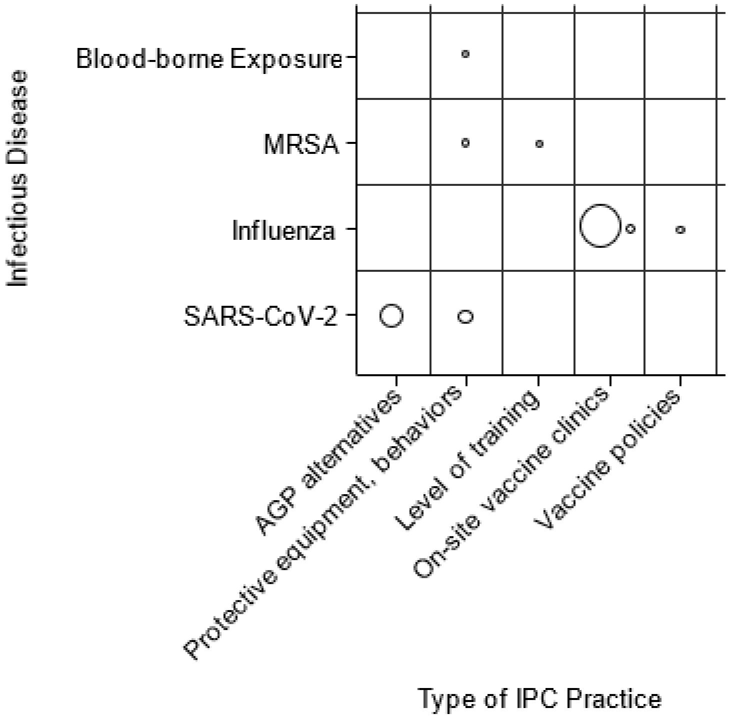
Standard Practice

Grant descriptively reported higher selected self-reported PPE use among firefighters/paramedics, such as for gloves, N-95 respirators and eye protection, on medical versus non-medical runs.[41] The study further detailed self-reported PPE use among firefighters/paramedics before versus after a Department of Public Health shelter-in-place order.[41] On non-medical runs, use of individual PPE measures increased significantly after the shelter-in-place order ($p<0.0001$ for surgical masks, N-95 respirators, eye protection, and gowns; $p<0.05$ for gloves), while self-reported use of "no PPE" decreased significantly ($p<0.0001$). On medical runs, use of individual PPE increased significantly after the shelter-in-place order ($p<0.0001$) for surgical masks, N-95 respirators, eye protection, and gowns) while self-reported use of "no PPE" did not differ before versus after the shelter-in-place order.

GQ 2/3d: Reported Effectiveness of EMS and 911 Workforce Practices To Prevent, Recognize, and Control Infectious Diseases

Eight studies reported on the effectiveness of preventing infectious diseases among the EMS and 911 workforce.[8, 18, 21, 22, 24, 26-28] The studies were very heterogeneous, involving five distinct types of IPC practices and focusing on four different infectious diseases. The studies were so different from each other that it would not be feasible to perform any meta-analysis. Figure 12 demonstrates our evidence map of studies reporting on the effectiveness of EMS and 911 workforce practices to prevent, recognize, and control infectious diseases. The most common infectious disease studied was influenza, and on-site vaccine clinics were the most commonly studied workforce practice.

Figure 12. Evidence map of studies reporting on the effectiveness of EMS and 911 workforce practices to prevent, recognize, and control infectious diseases



Each study is represented by a circle. The size of the circle is proportional to the sample size. The placement of the circle within each cell does not signify anything.
AGP=aerosol-generating procedure; EMS=emergency medical services; IPC = infection prevention and control; MRSA=methicillin-resistant *Staphylococcus aureus*; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2

Alternatives to Aerosol-Generating Procedures

Aerosol-generating procedures (AGPs) are procedures such as intubation or the use of positive airway pressure therapy that generate copious amounts of potentially infectious aerosolized particles. In 2021, Brown reported that AGP procedures, even with full PPE (defined as a mask, eye protection, gloves, and a gown), were positively correlated with SARS-CoV-2 diagnoses (unadjusted incidence rate ratio [IRR] 1.64; 95% CI 0.22 to 12.26).[18] However, this data point is based on only one EMS clinicians developing COVID-19 infection in the cohort studied out of 182 total AGPs performed and 8,582 person-days at risk while in PPE and performing AGP. AGPs are included as a workforce practice due to the interest in decreasing aerosol particles through alternative treatment regimens such as metered-dose inhalers instead of nebulizer masks or the use of bag-valve mask ventilation prior to intubation.

Protective Equipment and Behaviors

Three studies reported on effectiveness of protective equipment and behaviors in preventing and controlling infectious disease.[8, 26, 28] Newberry found that lack of PPE or PPE breach were correlated with higher SARS-CoV-2 seropositivity (unadjusted risk ratio [RR] 4.2; 95% CI 1.03 to 17.22).[28] Orellana found that less frequent daily handwashing (survey-weight adjusted OR 4.20; 95% CI 1.02 to 17.27) and less frequent hand hygiene after glove use (survey-weight adjusted OR 10.51; 95% CI 2.54 to 43.45) were positively correlated with nasal colonization of MRSA.[26] Harris found that needlestick injuries were associated with never recapping needles

(unadjusted OR 1.49; 95% CI 0.44 to 5.04), always wearing a facemask (unadjusted OR 2.95; 95% CI 0.17 to 52.2), always disposing of needles in marked containers (unadjusted OR 1.8; 95% CI 0.22 to 14.6), and always using a protective device for resuscitation, such as a bag valve mask (unadjusted OR 1.72; 95% CI 0.09 to 31.0). Only disposing of other contaminated materials was negatively associated with needle stick injuries (unadjusted OR 0.2; 95% CI 0.06 to 0.64), perhaps indicating that improper disposal of contaminated materials is correlated with other poor safety practices.[8]

Level of Training

Miramonti found that practicing EMS workers (4.5%) and EMS students (5.3%) had similar levels of MRSA nasal colonization, suggesting that greater overall level of training and experience in EMS was not associated with a difference in this outcome measure.[27] No other studies reported on how infectious disease outcomes of interventions varied by level of training.

On-Site Vaccine Clinics

Two studies reported on the effectiveness of vaccine clinics at the work site.[21, 24] Hubble found that workers were more likely to be vaccinated against influenza if they recalled their employer offering the flu vaccine (unadjusted OR 3.3; 95% CI 1.3 to 8.3) and if they received training or education from their employer on the flu vaccine or influenza illness (unadjusted OR 1.5; 95% CI 1.2 to 2.1).[21] In a study by Glaser, the acceptance rate of the H1N1 influenza vaccination was 57.2 percent (5,746 out of 9,559) during a targeted, active, and dedicated vaccine program in a bio-preparedness drill as compared to 34.4 percent (362 out of 1053) during medical visits.[24] During the bio-preparedness drill, the EMS workers and firefighters also received targeted education.

Vaccine Policies

Rebmann found that emergency medical technicians whose employer had a mandatory vaccination policy were significantly more likely to receive the seasonal influenza vaccine (100% versus 75.6%) or the H1N1 influenza vaccine (100% versus 66.8%) compared with those without such a policy (unadjusted $p<0.001$ and $p<0.01$, respectively).[22]

GQ 4: Context and Implementation Factors of Studies With Effective EMS and 911 Workforce Practices

Studies relevant to GQ 4 included evaluation of a PPE protocol and examination of the context and implementation factors of previously mentioned studies on GQ 2/3d.

During the beginning of the COVID-19 pandemic, Brown et al. examined the risk for COVID-19 infection among EMS clinicians in King County, Washington. They deployed and studied a PPE protocol,[18] which included appropriate masks, eye protection, gown, and gloves (MEGG). Surgical masks were deemed sufficient for routine patient encounters, but an N95 respirator was required PPE for AGPs. For any physical contact with the patient, a gown was required. EMS clinicians were advised to don full MEGG PPE if a patient had a febrile respiratory illness or had recently traveled from an endemic area. Later in the study period, as cases increased, EMS clinicians began to treat all congregate living facilities and dialysis centers as having elevated risk for exposure.

Using the MEGG PPE protocol model described above, the study group was able to identify one COVID-19 infection potentially occurring due to a patient encounter with an AGP. There

were 1,592 EMS clinicians with one or more COVID-19 patient encounters and 520 (33%) with 3 or more COVID-19 patient encounters. During the study period, 30 EMS clinicians tested positive for COVID-19 by polymerase chain reaction (PCR), although 11 of these had never had a documented patient exposure. Of the remaining clinicians, 18 had a COVID-19 patient encounter but did not develop infection within the exposure window of 2-14 days, and only one clinician developed COVID-19 after an AGP within the exposure window.

The authors noted that these findings may be difficult to interpret because one third of their COVID-19 patients did not display any common symptoms, such as fever, cough, or shortness of breath. In addition, sources of infection risk for EMS personnel for SARS-CoV-2 are not confined to patients. They observed that most of the COVID-19 illness was potentially a consequence of encounters other than with patients.

Implementation factors from studies with effective EMS workforce practices included those associated with vaccine promotion and education. Glaser et al. demonstrated that active, targeted education modules, given on-site during a dedicated vaccine program for H1N1 influenza was effective at increasing vaccination rates.[24] Workers were more likely to be accepting of a vaccine during an on-site vaccine clinic when surrounded by their peers who were also receiving the vaccine. In addition, the authors noted that supervisor and peer buy-in was a factor during the vaccine clinics. Another study by Hubble et al.[21] emphasized the success of on-site vaccine clinics for seasonal influenza vaccine. Mandatory employee vaccination policies for both seasonal and H1N1 influenza vaccination were found to be effective at increasing vaccination uptake.[22]

Results From the Gray Literature

The EPC study team identified gray literature published by domestic organizations and agencies related to EMS and 911 workforce infection control practices. This included seven documents from the Department of Health and Human Services (HHS), the Assistant Secretary for Preparedness and Response (ASPR) along with its Technical Resources Assistance Center and Information Exchange (TRACIE), CDC, Society for Healthcare Epidemiology of America (SHEA), and the Association for Professionals in Infection Control and Epidemiology (APIC). The gray literature was characterized by a high degree of heterogeneity, ranging from description of training and educational sessions, and retrospective reports on public health emergency response, to IPC guidance aimed at prehospital care. Gray literature information most relevant to the GQs were derived from synthesis of official or best practice information reviewed by subject matter experts. Thus, by design, no comparators were provided. Furthermore, most of the gray literature on the topic of IPC included but did not pertain specifically or exclusively to the EMS and 911 workforce. Appendix D provides details of the results of the Gray Literature Searches.

GQ 1: Characteristics, Incidence, Prevalence, and Severity of Occupationally Acquired Infectious Diseases and Related Exposures for the EMS and 911 Workforce

Guide to Infection Prevention in EMS

An implementation guide from APIC for EMS released in 2013 provides a summary of potentially life-threatening infectious diseases and routes of transmission to which emergency response employees may be exposed.[42] No other specific information on incidence, prevalence,

and severity of occupationally acquired infectious disease and related exposures pertaining to this GQ was found in the gray literature.

GQ 2/3: Characteristics and Reported Effectiveness of EMS and 911 Workforce Practices To Prevent, Recognize, and Control Infectious Diseases

Best Practice Information

ASPR EMS Infectious Disease Playbook

This 86-page document was created using official or best practice information taken from multiple organizations. The playbook was vetted and assembled by subject matter experts working for TRACIE at the request of the ASPR.[43] It was intended to unify multiple sources of information in a single planning document addressing the full spectrum of infectious agents and to create a concise reference resource for EMS agencies developing their service policies. Topics included: ***dispatch/ responder actions, standard precautions, contact precautions, droplet precautions, airborne precautions, special respiratory precautions, Ebola virus disease and viral hemorrhagic fever precautions, resources, and special considerations***.

Guide to Infection Prevention in EMS

The APIC implementation guide noted above discusses ***work restrictions/duration*** following occupationally acquired infectious diseases and related exposures, ***immunization recommendations*** and ***immunization schedules, risk factors,*** and ***risk assessment*** of infectious hazards. The implementation guide further discusses ***engineering, work practice controls, and PPE***.[42]

Knowledge Sharing

COVID-19 Clinical Rounds

As a mechanism to enable rapid sharing of promising practices for treatment and other response activities, the ASPR and Project ECHO (Extension for Community Health Outcomes) developed COVID-19 Clinical Rounds, a series of sessions designed to provide peer-to-peer, ***real-time knowledge-sharing*** regarding challenges and success in COVID-19 treatment for frontline, primarily pre-hospital and hospital-based clinicians.[44] As of December 22, 2020, a total of 103 clinical rounds were held including presentations from expert clinicians complemented by question-and-answer time, with 10,866 session recording views and 40,826 participants.

Patient Management, Use of PPE, Non-Pharmaceutical Interventions

Two documents from the CDC offered guidance related to ***IPC patient management and PPE practices*** in the context of COVID-19 and Ebola virus disease.[45] The third document from HHS highlights several considerations including use of ***respiratory protection*** and ***use of non-pharmaceutical interventions (NPIs)***.[46]

Interim Recommendations for EMS Systems and 911 Public Safety Answering Points in the US During the COVID-19 Pandemic

This document from the CDC offers guidance applicable to all U.S. settings where healthcare is delivered, without specifying the prehospital environment.[45] Important topics relevant to the EMS and 911 workforce include: *Establishing a Process to Identify and Manage Individuals with Suspected or Confirmed SARS-CoV-2 Infection,* to include implementation of source control measures such as use of respirators or well-fitting facemasks, universal use of PPE for healthcare clinicians, physical distancing, SARS-CoV-2 testing, and a process to respond to SARS-CoV-2 exposures; *Recommendation of IPC practices when caring for a patient with suspected or confirmed SARS CoV-2 infection,* to include patient placement and PPE; and *Duration of Transmission-Based Precautions*, with setting-specific considerations and specific EMS considerations.

Interim Recommendations for EMS Systems and 911 Public Safety Answering Points for Management of Patients Under Investigation for Ebola Virus Disease in the US

The purpose of this CDC guidance is to assure EMS and first responders are safe and patients are appropriately managed while responding to persons under investigation (PUIs) for Ebola virus disease.[46] It covers the topics of *Patient Assessment, Safety and PPE, Patient Management and Infection Control, EMS Transport of Patient to a Healthcare Facility, Interfacility Transport, Documentation of Patient Care, Cleaning EMS Transport Vehicles, and Followup and Reporting by EMS Clinicians After Caring for a PUI.* These recommendations apply to ***EMS clinicians*** (including emergency medical responders, emergency medical technicians, advanced emergency medical technicians, paramedics, and other first responders who could be providing patient care in the field, such as law enforcement and fire service personnel), managers of 911 Emergency Communications Centers/Public Safety Answering Points, EMS agencies, EMS systems, and agencies with medical first responders.

2009 H1N1 Improvement Plan

The HHS 2009 H1N1 Influenza Improvement Plan outlines priorities for those aspects of pandemic influenza preparedness that are influenza specific and describes the ways in which those next steps need to be accomplished, informed by the 2009 H1N1 influenza pandemic experience.[47] Of direct relevance to the ***EMS and 911 workforce***, the plan advocated for conducting research to better understand influenza transmission, ***effectiveness of respiratory protection devices***, clarification of when surgical masks are sufficient, and when the use of N95 respirators or other devices may be more appropriate. The report further urged updated ***recommendations and guidance for the use of NPIs*** during a pandemic that incorporate the latest scientific findings, including transmissibility of the virus, availability of pharmaceutical interventions, and the practicality of implementation by states, locals, employers, and providers.

Vaccination

Although some reports were identified pertaining to GQ 2/3 on vaccine effectiveness,[48] none were found to provide distinct breakdowns for the EMS workforce.

GQ 4: Context and Implementation Factors of Studies With Effective EMS and 911 Workforce Practices

Infrastructure

CDC Infection Control in Healthcare Personnel: Infrastructure and Routine Practices for Occupational Infection Prevention and Control Services

This 70-page CDC document released in 2019 reflects updates to the Guideline for Infection Control in Health Care Personnel, 1998, and describes the infrastructure and routine practices for providing IPC services to healthcare personnel as well as special considerations associated with *emergency response personnel*.[49]

Retrospective Reporting

HHS Retrospective on 2009 H1N1 Influenza Pandemic to Advance All Hazards Preparedness

This 121-page HHS retrospective report on the 2009 H1N1 influenza pandemic concluded that the response was largely successful while noting that there were elements of preparedness that were not stressed in our response to the 2009 H1N1 pandemic, but could be in a very severe pandemic, as experienced in 1918.[50] Of relevance to the EMS and 911 workforce, notable successes included the rapid identification and characterization of the 2009 H1N1 pandemic virus; the development and production of a 2009 H1N1 vaccine in record time; the efficient distribution of antiviral medications from the Strategic National Stockpile to the states; the use of Emergency Use Authorizations (EUAs) to increase the availability of antiviral medications and speed the availability of diagnostics; the development and rapid updating of clinical guidance on the treatment of 2009 H1N1; and the effective communication with the public regarding methods to prevent transmission of the influenza virus.

Information Needs

The HHS report recognized that while the CDC updated the clinical guidance as new data were received, keeping up with frequent changes may have been challenging for clinicians and by extension, EMS and 911 agencies. As an example, guidance for antiviral use was issued and updated throughout the pandemic 2009. Locating portions of the guidance that were clinically relevant to EMS and 911 needs was seen to be challenging. The Joint Information Center within the CDC also held more than 30 Clinician Outreach and Communication Activity calls for organizations representing physicians, nurses, ***emergency medical technicians***, lab technicians, and veterinarians, which then delivered the information to their group members.

PPE/NPIs

The HHS report noted that priorities for PPE use may have been too narrowly focused on healthcare providers while overlooking ***other frontline workers*** also at risk for occupational exposure to the 2009 H1N1 virus. The report acknowledged the lack of scientific evidence on the effectiveness of respiratory PPE, which includes masks and respirators as a mitigation strategy. Other non-pharmaceutical methods to reduce disease transmission were critical to the 2009 H1N1 pandemic response with substantial effort invested by the United States government in

developing and implementing risk communication messages about respiratory etiquette, hand hygiene, and staying home when sick.

Funding

On April 30, 2009, shortly after the HHS Secretary declared a public health emergency, a request was made to Congress for $1.5 billion to respond to the H1N1 pandemic. On June 24, 2009, a second request for an additional $2 billion was sent. On June 24, 2009, the supplemental appropriations for the 2009 H1N1 pandemic (P.L. 111-32) was signed into law, which included $7.65 billion to fund the pandemic response. HHS allocated the funding for a range of activities to prepare for and respond to the 2009 H1N1 pandemic, including: developing, purchasing, and distributing 2009 H1N1 vaccine; enhancing influenza surveillance; and assisting state and local health departments with mass vaccination plans and 2009 H1N1 response.

Discussion and Implications

Summary of Main Findings

Epidemiology of Occupationally Acquired Infections in the Emergency Medical Services and 911 Workforce

We found 25 observational studies on the characteristics, incidence, prevalence, and/or severity of occupationally acquired infectious diseases and related exposures in the emergency medical services (EMS) and 911 workforce (Guiding Question [GQ] 1). Twenty-two studies were published in the last 2 years (Figure 3), and most of them focused on severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Thus, much of the evidence on occupationally acquired infections in the EMS and 911 workforce is limited to SARS-CoV-2. The incidence, prevalence, and severity of infections generally did not differ according to demographic differences in the EMS and 911 workforce, except for one study that reported an increased prevalence of hepatitis C in older versus younger EMS and 911 workers,[29] and one study that reported a very large increased prevalence of SARS-CoV-2 in Black non-Hispanics and other Hispanics compared with White non-Hispanics.[13] In the latter study, the associated 95% confidence intervals were very wide because of the low numbers of Black or Hispanic EMS and 911 workers in the study.

Only six studies reported on how occupationally acquired infectious diseases and related exposures differ by EMS and 911 workforce characteristics. The only significant differences were an increased prevalence and risk of hospitalization or death from SARS-CoV-2 in EMS workers versus firefighters,[32] and a mildly increased prevalence of hepatitis C in EMS workers versus firefighters.[29] One other study examined differences in risk exposures between advanced life support (ALS) versus basic life support (BLS) certified/licensed EMS workers, and the authors reported that ALS-certified/licensed EMS workers had an increased risk of blood exposure, fluids exposure, and needle sticks.[8] Another study found no difference in methicillin-resistant *Staphylococcus aureus* (MRSA) nasal colonization based on years of experience, density of patient population served, or level of care.[26] No comparative studies were identified that reported on the epidemiology of occupationally acquired infections in dispatchers or telecommunicators.

Effectiveness of IPC Practices in the EMS and 911 Workforce

We found eleven observational studies on the characteristics and effectiveness of infection prevention and control (IPC) practices in the EMS and 911 workforce (GQ 2 and 3). Several workforce practices were examined, including hand hygiene, standard precautions, on-site vaccine clinics, and mandatory vaccination policies. The studies provided little information about contextual factors influencing the implementation and effectiveness of interventions, except as noted below.

Orellana found that both daily ***hand hygiene*** and hand hygiene following use of gloves were negatively correlated with nasal colonization of MRSA.[26] While it is accepted that hand hygiene is effective, the real-world application of the practice is challenging and often disrupted by changing between multiple care sites and lack of access to water or hand sanitizer.

The increased use of ***standard precautions***[51] such as face masks, gloves, and protective devices for resuscitation was associated with a decreased likelihood of a needlestick.[8] This study

also reported that properly recapping needles and disposing of needles in marked containers were associated with fewer needlesticks. A study by Kinlin et al performed in healthcare workers (non-prehospital) has also shown that gloves decrease needlesticks.[52]

One study examined the real-world implementation and effectiveness of a masks, eye protection, gloves and gowns (MEGG) protocol which included appropriate masks, eye protection, gown, and gloves at the beginning of the Coronavirus disease 2019 (COVID-19) pandemic in Washington state.[18] Brown reported that AGP procedures, even with full personal protective equipment (PPE), were associated with SARS-CoV-2 diagnosis. This finding was limited by having only one EMS clinician developing COVID-19 infection during 8,582 person-days at risk while in PPE and performing aerosol-generating procedures (AGP). No study that fit our inclusion criteria examined the protectiveness of N95 respirators or Powered Air-Purifying Respirators during AGPs in comparison to surgical masks alone or when paired with a face shield. However, Newberry found that lack of PPE or PPE breach were correlated with higher SARS-CoV-2 seropositivity.[28]

Other studies have examined workforce practices that prevent or control infectious diseases, but they were not included in our analysis because they did not focus on EMS and 911 workers. Bartoszko et al, reviewed four articles in a systematic review performed in Canada.[53] The authors found no convincing evidence that surgical masks are inferior to N95 respirators for protecting healthcare workers against viral respiratory infections during routine care. However, this data does not extend to AGPs and does not address more recent evidence of the small particle size and airborne nature of the SARS-CoV-2 virus in small poorly ventilated spaces (such as the back of an ambulance).[54] Another systematic review performed in Australia in 2021, conducted by Kunstler et al., found that the existing epidemiological evidence does not enable definitive assessment of the effectiveness of respirators compared to surgical masks in prevention of SARS-CoV-2 infection.[55]

The Hubble study on seasonal influenza[21] and the Glaser study on H1N1 influenza[24] highlighted the success of ***on-site vaccine clinics***. They stressed the importance of the difference between mere availability of vaccines in a passive program and an active program with education, social influence, and advice from supervisors. Vaccine uptake and acceptance were enhanced not only by the presence of a vaccination program, but also by accompanying educational modules and buy-in from supervisors and trusted peers.

Mandatory vaccination policies for seasonal influenza and H1N1 influenza also were shown to be effective at increasing vaccine uptake amongst EMS and 911 workers.[22] No studies on mandatory vaccination policies for SARS-CoV-2 fit within our inclusion criteria.

Challenges in Field EMS Research

We did not find any studies that used an experimental design to assess the effectiveness of IPC practices in the EMS and 911 workforce. Thus, health systems and policy makers must rely on observational studies to estimate the risk of occupationally acquired infections and the effectiveness of IPC practices in the EMS and 911 workforce. Another challenge in EMS research is the multiple different levels of providers in systems and heterogeneity of provider levels in different states across the US.

The lack of comparison groups and experimental designs undoubtedly stems from difficulties implementing such studies in a dynamic field environment. The field challenges to research create barriers to using an experimental design for testing workforce practices and make it difficult to obtain institutional review board approval for EMS research studies. A major concern

arises in patient care situations requiring emergent intervention because of the inability to obtain informed consent from patients.

Other barriers to research in the prehospital field setting contribute to the limited nature of the science in EMS care today. Study recruitment and data collection are particularly challenging in the mobile work environment with multiple care sites such as homes, streets, outdoor venues, and the hospital. Previous research into IPC for EMS and 911 workers has been heterogeneous and qualitative in nature given these barriers to experimental design and quantitative data collection in the field environment.

Increase in Research Since Onset of the COVID-19 Pandemic

Since the onset of the COVID-19 pandemic, the examination of infectious diseases in EMS care has increased. Accordingly, most publications meeting our inclusion criteria have been published in the last two years, mostly focusing on the epidemiology of infections or exposures in the prehospital workforce. Several studies, however, examined workforce practices.

The effectiveness of PPE in AGPs was examined in one study which was limited by a small number of EMS clinicians infected with COVID-19.[18] With evolution of SARS-CoV-2 to an endemic infection and with an overwhelmed public health contact tracing system, it was also challenging to determine whether COVID-19 infections in EMS clinicians were the result of occupational or non-occupational exposures. Prior to the COVID-19 pandemic, a small number of studies examined the epidemiology of exposure and effectiveness of workforce practices regarding influenza (including H1N1), MRSA, and hepatitis C.

No studies were identified that examined dispatchers or telecommunicators specifically.

Strengths and Limitations of the Evidence

This Technical Brief uses figures to provide a map of the evidence from studies of the epidemiology of occupationally acquired infections in the EMS and 911 workforce as well as studies of the effectiveness of IPC practices in the EMS and 911 workforce. The epidemiologic studies of incidence, prevalence, and severity of infections are representative of the target population of EMS and 911 workers in the United States, and most of those studies reported on the validity of the tests or measures of interest, and thus should provide appropriate estimates. The studies varied in reporting differences by age, gender, race, and other characteristics of the EMS and 911 workforce, partly because many of the studies were not large enough to support precise estimates of differences. Although we looked for studies that included 911 telecommunicators and emergency dispatchers, the studies in this review did not provide separate information about infections in that subset of the workforce.

While most of the studies were set in urban areas, most did not report whether their departments used salaried employees or were staffed by volunteers. In addition, although the name of the jurisdiction may have been listed, most studies did not explicitly state if they were a third service, fire-based, or hospital-based service. Studies were present from every region of the United States, and two were nationwide. No studies self-identified their jurisdiction as high-performance. Interventions reported in the studies include the workforce practices of hand-hygiene, standard precautions, educational sessions, on-site vaccine clinics, and vaccine mandates. One study reported on the effectiveness of PPE in preventing COVID-19, but this study was limited by sample size. These workforce practices appear to be similar to nationwide practices, however no published evidence was found to support this. Also, we found no study of on-site vaccine clinics or mandates focused on preventing COVID-19.

Studies of IPC practices included in this review are limited to those having a comparison group because effectiveness of a public health intervention cannot be reliably determined without a comparison group. Nevertheless, it is difficult to derive strong conclusions about the effectiveness of reported interventions when there have been no experimental study designs. Although the observational studies of IPC practices included EMS and 911 workers representative of the target population of interest, most of the studies did not provide enough information to assess potential selection bias and confounding factors. This limitation makes it even more difficult to draw firm conclusions about the effectiveness of the reported IPC practices in the EMS and 911 population. In addition, the studies of IPC practices provided sparse information about how practices differed by age, gender, race, and other characteristics of the EMS and 911 workforce. These studies also did not provide separate information about the effectiveness of IPC practices in 911 telecommunicators and emergency dispatchers.

Implications for Clinical Practice, Education, and Health Policy

The evidence in this Technical Brief demonstrates that EMS clinicians are at higher risk for exposure to infectious diseases than other first responders such as firefighters and the police. This evidence seems logical given the medical care and procedures provided and close patient contact. Policy makers recognizing this increased risk may allocate increased funds for protective measures, appropriate PPE, and educational programs for EMS clinicians. In addition, EMS clinicians could be prioritized to receive PPE when national stockpiles are activated or shortages occur. Organizations and departments may review their use of safety officers or their own culture of safety within their groups to determine if changes could be made in regard to educational programs and modeling behaviors of senior personnel for junior personnel.

The review also indicates that on-site vaccine clinics and educational programs have been effective at increasing vaccine uptake. In some jurisdictions, implementation of an on-site vaccine clinic may require a pivot in terms of how vaccines are offered and increased attention to logistical measures. In addition, some jurisdictions may not be able to afford the cost of some vaccines such as influenza or hepatitis C vaccines not covered by the government. Although vaccine mandates are controversial, evidence supports the effectiveness of vaccine mandates for prevention and control of influenza in the EMS and 911 workforce. While no studies were found on vaccine mandates for preventing SARS-CoV-2 infection, perceived risk, medical mistrust and vaccine confidence were strongly associated with COVID-19 vaccination, highlighting the challenges of promoting vaccination campaigns in the face of lower perceived risk, medical mistrust and issues surrounding vaccine confidence.

Future Research Needs

This Technical Brief has identified the current gaps in the evidence on the epidemiology of occupationally acquired infections and the effectiveness of IPC practices in the EMS and 911 workforce. Previous efforts and reports such as The National Occupational Research Agenda for Public Safety in 2019 called for additional research in EMS-related infectious disease risk.[56] EMS Agenda 2050, also released in 2019, notes that EMS care needs to be evidenced-based and outcomes driven. Similar consensus based processes could be used to develop new research agendas. This evidence review has found that more research is needed on the effectiveness of diverse types of IPC interventions for the full range of occupationally acquired infections in the

EMS and 911 workforce.[57] Specific examples of future research needs include: (1) Studies on workforce practices or engineering methods to improve hand hygiene in the field; (2) Studies examining the effectiveness of various levels of PPE in the field; (3) Studies regarding the creation of a culture of safety in regard to infectious diseases; (4) Studies of multi-component strategies for improving vaccine uptake by targeting predisposing, enabling, and reinforcing factors; (5) Studies on the training and education of the workforce regarding infectious diseases; and (6) Studies on workforce retention of experienced clinicians. Research and policy teams proposing new agendas ideally would be interdisciplinary and include infectious disease experts, EMS clinicians, and administrators. Representation from national organizations such as the National Association of Emergency Medical Technicians (NAEMT), the National Association of EMS Physicians (NAEMSP), and the National Association of State EMS Officials (NASEMSO), is also important to engage stakeholders from across the country.

The studies in this review were very heterogeneous, making it challenging to determine the effectiveness of specific workforce practices. The usefulness of future research to policy makers will be enhanced by more uniform approaches to the assessment of outcomes, more consistent attention to selection bias and confounding factors in comparative studies, a more extensive analysis of how the effectiveness of interventions differs according to the characteristics of the targeted workforce and their practice setting, and more attention to the resources needed to implement IPC interventions in EMS settings. The field of EMS research could benefit from developing practical guidance on how to conduct such studies in the highly challenging mobile environments in which EMS personnel work, ideally taking advantage of opportunities for analysis of natural experiments in the implementation of IPC practices. Such studies could help to strengthen IPC standards such as those established by the National Fire Protection Association (NFPA) including the 1581 standard on fire department infection control and the 1582 standard on having a comprehensive occupational medical program for fire departments.[58, 59]

Conclusions

A moderate amount of evidence exists on the incidence, prevalence, and severity of occupationally acquired infections in the EMS and 911 workforce, but much of that evidence has been published in the last 2 years and mostly focuses on SARS-CoV-2. The incidence, prevalence, and severity of infections do not differ according to characteristics of the EMS and 911 workforce, with a few exceptions. A moderate amount of evidence exists on the characteristics and effectiveness of IPC practices in the EMS and 911 workforce, mostly focusing on the effectiveness of hand hygiene, standard precautions, on-site vaccine clinics, and mandatory vaccination policies. The evidence is limited by lack of experimental study designs in the EMS setting and insufficient attention to potential selection bias and confounding in observational studies. Studies provided little information about contextual factors influencing implementation and effectiveness of interventions.

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Abbreviations and Acronyms

AGP	Aerosol-generating procedures
ALS	Advanced life support
aOR	Adjusted odds ratio
APIC	Association for Professionals in Infection Control and Epidemiology
ASPR	Assistant Secretary for Preparedness and Response
BLS	Basic life support
CDC	Centers for Disease Control and Prevention
CI	Confidence interval
COVID-19	Coronavirus disease 2019
ECC/PSAPS	Emergency Communications Centers/Public Safety Answering Points
EMS	Emergency medical services
EPC	Evidence-based Practice Center
EUA	Emergency Use Authorization
EVD-VHF	Ebola virus disease-viral hemorrhagic fever
GQ	Guiding Question
HHS	Department of Health and Human Services
HIV	Human immunodeficiency virus
IPC	Infection prevention and control
MEGG	Masks, eye protection, gown, and gloves
MRSA	Methicillin-resistant *Staphylococcus aureus*
NAEMSP	National Association of EMS Physicians
NAEMT	National Association of Emergency Medical Technicians
NASEMSO	National Association of State EMS Officials
NPI	Non-pharmaceutical interventions
NREMT	National Registry of Emergency Medicine Technicians
OR	Odds ratio
PAHPA	Pandemic and All-Hazards Preparedness Act
PCR	Polymerase chain reaction
PICOTS	Population, intervention, comparison, outcome, timing, setting, and study design
PPE	Personal protective equipment
PUI	Persons under investigation
RPDs	Respiratory protection devices
RR	Risk ratio
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
SEADS	Supplemental Evidence and Data for Systematic Reviews
SHEA	Society for Healthcare Epidemiology of America

SOP	Standard operating procedures
TRACIE	Technical Resources, Assistance Center, and Information Exchange

Appendix A. Methods Appendix

Search Strategies for Published Literature

Table A-1. PubMed search strategy

#	Term
1	"emergency medical services"[tiab] OR EMS[tiab] OR ("emergency medical services"[mh] NOT ("emergency service, hospital"[mh] OR "advanced trauma life support care"[mh] OR "poison control centers"[mh]))
2	"emergency medical responder" [tiab]
3	"Advanced EMT"[tiab] OR "advanced emergency medical technician"[tiab] OR AEMT[tiab]
4	Paramedic*[tiab]
5	"emergency medical services"[tiab] OR EMS[tiab]
6	"emergency medical technician"[tiab] OR "emergency medical technicians"[tiab]
7	"emergency responders"[tiab] OR "Emergency Responders"[mh]
8	"first responder"[tiab] OR "first responders"[tiab]
9	"law enforcement"[tiab] OR police[tiab] OR police[mh]
10	Firefighters[tiab]
11	"fire department"[tiab]
12	"police dispatcher"[tiab] OR dispatcher[tiab]
13	"emergency medical dispatcher"[tiab] OR "emergency medical dispatcher"[mh] OR "medical dispatcher"[tiab]
14	((911[tiab] OR "9/11" [tiab] OR "9-11" [tiab] OR "9-1-1" [tiab] OR "9 1 1" [tiab]) AND dispatcher[tiab])
15	"field dispatcher"[tiab] OR "field responder"[tiab]
16	Ambulance[tiab] OR ambulances[mh] OR "emergency mobile unit"[tiab]
17	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16
18	Infection*[tiab] OR Infections[mh] OR Infectious[tiab] OR "infectious disease"[tiab] OR "Virus Diseases"[tiab] OR "Virus Diseases"[mh] OR contaminat*[tiab]
19	"Communicable Diseases"[mh] OR "Infectious Disease Transmission, Patient-to-Professional"[mh]
20	"Covid-19"[tiab] OR "Covid19"[tiab] OR "Covid 19"[tiab] OR "COVID-19"[mh] OR "SARS-CoV-2"[tiab] OR "SARS-CoV2"[tiab] OR "SARS CoV 2"[tiab] OR "SARS-CoV-2"[mh] OR "2019-nCoV"[tiab] OR "COVID-19 Vaccines"[mh] OR "2019 Novel Coronavirus"[tiab]
21	Influenza[tiab] OR "Influenza, Human"[mh] OR "flu"[tiab]
22	Tuberculosis[tiab] OR Tuberculosis[mh]
23	HIV[tiab] OR HIV[mh] OR "human immunodeficiency virus"[tiab] OR "acquired immunodeficiency syndrome"[tiab] OR AIDS[tiab] OR "Acquired Immunodeficiency Syndrome"[mh]
24	"Hepatitis B"[tiab] OR "hepatitis-b"[tiab] OR "Hepatitis B"[mh]
25	"Hepatitis C"[tiab] OR "hepatitis"[tiab] OR "Hepatitis C"[mh]
26	"Respiratory infection"[tiab] OR "Respiratory Tract Infections"[mh]
27	#18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26
28	#17 AND #27
29	English[la]
30	Animals[mh] NOT humans[mh]
31	Study protocol[ti] OR trial protocol[ti] OR review protocol[ti] OR editorial[pt] OR letter[pt] OR case reports[pt]
32	#28 AND #29 NOT #30 NOT #31
33	Date limits 2006-present

Table A-2. Embase search strategy

#	Term
1	'emergency medical services':ti,ab OR EMS:ti,ab OR 'emergency medical dispatch'/de
2	'emergency medical responder':ti,ab OR 'emergency medical responders':ti,ab
3	'Advanced EMT':ti,ab OR 'advanced emergency medical technician':ti,ab OR AEMT:ti,ab
4	Paramedic*:ti,ab
5	'emergency medical technician':ti,ab OR 'emergency medical technicians':ti,ab
6	'emergency responder':ti,ab OR 'emergency responders':ti,ab OR 'rescue personnel'/exp
7	'first responder':ti,ab OR 'first responders':ti,ab

#	Term
8	‘law enforcement’:ti,ab OR police:ti,ab OR police/exp
9	Firefighter:ti,ab OR firefighters:ti,ab OR ‘fire fighter’:ti,ab OR ‘fire fighters’:ti,ab
10	‘fire department’:ti,ab OR ‘fire departments’:ti,ab
11	‘police dispatcher’:ti,ab OR dispatcher:ti,ab
12	‘emergency medical dispatcher’:ti,ab OR ‘emergency medical dispatcher’/exp OR ‘medical dispatcher’:ti,ab
13	((911:ti,ab OR ‘9/11’:ti,ab OR ‘9-11’:ti,ab OR ‘9-1-1’:ti,ab OR ‘9 1 1’:ti,ab) AND dispatcher:ti,ab)
14	‘field dispatcher’:ti,ab OR ‘field dispatchers’:ti,ab OR ‘field responder’:ti,ab OR ‘field responders’:ti,ab
15	Ambulance:ti,ab OR ambulances:ti,ab OR ambulances/exp OR ‘emergency mobile unit’:ti,ab
16	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15
17	Infection*:ti,ab OR ‘Infection’/de OR ‘airborne infection’/de OR ‘bloodstream infection’/de OR ‘communicable disease’/de OR ‘skin infection’/exp OR Infectious:ti,ab OR ‘infectious disease’:ti,ab OR ‘infectious diseases’:ti,ab OR ‘viral disease’:ti,ab OR ‘viral diseases’:ti,ab OR ‘virus diseases’:ti,ab OR ‘virus infection’/de OR contaminat*:ti,ab
18	‘communicable disease’/exp OR ‘communicable disease’:ti,ab OR ‘communicable diseases’:ti,ab OR ‘patient-to-professional transmission’/exp
19	‘Covid-19’:ti,ab OR ‘Covid19’:ti,ab OR ‘Covid 19’:ti,ab OR ‘coronavirus disease 2019’/exp OR ‘SARS-CoV-2’:ti,ab OR ‘SARS-CoV2’:ti,ab OR ‘SARS CoV 2’:ti,ab OR ‘Severe acute respiratory syndrome coronavirus 2’/exp OR ‘2019-nCoV’:ti,ab OR ‘SARS-CoV-2 vaccine’/exp OR ‘2019 Novel Coronavirus’:ti,ab OR ‘SARSCov2’:ti,ab OR ‘severe acute respiratory syndrome coronavirus’:ti,ab OR COVID:ti,ab
20	Influenza:ti,ab OR ‘Influenza’/exp OR ‘flu’:ti,ab
21	Tuberculosis:ti,ab OR ‘lung tuberculosis’/de
22	HIV:ti,ab OR ‘Human immunodeficiency virus infection’/exp OR ‘human immunodeficiency virus’:ti,ab OR ‘human immuno-deficiency virus’:ti,ab OR ‘human immune-deficiency virus’:ti,ab OR ‘acquired immunodeficiency syndrome’:ti,ab OR ‘acquired immune-deficiency syndrome’:ti,ab OR AIDS:ti,ab OR ‘acquired immune deficiency syndrome’/exp
23	‘Hepatitis B’:ti,ab OR ‘hepatitis-b’:ti,ab OR ‘hepatitis B’/exp
24	‘Hepatitis C’:ti,ab OR ‘hepatitis’:ti,ab OR ‘hepatitis C’/exp
25	‘Respiratory infection’:ti,ab OR ‘respiratory tract infection’/de
26	#17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25
	Workforce AND Infection terms
27	#16 AND #26
28	English:la
29	Animals/exp NOT humans/exp
30	Study protocol:ti OR trial protocol:ti OR review protocol:ti OR editorial:it OR letter:it OR ‘case reports’:it OR ‘conference abstract’:pt
31	#27 AND #28 NOT #29 NOT #30
32	Date limits 2006-present

Table A-3. CINAHL search strategy

#	Term
1	TI (“emergency medical services” OR EMS) OR AB (“emergency medical services” OR EMS) OR MM (“emergency medical services” NOT (“trauma centers” OR “poison control centers”))
2	TI (“emergency medical responder” OR “Advanced EMT” OR “advanced emergency medical technician” OR AEMT OR Paramedic* OR “emergency medical technician” OR “emergency medical technicians”) OR AB (“emergency medical responder” OR “Advanced EMT” OR “advanced emergency medical technician” OR AEMT OR Paramedic* OR “emergency medical technician” OR “emergency medical technicians”)
3	TI (“emergency responders” OR “first responder” OR “first responders”) OR AB (“emergency responders” OR “first responder” OR “first responders”)
4	TI (“law enforcement” OR police) OR AB (“law enforcement” OR police) OR (MM police)
5	TI (firefighters OR “fire departments”) OR AB (firefighters OR “fire departments”)
6	TI (“police dispatcher” OR dispatcher OR “emergency medical dispatcher” OR “medical dispatcher” OR “field dispatcher” OR “field responder”) OR AB (“police dispatcher” OR dispatcher OR “emergency medical dispatcher” OR “medical dispatcher” OR “field dispatcher” OR “field responder”)
7	(TI ((911 OR “9/11” OR “9-11” OR “9-1-1” OR “9 1 1”) AND dispatcher)) OR (AB ((911 OR “9/11” OR “9-11” OR “9-1-1” OR “9 1 1”) AND dispatcher))
8	TI (ambulance OR “emergency mobile unit”) OR (MM ambulances) OR AB (ambulance OR “emergency mobile unit”)
9	1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9

#	Term
10	TI (Infection* OR Infectious OR “infectious disease” OR “Virus Diseases” OR contaminat*) OR AB (Infection* OR Infectious OR “infectious disease” OR “Virus Diseases” OR contaminat*) OR MM (Infection OR “virus diseases”)
11	MM (“Communicable Diseases” OR “Disease Transmission, Patient-to-Professional”)
12	TI (“Covid-19” OR “Covid19” OR “Covid 19” OR “SARS-CoV-2” OR “SARS-CoV2” OR “SARS CoV 2” OR ”2019-nCoV” OR “2019 Novel Coronavirus”) OR (MM “COVID-19”) OR AB (“Covid-19” OR “Covid19” OR “Covid 19” OR “SARS-CoV-2” OR “SARS-CoV2” OR “SARS CoV 2” OR ”2019-nCoV” OR “2019 Novel Coronavirus”) OR (MM “COVID-19”) OR (MM “SARS-CoV-2”) OR (MM “COVID-19 Vaccines”)
13	TI (Influenza OR flu) OR AB (Influenza OR flu) OR (MM “Influenza, Human”)
14	TI (Tuberculosis) OR AB (Tuberculosis) OR (MM Tuberculosis)
15	TI (HIV OR “human immunodeficiency virus” OR “acquired immunodeficiency syndrome” OR AIDS) OR AB (HIV OR “human immunodeficiency virus” OR “acquired immunodeficiency syndrome” OR AIDS) OR (MM “Human Immunodeficiency Virus”) OR (MM “Acquired Immunodeficiency Syndrome”)
16	TI (“Hepatitis B” OR “hepatitis-b”) OR AB (“Hepatitis B” OR “hepatitis-b”) OR (MM “Hepatitis B”)
17	TI (“Hepatitis C” OR “hepatitis-c”) OR AB (“Hepatitis C” OR “hepatitis-c”) OR (MM “Hepatitis C”)
18	TI (“Respiratory infection”) OR AB (“Respiratory infection”) OR (MM “Respiratory Tract Infections”)
19	10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18
20	9 AND 19
21	(LA English)
22	MM (Animals NOT human)
23	TI (“study protocol” OR “trial protocol” OR “review protocol”) OR (PT editorial) OR (PT letter) OR (PT “case reports)
24	20 AND 21 NOT 22 NOT 23
25	Date limit 2006 - present
26	24 AND 25

Table A-4. SCOPUS search strategy

#	Term
1	TITLE-ABS-KEY ("emergency medical services" OR ems “emergency medical responder” OR "emergency medical responders" OR "emergency medical responder" OR "emergency medical responders" OR "advanced emt" OR "advanced emergency medical technician" OR aemt OR "advanced emts" OR "advanced emergency medical technicians" OR aemts OR paramedic* OR "emergency responder" OR "emergency responders" OR "emergency medical technician" OR "emergency medical technicians" OR "first responder" OR "first responders" OR "law enforcement" OR "police" OR firefighter OR firefighters OR "fire fighter" OR "fire fighters" OR "fire department" OR "fire departments" OR "police dispatcher" OR dispatcher* OR "emergency medical dispatcher" OR "medical dispatcher" OR ((911 OR "9/11" OR "9-11" OR "9-1-1" OR "9 1 1") AND dispatcher*) OR "field dispatcher" OR "field dispatchers" OR "field responder" OR "field responders" OR ambulance OR ambulances OR "emergency mobile unit") AND TITLE-ABS-KEY (infection* OR Infectious OR “infectious disease” OR “Virus Diseases” OR contaminat* OR “communicable disease” OR “communicable diseases” OR “Covid-19” OR “Covid19” OR “Covid 19” OR “SARS-CoV-2” OR “SARS-CoV2” OR “SARS CoV 2” OR ”2019-nCoV” OR “2019 Novel Coronavirus” OR SARSCoV2 OR “severe acute respiratory syndrome coronavirus” OR influenza OR flu OR tuberculosis OR HIV OR “human immunodeficiency virus” OR “human immuno-deficiency virus” OR “human immune-deficiency virus” OR “acquired immunodeficiency syndrome” OR “acquired immune-deficiency syndrome” OR AIDS or “hepatitis B” OR “hepatitis-b” OR “hepatitis C” OR “hepatitis-C” OR “respiratory infection”)

Appendix B. List of Excluded Studies

1. Abramson TM, Kashani S, Sanko S, et al. 80 Los Angeles Fire Department Telemedicine Program: An Emergency Dispatch Center Based Pilot. Annals of Emergency Medicine. 2020;76(4):S32. doi: 10.1016/j.annemergmed.2020.09.090. **- Is a meeting abstract**

2. Ahmed A, Zhong Z, Suprono M, et al. Enhancement of peripheral seal of medical face masks using a 3-dimensional-printed custom frame. J Am Dent Assoc. 2021 Jul;152(7):542-50. doi: 10.1016/j.adaj.2021.03.011. PMID: 34176568. **- Does not evaluate emergency medical services workforce who have been exposed to or are at risk of exposure to an occupationally acquired infectious disease**

3. Akinbami LJ, Biggerstaff BJ, Chan PA, et al. Reinfection with SARS-CoV-2 among previously infected healthcare personnel and first responders. Clin Infect Dis. 2021 Nov 15doi: 10.1093/cid/ciab952. PMID: 34791108. **- A mixed population with <50% EMS or 911 responders and does not report data separately**

4. Akinbami LJ, Petersen LR, Sami S, et al. Coronavirus Disease 2019 Symptoms and Severe Acute Respiratory Syndrome Coronavirus 2 Antibody Positivity in a Large Survey of First Responders and Healthcare Personnel, May-July 2020. Clin Infect Dis. 2021 Aug 2;73(3):e822-e5. doi: 10.1093/cid/ciab080. PMID: 33515250. **- A mixed population with <50% EMS or 911 responders and does not report data separately**

5. Albright A, Gross K, Hunter M, et al. A Dispatch Screening Tool to Identify Patients at High Risk for COVID-19 in the Prehospital Setting. West J Emerg Med. 2021 Oct 27;22(6):1253-6. doi: 10.5811/westjem.2021.8.52563. PMID: 34787547. **- Evaluates effectiveness of an emergency medical services/911 workforce practice but does not have a comparison group**

6. Alexander AB, Masters MM, Warren K. Caring for Infectious Disease in the Prehospital Setting: A Qualitative Analysis of EMS Providers Experiences and Suggestions for Improvement. Prehosp Emerg Care. 2020 Jan-Feb;24(1):77-84. doi: 10.1080/10903127.2019.1601313. PMID: 30917729. - **Describes intervention of interest but does NOT assess infection control**

7. Alexandre ACS, Galindo Neto NM, Souza Silva MA, et al. Construction and validation of checklist for disinfecting ambulances to transport Covid-19 patients. Rev Gaucha Enferm. 2021;42(spe):e20200312. doi: 10.1590/1983-1447.2021.20200312. PMID: 34161544. **- Is not conducted in the United States**

8. Alhazmi RA, Parker RD, Wen S. Standard Precautions Among Emergency Medical Services in Urban and Rural Areas. Workplace Health and Safety. 2020;68(2):73-80. doi: 10.1177/2165079919864118. - **Describes intervention of interest but does NOT assess infection control**

9. Alves DW, Bissell RA. Bacterial pathogens in ambulances: results of unannounced sample collection. Prehosp Emerg Care. 2008 Apr-Jun;12(2):218-24. doi: 10.1080/10903120801906721. PMID: 18379921. **- Does not evaluate emergency medical services workforce who have been exposed to or are at risk of exposure to an occupationally acquired infectious disease**

10. Andersen BM, Rasch M, Hochlin K, et al. Decontamination of rooms, medical equipment and ambulances using an aerosol of hydrogen peroxide disinfectant. Journal of Hospital Infection. 2006;62(2):149-55. doi: 10.1016/j.jhin.2005.07.020. **- Does not report on an outcome of interest**

11. Avari H, Hiebert RJ, Peddle MB, et al. A quantitative study of particle dispersion due to respiratory support modalities in pre-hospital and in-hospital critical care environments. American Journal of Respiratory and Critical Care Medicine. 2021;203(9)doi: 10.1164/ajrccm-conference.2021.203.1_MeetingAbstracts.A2600. **- Is a meeting abstract**

12. Banerjee P, Ganti L, Stead T, et al. 34 Polk COVID-19 and Flu Response Clinical Trial. Annals of Emergency Medicine. 2021;78(2):S16-S7. doi: 10.1016/j.annemergmed.2021.07.035. **- Is a meeting abstract**

13. Belfroid E, Hautvast JL, Hilbink M, et al. Selection of key recommendations for quality indicators describing good quality outbreak response. BMC Infect Dis. 2015 Mar 31;15:166. doi: 10.1186/s12879-015-0896-x. PMID: 25888491. **- No original data (e.g., review article, commentary, or editorial)**

14. Bielawska-Drózd A, Cieślik P, Bohacz J, et al. Microbiological analysis of bioaerosols collected from Hospital Emergency Departments and ambulances. Ann Agric Environ Med. 2018 Jun 20;25(2):274-9. doi: 10.26444/aaem/80711. PMID: 29936812. **- Does not report on an outcome of interest**

15. Biggerstaff BJ, Akinbami LJ, Hales C, et al. Duration of Viral Nucleic Acid Shedding and Early Reinfection With Severe Respiratory Syndrome Coronavirus 2 in Healthcare Workers and First Responders. J Infect Dis. 2021 Dec 1;224(11):1873-7. doi: 10.1093/infdis/jiab504. PMID: 34610137. **- Not related to the epidemiology of occupationally acquired exposures or the effectiveness of emergency medical services/911 workforce practices to prevent, recognize, or control infectious diseases**

16. Bledsoe BE, Sweeney RJ, Berkeley RP, et al. EMS provider compliance with infection control recommendations is suboptimal. Prehosp Emerg Care. 2014 Apr-Jun;18(2):290-4. doi: 10.3109/10903127.2013.851311. PMID: 24401023. **- Does not evaluate emergency medical services workforce who have been exposed to or are at risk of exposure to an occupationally acquired infectious disease**

17. Brant-Zawadzki M, Fridman D, Robinson PA, et al. Prevalence and Longevity of SARS-CoV-2 Antibodies Among Health Care Workers. Open Forum Infect Dis. 2021 Feb;8(2):ofab015. doi: 10.1093/ofid/ofab015. PMID: 33604403. **- A mixed population with <50% EMS or 911 responders and does not report data separately**

18. Brown R, Minnon J, Schneider S, et al. Prevalence of methicillin-resistant Staphylococcus aureus in ambulances in southern Maine. Prehosp Emerg Care. 2010 Apr-Jun;14(2):176-81. doi: 10.3109/10903120903564480. PMID: 20199231. **- Not related to the epidemiology of occupationally acquired exposures or the effectiveness of emergency medical services/911 workforce practices to prevent, recognize, or control infectious diseases**

19. Bruce G. Paramedic services workplace program improves influenza immunization rates among paramedics. Can J Infect Control. 2007 Fall;22(3):156-8, 60-1. PMID: 18044385. **- Does not report on an outcome of interest**

20. Bucher J, Donovan C, Ohman-Strickland P, et al. Hand Washing Practices Among Emergency Medical Services Providers. West J Emerg Med. 2015 Sep;16(5):727-35. doi: 10.5811/westjem.2015.7.25917. PMID: 26587098. - **Describes intervention of interest but does NOT assess infection control**

21. Butterbaugh MW, Washick M, Wesley K. Dirty ambulances; Adenosine triphosphate (ATP) bioluminescence measurement in the surveillance of ambulance cleanliness. American Journal of Infection Control. 2018;46(6):S46. **- Is a meeting abstract**

22. Caban-Martinez AJ, Santiago KM, Louzado-Feliciano P, et al. Influenza Vaccination Coverage and (SARS-CoV-2) Seroprevalance in a Fire Department. Annals of Epidemiology. 2020;52:115. doi: 10.1016/j.annepidem.2020.08.058. **- Is a meeting abstract**

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107. Sarfraz Z, Sarfraz A, Sarfraz M, et al. Lessons learnt from emergency medicine services during the COVID-19 pandemic: A case study of India and the United States. Ann Med Surg (Lond). 2022 Jan;73:103197. doi: 10.1016/j.amsu.2021.103197. PMID: 34956642. - **Describes intervention of interest but does NOT assess infection control**

108. Schultz JS, McCarthy MK, Rester C, et al. Development and Validation of a Multiplex Microsphere Immunoassay Using Dried Blood Spots for SARS-CoV-2 Seroprevalence: Application in First Responders in Colorado, USA. J Clin Microbiol. 2021 May 19;59(6)doi: 10.1128/jcm.00290-21. PMID: 33795412. **- Does not evaluate emergency medical services workforce who have been exposed to or are at risk of exposure to an occupationally acquired infectious disease**

109. Schumacher J, Gray SA, Michel S, et al. Respiratory protection during simulated emergency pediatric life support: a randomized, controlled, crossover study. Prehosp Disaster Med. 2013 Feb;28(1):33-8. doi: 10.1017/s1049023x12001525. PMID: 23089080. **- Is not conducted in the United States**

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116. Song L, Li W, He J, et al. Development of a Pulsed Xenon Ultraviolet Disinfection Device for Real-Time Air Disinfection in Ambulances. J Healthc Eng. 2020;2020:6053065. doi: 10.1155/2020/6053065. PMID: 32184979. **- Does not report on an outcome of interest**

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122. Thompson MG, Burgess JL, Naleway AL, et al. Interim Estimates of Vaccine Effectiveness of BNT162b2 and mRNA-1273 COVID-19 Vaccines in Preventing SARS-CoV-2 Infection Among Health Care Personnel, First Responders, and Other Essential and Frontline Workers - Eight U.S. Locations, December 2020-March 2021. MMWR Morb Mortal Wkly Rep. 2021 Apr 2;70(13):495-500. doi: 10.15585/mmwr.mm7013e3. PMID: 33793460. - **Describes intervention of interest but does NOT assess infection control**

123. Thompson MG, Burgess JL, Naleway AL, et al. Prevention and Attenuation of Covid-19 with the BNT162b2 and mRNA-1273 Vaccines. N Engl J Med. 2021 Jul 22;385(4):320-9. doi: 10.1056/NEJMoa2107058. PMID: 34192428. **- A mixed population with <50% EMS or 911 responders and does not report data separately**

124. Tsukahara K, Naito H, Nojima T, et al. Feasibility study of a portable transparent vinyl chloride shield for use in an ambulance during the COVID-19 pandemic. Critical Care. 2020;24(1)doi: 10.1186/s13054-020-03381-9. **- No original data (e.g., review article, commentary, or editorial)**

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132. Webb LM, Tubach SA, Hunt DC. Outbreak of cryptosporidiosis among responders to a rollover of a truck carrying calves - Kansas, April 2013. MMWR Morb Mortal Wkly Rep. 2014 Dec 19;63(50):1185-8. PMID: 25522085. **- Not related to the epidemiology of occupationally acquired exposures or the effectiveness of emergency medical services/911 workforce practices to prevent, recognize, or control infectious diseases**

133. Wessling EG, Randolph AH, Neill LA, et al. Rapid Emergency Department Physical Space Modifications for COVID-19: Keeping Patients and Health Care Workers Safe. Disaster Med Public Health Prep. 2021 Aug 4:1-4. doi: 10.1017/dmp.2021.248. PMID: 34346305. **- Is not conducted in the United States**

134. Whittle J, Weber K, Thundiyil J, et al. Prevalence of methicillin-resistant staphylococcus aureus in EMS personnel. Academic Emergency Medicine. 2010;17:S135. doi: 10.1111/j.1553-2712.2010.00743.x. **- Is a meeting abstract**

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Appendix C. Evidence Tables

Evidence Table C-1. Study characteristics of studies investigating the characteristics, incidence, prevalence, and severity of occupationally acquired exposures to infectious diseases for the EMS/911 workforce (Guiding Question 1)

Author, Year	Study Design	Setting	Location	High-Performing EMS System	Number of Providers Engaged	Type of Transport	Volunteer or Funded Department	Population	Infectious Disease
Akinbami, 2020[1]	Cross-sectional	Urban	Michigan: Detroit	No/not reported	1558	Not reported	Not reported	Emergency medical service workers including firefighters	SARS-COV2
Al Amiry, 2013[2]	Cross-sectional	Urban, suburban	Maryland: Baltimore area	No/not reported	110	Ground	Funded	Emergency medical service workers including firefighters	MRSA
Caban-Martinez, 2020[3]	Prospective cohort	Unclear/not reported	Multiple states: Arizona, Florida, Oregon, Minnesota, Texas, Utah	No/not reported	1415	Not reported/unclear	Unclear/not reported	First responders	SARS-COV2
Caban-Martinez, 2020[4]	Cross-sectional	Not reported	Florida: South Florida	No/not reported	203	Not reported	Not reported	Firefighters only	SARS-COV2
El Sayed, 2012[5]	Retrospective cohort	Urban	Massachusetts: Boston	No/not reported	397	Not reported	Not reported	Emergency medical service workers not including firefighters	Meningitis, TB, viral respiratory infection, skin membrane splash, eye splash, rash, mammalian bite, scratch, needlestick

Author, Year	Study Design	Setting	Location	High-Performing EMS System	Number of Providers Engaged	Type of Transport	Volunteer or Funded Department	Population	Infectious Disease
Elie-Turenne, 2010[6]	Cross-sectional	Urban	New Jersey: Newark	No/not reported	52	Not reported	Not reported	Emergency medical service workers not including firefighters	MRSA
Ellingson, 2021[7]	Prospective cohort	Multiple settings (specify)	Arizona: statewide	No/not reported	228	Not reported/unclear	Unclear/not reported	Emergency medical service workers including firefighters	SARS-COV2
Firew, 2020[8]	Cross-sectional	Urban, suburban, rural	Nationwide	No/not reported	266	Not reported	Not reported	Emergency medical service workers not including firefighters	SARS-COV2
Grant, 2021[9]	Cross-sectional	Urban	California: San Francisco	No/not reported	1231	Not reported/unclear	Unclear/not reported	Firefighters only	SARS-COV2
Harris, 2010[10]	Cross-sectional	Urban, suburban, rural	Virginia: Greater Richmond area	No/not reported	311	Ground	Mixed department (both volunteers and funded)	Emergency medical service workers including firefighters	Any type of blood-borne exposure
McGuire, 2021[11]	Cross-sectional	Not reported	Minnesota: Rochester	No/not reported	255	Ground	Not reported	Pre-hospital provider (EMS or fire but unclear)	SARS-COV2
Mohanty, 2021[12]	Prospective cohort	Unclear/not reported	Unclear:	No/not reported	224	Not reported/unclear	Unclear/not reported	Emergency medical service workers not including firefighters	SARS-COV2

Author, Year	Study Design	Setting	Location	High-Performing EMS System	Number of Providers Engaged	Type of Transport	Volunteer or Funded Department	Population	Infectious Disease
Montague, 2022[13]	Prospective cohort	Multiple settings	Colorado: Statewide	No/not reported	Firefighters: 414; EMS: 241	Not reported/unclear	Unclear/not reported	Emergency medical service workers including firefighters	SARS-COV2
Mulligan, 2022[14]	Cross-sectional	Urban	California: Los Angeles	No/not reported	686	Not reported/unclear	Unclear/not reported	Firefighters only	SARS-COV2
Murphy, 2020[15]	Retrospective cohort	Urban, suburban, rural	Washington: King County	No/not reported	700	Not reported	Not reported	Emergency medical service workers including firefighters	SARS-COV2
Newberry, 2021[16]	Cross-sectional	Urban	California: Santa Clara County	No/not reported	983	Not reported	Not reported	Emergency medical service workers including firefighters	SARS-COV2
Orellana, 2016[17]	Cross-sectional	Urban, suburban, rural	Ohio: Statewide	No/not reported	280	Not reported	Not reported	Emergency medical service workers not including firefighters	MRSA
Prezant, 2020[18]	Retrospective cohort	Urban	New York: New York City	No/not reported	15638	Not reported	Not reported	Emergency medical service workers including firefighters	SARS-COV2
Sami, 2021[19]	Cross-sectional	Urban	New York: New York City	No/not reported	22647	Not reported	Not reported	Emergency medical service workers including firefighters	SARS-COV2

Author, Year	Study Design	Setting	Location	High-Performing EMS System	Number of Providers Engaged	Type of Transport	Volunteer or Funded Department	Population	Infectious Disease
Shukla, 2020[20]	Cross-sectional	Urban, suburban	Arizona: Phoenix, Tempe, Glendale, Peoria, Surprise and Chandler	No/not reported	3326	Ground	Not reported	Emergency medical service workers including firefighters	SARS-COV2
Shukla, 2021[21]	Retrospective cohort	Urban	Arizona: Phoenix	No/not reported	201	Not reported/unclear	Unclear/not reported	Firefighters only	SARS-COV2
Tarabichi, 2021[22]	Cross-sectional	Urban	Ohio: Cleveland	No/not reported	296	Ground	Not reported	Emergency medical service workers including firefighters	SARS-COV2
Vieira, 2021[23]	Cross-sectional	Urban	California: Orange County	No/not reported	923	Not reported	Not reported	Firefighters only	SARS-COV2
Webber, 2018[24]	Prospective cohort	Urban	New York: New York City	No/not reported	11374	Not reported	Not reported	Emergency medical service workers including firefighters	Hepatitis C
Weiden, 2021[25]	Cross-sectional	Urban	New York: New York City	No/not reported	14290	Not reported	Not reported	Emergency medical service workers including firefighters	SARS-COV2

EMS=emergency medical service; MRSA= Methicillin-resistant Staphylococcus aureus; TB=tuberculosis

Evidence Table C-2. Patient characteristics of studies investigating the characteristics, incidence, prevalence, and severity of occupationally acquired exposures to infectious diseases for the EMS/911 workforce (Guiding Question 1)

Author, Year	Age	Gender, Males n (%)	Race, n (%)	Experience	Type of Training, n (%)	Vaccination Status
Akinbami, 2020[1]	Not Reported	Not reported	Not Reported	Not Reported	Not reported	Not reported
Al Amiry, 2013[2]	Mean: 35.2	92 (83.6)	Not Reported	Mean: 10.5	EMT-Basic: 45 EMT-Intermediate6 EMT-Paramedic: 59	Not reported
Caban-Martinez, 2020[3]	Mean: 41.3	1113 (79)	White: 1338 (95)	Not Reported	EMR: 141 (10) Firefighter: 964 (68)	Pfizer, Moderna, Johnson and Johnson: 829 (59)
Caban-Martinez, 2020[4]	Range: 21 - 30: 33; 31 - 40: 51; 41 - 50: 67; 51+: 52	188 (93.5)	White: 154 (78.2) African-American: 9 (4.6) Other: 34 (17.3)	Mean: 15.3 +/- 9.1	Not reported	Not reported
El Sayed, 2012[5]	Not Reported	Not reported	Not Reported	Not Reported	Not reported	Not reported
Elie-Turenne, 2010[6]	Not Reported	Not reported	Not Reported	Not Reported	Not reported	Not reported
Ellingson, 2021[7]	Mean: 42.8	248 (62.8)	Not Reported	Not Reported	EMR: 86 Firefighter: 142	Not reported
Firew, 2020[8]	Not Reported	Not reported	Not Reported	Not Reported	Not reported	Not reported
Grant, 2021[9]	Mean: 44.1 Range: 21-68	1019 (85.4)	White: 715 (52.7) African-American: 107 (7.9) Asian: 261 (19.2) Hispanic: 194 (14.3) Other: 80 (5.9)	Mean: 12.6 Range: 0-51	Firefighter: 569 (47.1)	Not reported
Harris, 2010[10]	Mean: 37 Range: 17 to 72	(56)	White: (85) African-American: (8.9) Asian: (1) Hispanic: (2.6) Other: (2)	Mean: 6 Range: 0.5 to 25	EMR: 5 EMT-Basic: 226 EMT-Paramedic: 2	Not reported
McGuire, 2021[11]	Not Reported	Not reported	Not Reported	Not Reported	Firefighter: 92 (1)	Not reported
Mohanty, 2021[12]	Not Reported	Not reported	Not Reported	Not Reported	Not reported	Not reported

Author, Year	Age	Gender, Males n (%)	Race, n (%)	Experience	Type of Training, n (%)	Vaccination Status
Montague, 2022[13]	Median: Fire: 43; EMS: 34	Fire: 377 (92); EMS 162 (70)	White: Fire: 380 (92); EMS: 210 (87) African-American: Fire: 6 (1); EMS: 2 (1) Asian: Fire: 4 (1): EMS: 1 (<1) Hispanic: Fire: 21 (5); EMS: 18 (8) Other: Fire: 17 (4); EMS: 13 (7)	Not Reported	Not reported	Pfizer or Moderna COVID-19 Mrna vaccine: Fire: 9 (2); EMS: 12 (5)
Mulligan, 2022[14]	Mean: 42	601 (87.6)	White: 357 (52) African-American: 46 (6.7) Asian: 64 (9.3) Hispanic: 197 (28.7) Other: 22 (3.2)	Not Reported	Not reported	Not reported
Murphy, 2020[15]	Not Reported	Not reported	Not Reported	Not Reported	Not reported	Not reported
Newberry, 2021[16]	Range: 18-34: 206 (21%); 35-49: 556 (56.6%); 50+: 221 (22.5%)	942 (95.8)	White: 594 (60.4) African-American: 26 (2.6) Asian: 78 (7.9) Hispanic: 192 (19.5) Other: 93 (9.5)	Not Reported	Not reported	Not reported
Orellana, 2016[17]	Mean: 36.9	246 (87.9)	White: 278 Other: 2	Range:< 16 years: 178; 16+ years: 102	Not reported	Not reported
Prezant, 2020[18]	Mean: 35.8 +/- 10.2 (EMS); 38.9 +/- 8.3 (Fire)	5135 (out of population on medical leave); 1305 EMS and 3830 Fire (72.8% EMS; 98.9% Fire)	Not Reported	Not Reported	Not reported	Not reported
Sami, 2021[19]	Not Reported	Not reported	Not Reported	Not Reported	Not reported	Not reported
Shukla, 2020[20]	Mean: 41.4 Range: 18–24 yrs 100 (3.1%) 25–34 yrs 730 (22.2%) 35–44 yrs 1,186 (36.1%) 45–54 yrs 984 (30.0%) 55–64 yrs 266 (8.1%) 65+ yrs 16 (0.5%)	2637 (82.9)	Not Reported	Not Reported	Not reported	Not reported
Shukla, 2021[21]	Not Reported	Not reported	Not Reported	Not Reported	Not reported	Not reported

Author, Year	Age	Gender, Males n (%)	Race, n (%)	Experience	Type of Training, n (%)	Vaccination Status
Tarabichi, 2021[22]	Mean: 43.8 (negative) 50.1 (positive) Range: 22-65 (negative) 35.4-60.6 (positive)	253 (85)	White, Non-Hispanic: 200 (71.4%) White, Other: 27 (9.6%) Black, Non-Hispanic: 21 (7.5%) White, Hispanic: 12 (4.3%) Other, Hispanic: 10 (3.6%) Other: 10 (1.6%)	Not Reported	EMR: 111 (37.5) Firefighter: 185 (62.5)	Not reported
Vieira, 2021[23]	Range: 21-30: 112 (12.1%); 31-40: 324 (35.1%); 41-50: 286 (31.0%); 51+: 201 (21.8%)	897 (97.2)	White: 827 (89.6) African-American: 11 (1.2) Asian: 60 (6.5) Hispanic: 174 (18.9) Other: 25 (2.7)	Not Reported	Not reported	Not reported
Webber, 2018[24]	Range: 40 years FF; 37 years EMS (on 9/11)	(100)	White: 10077 (89) African-American: 546 (5) Asian: 60 (1) Hispanic: 682 (6) Other: 9 (0)	Not Reported	EMR: 1327 (12) Firefighter: 10047 (88)	Not reported
Weiden, 2021[25]	Mean: 40.4	(92)	White: (97.8) African-American: (11.2) Hispanic: (16.6) Other: (4.4)	Not Reported	Not reported	Not reported

EMR=emergency medical responders; EMS=emergency medical services; EMT=emergency medical technician; Fire=firefighters

Evidence Table C-3. Risk of bias assessment (modified EPHPP) of studies investigating the characteristics, incidence, prevalence, and severity of occupationally acquired exposures to infectious diseases for the EMS/911 workforce (Guiding Question 1)

Author, Year	Completeness: Are the Targeted Individuals Likely To Be Representative of the Target Population?	Completeness: What Percentage of Targeted Individuals Agreed To Participate?	Accuracy: Did the Study Report any Data on the Validity of the Tests of Interest?
Akinbami, 2020[1]	Very likely	Can't tell	Yes
Al Aminy, 2013[2]	Very likely	Can't tell	Yes
Caban-Martinez, 2020[4]	Very likely	80-100% agreement	Yes
El Sayed, 2012[5]	Very likely	80-100% agreement	Yes
Elie-Turenne, 2010[6]	Somewhat likely	less than 60% agreement	Yes
Firew, 2020[8]	Not likely	Can't tell	Self-Report
Harris, 2010[10]	Somewhat likely	less than 60% agreement	Self-Report
McGuire, 2021[11]	Very likely	80-100% agreement	Yes
Murphy, 2020[15]	Very likely	80-100% agreement	Yes
Newberry, 2021[16]	Very likely	60-79% agreement	Can't tell
Orellana, 2016[17]	Very likely	Can't tell	Yes
Prezent, 2020[18]	Very likely	80-100% agreement	Can't tell
Sami, 2021[19]	Can't tell	less than 60% agreement	Yes
Shukla, 2020[20]	Very likely	80-100% agreement	Yes
Tarabichi, 2021[22]	Very likely	Can't tell	Yes
Vieira, 2021[23]	Very likely	80-100% agreement	Yes
Webber, 2018[24]	Very likely	80-100% agreement	Can't tell
Weiden, 2021[25]	Very likely	80-100% agreement	Yes
Shukla, 2021[21]	Very likely	Can't tell	Yes
Ellingson, 2021[7]	Somewhat likely	Can't tell	Self-Report
Mohanty, 2020[12]	Can't tell	Can't tell	Yes
Grant, 2021[9]	Very likely	60-79% agreement	Self-Report
Caban-Martinez, 2020[3]	Somewhat likely	Can't tell	Can't tell
Mulligan, 2022[14]	Somewhat likely	less than 60% agreement	Can't tell
Montague, 2022[13]	Can't tell	Can't tell	Can't tell

EPHPP=Effective Public Healthcare Panacea Project quality assessment tool

Evidence Table C-4. Results of studies investigating the incidence, prevalence, and severity of exposures by demographic characteristics for the EMS/911 workforce (Guiding Question 1a)

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Caban-Martinez, 2020[4]	Age, 21 - 30	Prevalence	Seroprevalence based on IgG test	SARS-COV2	33	n with event: 2
Caban-Martinez, 2020[4]	Age, 31 - 40	Prevalence	Seroprevalence based on IgG test	SARS-COV2	51	n with event: 6
Caban-Martinez, 2020[4]	Age, 41 - 50	Prevalence	Seroprevalence based on IgG test	SARS-COV2	67	n with event: 7
Caban-Martinez, 2020[4]	Age, 51+	Prevalence	Seroprevalence based on IgG test	SARS-COV2	52	n with event: 3
Caban-Martinez, 2020[4]	Gender, Male	Prevalence	Seroprevalence based on IgG test	SARS-COV2	188	n with event: 16
Caban-Martinez, 2020[4]	Gender, Female	Prevalence	Seroprevalence based on IgG test	SARS-COV2	13	n with event: 2
Caban-Martinez, 2020[4]	Race, White	Prevalence	Seroprevalence based on IgG test	SARS-COV2	154	n with event: 15
Caban-Martinez, 2020[4]	Race, Black	Prevalence	Seroprevalence based on IgG test	SARS-COV2	9	n with event: 0
Caban-Martinez, 2020[4]	Race, Other	Prevalence	Seroprevalence based on IgG test	SARS-COV2	34	n with event: 3
Caban-Martinez, 2020[4]	Race, Hispanic	Prevalence	Seroprevalence based on IgG test	SARS-COV2	149	n with event: 15
Caban-Martinez, 2020[4]	Race, Non-Hispanic	Prevalence	Seroprevalence based on IgG test	SARS-COV2	48	n with event: 3
Mulligan, 2022[14]	Age, 18-29	Prevalence	IgG or IgM seroprevalence test	SARS-COV2	93	n with event: 6.5%
Mulligan, 2022[14]	Age, 30-44	Prevalence	IgG or IgM seroprevalence test	SARS-COV2	287	n with event: (10.1%) Ref: Age, 18-29 aOR: 1.395 (95% CI, 0.52 to 3.76), adjusted for contextual characteristics of workplace zip codes
Mulligan, 2022[14]	Age, 45-60	Prevalence	IgG or IgM seroprevalence test	SARS-COV2	270	n with event: (8.9%) Ref: Age, 18-29 aOR: 1.090 (95% CI, 0.39 to 3.05), adjusted for contextual characteristics of workplace zip codes

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Mulligan, 2022[14]	Age, >=60	Prevalence	IgG or IgM seroprevalence test	SARS-COV2	36	n with event: (5.6%) Ref: Age, 18-29 aOR: 0.902 (95% CI, 0.16 to 5.26), adjusted for contextual characteristics of workplace zip codes
Mulligan, 2022[14]	Female	Prevalence	IgG or IgM seroprevalence test	SARS-COV2	83	n with event: 4.8%
Mulligan, 2022[14]	Male	Prevalence	IgG or IgM seroprevalence test	SARS-COV2	601	n with event: (9.5%) Ref: Female aOR: 0.490 (95% CI: 0.15 to 1.58), adjusted for contextual characteristics of workplace zip codes
Mulligan, 2022[14]	Non-binary/other	Prevalence	IgG or IgM seroprevalence test	SARS-COV2	2	n with event: 0%
Mulligan, 2022[14]	Non-Hispanic white	Prevalence	IgG or IgM seroprevalence test	SARS-COV2	357	n with event: 7.3%
Mulligan, 2022[14]	Non-Hispanic black	Prevalence	IgG or IgM seroprevalence test	SARS-COV2	46	n with event: (8.7%) Ref: Non-Hispanic white aOR: 1.396 (95% CI, 0.417 to 4.675), adjusted for contextual characteristics of workplace zip codes
Mulligan, 2022[14]	Non-Hispanic Asian	Prevalence	IgG or IgM seroprevalence test	SARS-COV2	64	n with event: (12.5%) Ref: Non-Hispanic white aOR: 2.208 (95% CI, 0.818 to 5.962), adjusted for contextual characteristics of workplace zip codes
Mulligan, 2022[14]	Hispanic	Prevalence	IgG or IgM seroprevalence test	SARS-COV2	197	n with event: (10.7%) Ref: Non-Hispanic white aOR: 2.387 (95% CI, 1.202 to 4.741), adjusted for contextual characteristics of workplace zip codes

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Mulligan, 2022[14]	Other/mixed race	Prevalence	IgG or IgM seroprevalence test	SARS-COV2	22	n with event: (9.1%) Ref: Non-Hispanic white aOR: 2.567 (95% CI, 0.465 to 14.17), adjusted for contextual characteristics of workplace zip codes
Newberry, 2021[16]	Age, 18-34	Prevalence	IgG seroprevalence test	SARS-COV2	206	n with event: 2 (1%)
Newberry, 2021[16]	Age, 18-34	Incidence	PCR test	SARS-COV2	206	n with event: 2 (1%)
Newberry, 2021[16]	Age, 35-49	Prevalence	IgG seroprevalence test	SARS-COV2	556	n with event: 17 (3%) Ref: Age, 18-34 RR: 3.15 (95% CI: 0.73 to 13.51)
Newberry, 2021[16]	Age, 35-49	Incidence	PCR test	SARS-COV2	556	n with event: 3 (1%) Ref: Age, 18-34 RR: 0.56 (95% CI: 0.09 to 3.3)
Newberry, 2021[16]	Age, 50+	Prevalence	IgG seroprevalence test	SARS-COV2	221	n with event: 6 (3%) Ref: Age, 18-34 RR: 2.8 (95% CI: 0.57 to 13.7)
Newberry, 2021[16]	Age, 50+	Incidence	PCR test	SARS-COV2	221	n with event: 4 (2%) Ref: Age, 18-34 RR: 1.86 (95% CI: 0.35 to 10.07)
Newberry, 2021[16]	Race, White	Prevalence	IgG seroprevalence test	SARS-COV2	594	n with event: 8 (1%)
Newberry, 2021[16]	Race, White	Incidence	PCR test	SARS-COV2	594	n with event: 6 (1%)
Newberry, 2021[16]	Race, Hispanic	Prevalence	IgG seroprevalence test	SARS-COV2	192	n with event: 9 (5%) Ref: Race, White RR: 3.48 (95% CI: 1.36 to 8.9)
Newberry, 2021[16]	Race, Hispanic	Incidence	PCR test	SARS-COV2	192	n with event: 3 (2%) Ref: Race, White RR: 1.55 (95% CI: 0.39 to 6.13)
Newberry, 2021[16]	Race, Black	Prevalence	IgG seroprevalence test	SARS-COV2	26	n with event: 1 (4%) Ref: Race, White RR: 2.86 (95% CI: 0.37 to 21.99)
Newberry, 2021[16]	Race, Black	Incidence	PCR test	SARS-COV2	26	n with event: 0 (0%)

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Newberry, 2021[16]	Race, Asian	Prevalence	IgG seroprevalence test	SARS-COV2	78	n with event: 3 (4%) RR: 2.86 (95% CI: 0.77 to 10.54)
Newberry, 2021[16]	Race, Asian	Incidence	PCR test	SARS-COV2	78	n with event: 0 (0%)
Newberry, 2021[16]	Race, Other	Prevalence	IgG seroprevalence test	SARS-COV2	93	n with event: 4 (4%) RR: 3.19 (95% CI: 0.98 to 10.39)
Newberry, 2021[16]	Race, Other	Incidence	PCR test	SARS-COV2	93	n with event: 0 (0%)
Orellana, 2016[17]	Age	Prevalence	Nasal colonization of MRSA	MRSA	NR	OR: 1.03, p = 0.2306
Tarabichi, 2021[22]	Gender, Male	Prevalence	Seroprevalence using IgG and IgM ELISA	SARS-COV2	253	n with event: 12
Tarabichi, 2021[22]	Gender, Female	Prevalence	Seroprevalence using IgG and IgM ELISA	SARS-COV2	42	n with event: 4
Tarabichi, 2021[22]	Age Mean	Prevalence	Seroprevalence using IgG and IgM ELISA	SARS-COV2	NR	Mean (negative): 43.8 years; Mean (positive): 50.1 years
Tarabichi, 2021[22]	Race, White, Non-Hispanic	Prevalence	Seroprevalence using IgG and IgM ELISA	SARS-COV2	200	n with event: 8
Tarabichi, 2021[22]	Race, White, Other	Prevalence	Seroprevalence using IgG and IgM ELISA	SARS-COV2	27	n with event: 0
Tarabichi, 2021[22]	Race, Black, Non-Hispanic	Prevalence	Seroprevalence using IgG and IgM ELISA	SARS-COV2	21	n with event: 5
Tarabichi, 2021[22]	Race, White, Hispanic	Prevalence	Seroprevalence using IgG and IgM ELISA	SARS-COV2	12	n with event: 0
Tarabichi, 2021[22]	Race, Other, Hispanic	Prevalence	Seroprevalence using IgG and IgM ELISA	SARS-COV2	10	n with event: 3
Tarabichi, 2021[22]	Race, Other	Prevalence	Seroprevalence using IgG and IgM ELISA	SARS-COV2	10	n with event: 0
Vieira, 2021[23]	Age, 21 - 30	Prevalence	IgG seroprevalence test	SARS-COV2	112	n with event: 5, p=0.678
Vieira, 2021[23]	Age, 31 - 40	Prevalence	IgG seroprevalence test	SARS-COV2	324	n with event: 20
Vieira, 2021[23]	Age, 41 - 50	Prevalence	IgG seroprevalence test	SARS-COV2	286	n with event: 12
Vieira, 2021[23]	Age, 51+	Prevalence	IgG seroprevalence test	SARS-COV2	201	n with event: 12
Vieira, 2021[23]	Gender, Male	Prevalence	IgG seroprevalence test	SARS-COV2	897	n with event: 49, p=0.454
Vieira, 2021[23]	Gender, Female	Prevalence	IgG seroprevalence test	SARS-COV2	26	n with event: 0
Vieira, 2021[23]	Race, White	Prevalence	IgG seroprevalence test	SARS-COV2	827	n with event: 46
Vieira, 2021[23]	Race, Asian	Prevalence	IgG seroprevalence test	SARS-COV2	60	n with event: 1
Vieira, 2021[23]	Race, Black	Prevalence	IgG seroprevalence test	SARS-COV2	11	n with event: 0
Vieira, 2021[23]	Race, Other	Prevalence	IgG seroprevalence test	SARS-COV2	25	n with event: 2
Vieira, 2021[23]	Race, Hispanic	Prevalence	IgG seroprevalence test	SARS-COV2	174	n with event: 8

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Webber, 2018[24]	Age, 18-29	Prevalence	Positive test from 2000 - 2012	Hepatitis C	947	n with event: 0
Webber, 2018[24]	Age, 30-39	Prevalence	Positive test from 2000 - 2012	Hepatitis C	4561	n with event: 12
Webber, 2018[24]	Age, 40-49	Prevalence	Positive test from 2000 - 2012	Hepatitis C	4578	n with event: 84
Webber, 2018[24]	Age, 50-59	Prevalence	Positive test from 2000 - 2012	Hepatitis C	1193	n with event: 55
Webber, 2018[24]	Age, 60+	Prevalence	Positive test from 2000 - 2012	Hepatitis C	95	n with event: 0
Webber, 2018[24]	Race, White	Prevalence	Positive test from 2000 - 2012	Hepatitis C	10077	n with event: 115
Webber, 2018[24]	Race, Hispanic	Prevalence	Positive test from 2000 - 2012	Hepatitis C	682	n with event: 15
Webber, 2018[24]	Race, Black	Prevalence	Positive test from 2000 - 2012	Hepatitis C	546	n with event: 21
Webber, 2018[24]	Race, Asian	Prevalence	Positive test from 2000 - 2012	Hepatitis C	60	n with event: 0
Webber, 2018[24]	Race, Other	Prevalence	Positive test from 2000 - 2012	Hepatitis C	9	n with event: 0
Weiden, 2021[25]	Gender	Healthcare Utilization	Hospitalization or death from COVID	SARS-COV2	NR	OR: Male sex 1.55 (95% CI: 0.60 to 4.02), p=0.365
Weiden, 2021[25]	Gender	Incidence	COVID diagnosis	SARS-COV2	NR	OR: 1.12 (95% CI: 0.88 to 1.44), p=0.355
Weiden, 2021[25]	Age	Healthcare Utilization	Hospitalization or death from COVID	SARS-COV2	NR	OR: Age per 10 years 1.59 (95% CI: 1.20 to 2.10), p=0.001
Weiden, 2021[25]	Age	Incidence	COVID diagnosis	SARS-COV2	NR	OR: 0.79 (95% CI: 0.74 to 0.84), p<0.001
Weiden, 2021[25]	Race	Healthcare Utilization	Hospitalization or death from COVID	SARS-COV2	NR	OR: Non-white race 2.46 (95% CI: 1.34 to 4.51), p=0.004
Weiden, 2021[25]	Race	Incidence	COVID diagnosis	SARS-COV2	NR	OR: 1.21 (95% CI: 1.06 to 1.38), p=0.004

CI=confidence interval; ELISA= Enzyme-linked immunosorbent assay; IgG= Immunoglobulin G; MRSA=Methicillin-resistant Staphylococcus aureus; n=number of participants; N=sample size; OR=odds ratio; PCR=polymerase chain reaction; Ref=reference; RR=risk ratio

Evidence Table C-5. Results of studies investigating the incidence, prevalence, and severity of exposures by workforce characteristics for the EMS/911 workforce (Guiding Question 1b)

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Caban-Martinez, 2020[3]	Firefighters	Incidence	Confirmed COVID-19	SARS-Cov-2	419	per 1,000 person weeks: 9.0 (95% CI: 6.4 to 12.7)
Caban-Martinez, 2020[3]	Firefighters	Incidence	Confirmed COVID-19	SARS-Cov-2	545	per 1,000 person weeks: 1.8 (95% CI: 1.1 to 2.8)
Caban-Martinez, 2020[3]	Other first responders	Incidence	Confirmed COVID-19	SARS-Cov-2	86	per 1,000 person weeks: 8.7 (95% CI: 4.6 to 16.4)
Caban-Martinez, 2020[3]	Other first responders	Incidence	Confirmed COVID-19	SARS-Cov-2	127	per 1,000 person weeks: 2.9 (95% CI: 1.3 to 6.3)
Ellingson, 2021[7]	Fire	Incidence	incidence per 1000 person weeks	SARS-Cov-2	142	13 incidence per 1000 person weeks (7 - 18) -- estimated from graph
Ellingson, 2021[7]	EMS	Incidence	incidence per 1000 person weeks	SARS-Cov-2	86	14 (6-22) estimated from graph
Harris, 2010[10]	Advanced Life Support	Incidence	Needlestick	Any type of blood-borne exposure	80	n with event: 10 Ref: Basic Life Support (FR/BLS) OR: 10.8 (95% CI: 2.89 to 40.3)
Harris, 2010[10]	Basic Life Support (FR/BLS)	Incidence	Needlestick	Any type of blood-borne exposure	230	n with event: 3
Harris, 2010[10]	Advanced Life Support	Incidence	Lancet stick	Any type of blood-borne exposure	80	n with event: 0 Ref: Basic Life Support (FR/BLS) OR: 0.23 (95% CI: 0.01 to 4.68)
Harris, 2010[10]	Basic Life Support (FR/BLS)	Incidence	Lancet stick	Any type of blood-borne exposure	231	n with event: 5
Harris, 2010[10]	Advanced Life Support	Incidence	Blood Exposure	Any type of blood-borne exposure	80	n with event: 66 Ref: Basic Life Support (FR/BLS) OR: 3.1 (95% CI: 1.63 to 5.78)
Harris, 2010[10]	Basic Life Support (FR/BLS)	Incidence	Blood Exposure	Any type of blood-borne exposure	231	n with event: 140
Harris, 2010[10]	Advanced Life Support	Incidence	Fluids Exposure	Any type of contact exposure	78	n with event: 67 Ref: Basic Life Support (FR/BLS) OR: 5.8 (95% CI: 2.93 to 11.6)
Harris, 2010[10]	Basic Life Support (FR/BLS)	Incidence	Fluids Exposure	Any type of contact exposure	231	n with event: 118
Harris, 2010[10]	Volunteer	Incidence	Needlestick	Any type of blood-borne exposure	129	n with event: 9 Ref: Professional OR: 0.74 (95% CI: 0.23 to 2.30)

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Harris, 2010[10]	Professional	Incidence	Needlestick	Any type of blood-borne exposure	54	n with event: 5
Montague, 2022[13]	Full group	Prevalence	Confirmed COVID-19	SARS-Cov-2	414	n with event: 20 (5%)
Montague, 2022[13]	Full group	Prevalence	Confirmed COVID-19	SARS-Cov-2	241	n with event: 13 (5%)
Montague, 2022[13]	Full group	Separation from the workforce	Episode of quarantine	SARS-Cov-2	414	n with event: 38 (9%)
Montague, 2022[13]	Full group	Separation from the workforce	Episode of quarantine	SARS-Cov-2	241	n with event: 14 (6%)
Orellana, 2016[17]	Work Experience	Prevalence	Nasal colonization of MRSA	MRSA	NR	16+ years OR: 0.83, p=0.8076
Orellana, 2016[17]	Geographic Area	Prevalence	Nasal colonization of MRSA	MRSA	NR	Urban vs rural OR: 0.94, p=0.9445
Orellana, 2016[17]	Work Level	Prevalence	nasal colonization of MRSA	MRSA	NR	ALS vs. BLS OR: 0.72, p=0.6754
Tarabichi, 2021[22]	EMS	Prevalence	Seroprevalence using IgG and IgM ELISA	SARS-COV2	111	n with event: 6 OR: 1 (95% CI: 0.35 to 2.83)* Ref: firefighters
Tarabichi, 2021[22]	Fire	Prevalence	Seroprevalence using IgG and IgM ELISA	SARS-COV2	185	n with event: 10 Ref
Webber, 2018[24]	Fire	Prevalence	Positive test from 2000 - 2012	Hepatitis C	10047	n with event: 123 Ref
Webber, 2018[24]	EMS	Prevalence	Positive test from 2000 - 2012	Hepatitis C	1327	n with event: 28 OR: 1.74 (95% CI: 1.15 to 2.63)* Ref: firefighters
Weiden, 2021[25]	EMS vs. Fire	Healthcare Utilization	Hospitalization or death from COVID	SARS-COV2	NR	EMS versus firefighter OR: 4.23 (95% CI: 2.20 to 8.15), p<0.001
Weiden, 2021[25]	EMS vs. Fire	Prevalence	COVID diagnosis	SARS-COV2	NR	OR: 1.28 (95% CI: 1.10 to 1.49), p=0.001

ALS=advanced life support; BLS=basic life support; CI=confidence interval; ELISA= Enzyme-linked immunosorbent assay; EMS=emergency medical services; Fire=firefighter; FR=first responder; IgG= Immunoglobulin G; MRSA=Methicillin-resistant Staphylococcus aureus; n=number of participants; N=sample size; OR=odds ratio
*Odds ratio calculated by Evidence-based Practice Center from available data in article

Evidence Table C-6. Study characteristics of studies investigating the characteristics and reported effectiveness in studies of EMS/911 workforce practices to prevent infectious diseases (Guiding Question 2/3)

Author, Year	Study Design	Setting	Location	High-Performing EMS System	Number of Providers Engaged	Type of Transport	Volunteer or Funded Department	Population	Infectious Disease
Brown, 2021[26]	Observational study with concurrent comparison group	Urban, suburban, and rural	Washington: King County	No/not reported	2920	Not reported	Not reported	Emergency medical service workers including firefighters	SARS-COV2
Glaser, 2011[27]	Observational study with concurrent comparison group	Urban	New York: New York City	No/not reported	10612	Not reported	Not reported	Emergency medical service workers including firefighters	Influenza
Halbrook, 2021[28]	Observational study with concurrent comparison group	Urban	California: Los Angeles	No/not reported	465	Not reported	Not reported	Emergency medical service workers including firefighters	SARS-COV2
Harris, 2010[10]	Observational study with concurrent comparison group	Urban, suburban, and rural	Virginia: Greater Richmond area	No/not reported	311	Ground	Mixed department (both volunteers and funded)	Emergency medical service workers including firefighters	Any type of blood-borne exposure
Harris, 2010[10]	Observational study with concurrent comparison group	Urban, suburban, and rural	Virginia: Greater Richmond area	No/not reported	311	Ground	Mixed department (both volunteers and funded)	Emergency medical service workers including firefighters	Any type of blood-borne exposure
Hubble, 2011[29]	Observational study with concurrent comparison group	Urban, suburban, and rural	North Carolina: 14 different agencies within the state	No/not reported	601	Not reported	Not reported	Emergency medical service workers not including firefighters	Influenza

Author, Year	Study Design	Setting	Location	High-Performing EMS System	Number of Providers Engaged	Type of Transport	Volunteer or Funded Department	Population	Infectious Disease
Grant, 2021[9]	Cross-sectional	Urban	California: San Francisco	No/not reported	1231	Not reported/unclear	Unclear/not reported	Firefighters only	SARS-COV2
Gregory, 2021[30]	Cross-sectional	Unclear/not reported	Nationwide:	No/not reported	2584	Not reported/unclear	Mixed department (both volunteers and funded)	Emergency medical service workers including firefighters	SARS-COV2
Miramonti, 2013[31]	Observational study with concurrent comparison group	Urban	Indiana	No/not reported	186	Not reported	Not reported	Emergency medical service workers not including firefighters	MRSA
Newberry, 2021[16]	Observational study with concurrent comparison group	Urban	California: Santa Clara County	No/not reported	983	Not reported	Not reported	Emergency medical service workers including firefighters	SARS-COV2
Orellana, 2016[17]	Observational study with concurrent comparison group	Urban, suburban, and rural	Ohio	No/not reported	280	Not reported	Not reported	Emergency medical service workers not including firefighters	MRSA
Rebmann, 2012[32]	Observational study with concurrent comparison group	Urban	Missouri: St. Louis	No/not reported	265	Not reported	Not reported	Emergency medical service workers including firefighters	Influenza

EMS=emergency medical service; MRSA= Methicillin-resistant Staphylococcus aureus

Evidence Table C-7. Intervention characteristics of studies investigating the characteristics and reported effectiveness in studies of EMS/911 workforce practices to prevent infectious diseases (Guiding Question 2/3)

Author, Year	Arm Name	Type of Intervention	Levels of the Hierarchy of Controls Addressed by the Intervention	Intervention	Single or Multi-Dimension Intervention	National, State, or Local Protocol	Intervention Setting
Brown, 2021[26]	AGP	PPE protocol	Engineering, PPE	EMS PPE protocols include wearing a mask, eye protection, gloves, and a gown. Surgical masks were considered sufficient for treating patients not requiring AGP, but an N95 respirator was required when patients underwent AGPs. HEPA (high efficiency particulate air) filters were added to ventilation bags. Otherwise, clinical protocols did not change in response to the pandemic	Single	Yes	Field
Glaser, 2011[27]	BIOPOD	Vaccines, on-site	Elimination	Vaccines offered during BIOPOD event, on-site clinic, education pre-BIOPOD- compliance with getting a flu vaccine was measured among both people who attended event and those who did not	Single	No	Station
Halbrook, 2021[28]	Vaccine Uptake	Level of training	Administrative	level of training: healthcare workers compared to EMS	Single	No	Not reported
Harris, 2010[10]	Recap needles, dispose of needles in marked container, and dispose of other contaminated materials in marked container	Disposal	Elimination	Self-reported behaviors (Recap needles, dispose of needles in marked container, and dispose of other contaminated materials in marked container)	Single	No	Not reported

Author, Year	Arm Name	Type of Intervention	Levels of the Hierarchy of Controls Addressed by the Intervention	Intervention	Single or Multi-Dimension Intervention	National, State, or Local Protocol	Intervention Setting
Harris, 2010[10]	Use of face mask, use of protective device for performing resuscitation, wear gloves for all calls	PPE protocol	PPE	Self-reported behaviors (Use of face mask, use of protective device for performing resuscitation, wear gloves for all calls)	Single	No	Not reported
Hubble, 2011[29]	Vaccine Clinic	Training and education, vaccines	Elimination	Survey: looked at vaccine rates among rural, urban, and suburban (vaccine as intervention); then asked participants about training, education, and whether employer offered vaccine	Multi	No	Not reported
Grant, 2021[9]	Post-Shelter in place order	Level of training	Administrative	Measures PPE use pre and post shelter in place order	Single	Yes	Field
Gregory, 2021[30]	Vaccine Uptake	Level of training	Administrative	Survey of EMS professionals on why or why not receive vaccination	Single	No	unclear/not reported
Miramonti, 2013[31]	Students	Training and education	No applicable	EMTS with at least six months of experience compared EMT students with less than two months of experience (including training); the "intervention" would be experience in the field	Single	No	Not reported
Newberry, 2021[16]	Full PPE	PPE protocol	PPE	Survey: asked if full PPE during exposure	Single	No	Not reported
Orellana, 2016[17]	Hygiene	Hand hygiene	Administrative	Survey: asked about hand hygiene and compared to MRSA colonization rates	Single	No	Station
Rebmann, 2012[32]	Mandate	Personnel policies	Elimination	Employers had a mandatory vaccination policy	Single	No	Station

AGP=aerosol generating procedures; BIOPOD= biologic points of distribution; EMS=emergency medical services; HEPA=high efficiency particulate air; PPE=personal protective equipment

Evidence Table C-8. Participant characteristics of studies investigating the characteristics and reported effectiveness in studies of EMS/911 workforce practices to prevent infectious diseases (Guiding Question 2/3)

Author, Year	Age	Gender, Males n (%)	Race, n (%)	Experience	Type of Training, n (%)	Vaccination Status
Brown, 2021[26]	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported
Glaser, 2011[27]	Range: <30: 1928; 30-39: 4071; 39+ 4613	10042 (94.6)	White: 8538 (80.46) African-American: 770 (7.26) Asian: 142 (1.34) Hispanic: 1153 (10.87) Other: 9 (8)	Not reported	EMR: 2254 (21.24) Firefighter: 8358 (78.76)	Influenza: 5831 (54.95)
Halbrook, 2021[28]	Range: 18-29: 26 (5.59%); 30-39: 139 (29.89%); 40-49: 124 (26.67%); 50-59: 160 (34.41%); 60+: 16 (3.44%)	428 (92)	White: 316 (68) African-American: 30 (6.5) Asian: 23 (5) Other: 96 (20.7)	Not Reported	Not reported	Not reported
Harris, 2010[10]	Mean: 37 Range: 17 to 72	(56)	White: (85) African-American: (8.9) Asian: (1) Hispanic: (2.6) Other: (2)	Mean: 6 Range: 0.5 to 25	EMR: 5 EMT-Basic: 226 EMT-Paramedic: 2	Not reported
Harris, 2010[10]	Mean: 37 Range: 17 to 72	(56)	White: (85) African-American: (8.9) Asian: (1) Hispanic: (2.6) Other: (2)	Mean: 6 Range: 0.5 to 25	EMR: 5 EMT-Basic: 226 EMT-Paramedic: 2	Not reported
Hubble, 2011[29]	Mean: 35.9	(64.8)	White: (94.3)	Not Reported	EMT-Basic: (11.7) EMT-Intermediate: (5) EMT-Paramedic: (83.2)	Influenza: (52.1)
Grant, 2021[9]	Range: 21-68	1019 (85.4)	White: 715 (52.7) African-American: 107 (7.9) Asian: 261 (19.2) Other: 80 (5.9)	Reported	EMT-Paramedic: Firefighter/Paramedic: 122 (10%); EMT/Paramedic: 176 (14.6%)	Not reported
Gregory, 2021[30]	Range: 18-83	1701 (66.7)	White: 2170 (87) Other: 323 (13)	Reported	EMT-Basic: 1072 (41.5)	Vaccine typ not reported: 1804 (69.8)
Miramonti, 2013[31]	Mean: EMS: 34.3; Control: 27	178	White: 261 African-American: 18	Not reported	EMT-Basic: 45 EMT-Paramedic: 89	Not reported

Author, Year	Age	Gender, Males n (%)	Race, n (%)	Experience	Type of Training, n (%)	Vaccination Status
Newberry, 2021[16]	Range: 18-34: 206 (21%); 35-49: 556 (56.6%); 50+: 221 (22.5%)	942 (95.8)	White: 594 (60.4) African-American: 26 (2.6) Asian: 78 (7.9) Hispanic: 192 (19.5) Other: 93 (9.5)	Not Reported	Not reported	Not reported
Orellana, 2016[17]	Mean: 36.9	246 (87.9)	White: 278 Other: 2	Range: < 16 years: 178; 16+ years: 102	Not reported	Not reported
Rebmann, 2012[32]	Range: 83.7% were between 31 - 60	212 (84.8)	White: 232 (87.5)	Range: 73.1% had 11+ years experience	Not reported	Influenza: 195 (73.6)

EMR=emergency medical responders; EMS=emergency medical services; EMT=emergency medical technician; n=number of participants

Evidence Table C-9. Risk of bias assessment (modified EPHPP) of studies investigating the characteristics and reported effectiveness in studies of EMS/911 workforce practices to prevent infectious diseases (Guiding Question 2/3)

Author, year	Selection Bias: Are the Individuals Selected To Participate in the Study Likely To Be Representative of the Target Population?	Selection Bias: What Percentage of Selected Individuals Agreed To Participate?	Selection Bias Rating*	Confounders: Were There Important Differences Between Groups Prior to the Intervention?	Confounders: If Yes, Indicate the Percentage of Relevant Confounders That Were Controlled?	Confounders Rating†
Brown, 2021[26]	Very likely	80-100% agreement	Strong	No	Not Applicable	Strong
Glaser, 2011[27]	Very likely	80-100% agreement	Strong	No	Not Applicable	Strong
Halbrook, 2021[28]	Somewhat likely	80-100% agreement	Moderate	Can't tell	Not Applicable	Weak
Harris, 2010[10]	Somewhat likely	Less than 60% agreement	Weak	Can't tell	Not Applicable	Weak
Hubble, 2011[29]	Somewhat likely	Can't tell	Weak	Can't tell	Not Applicable	Weak
Grant, 2021[9]	Very likely	60-79% agreement	Moderate	No	Not Applicable	Strong
Gregory, 2021[30]	Very likely	less than 60% agreement	Weak	Can't tell	Not Applicable	Weak
Miramonti, 2013[31]	Very likely	60-79% agreement	Moderate	Yes	Not Applicable	Weak
Newberry, 2021[16]	Very likely	60-79% agreement	Moderate	Can’t tell	Not Applicable	Weak
Orellana, 2016[17]	Very likely	Can't tell	Weak	Can't tell	Not Applicable	Weak
Rebmann, 2012[32]	Somewhat likely	Can't tell	Weak	Can't tell	Not Applicable	Weak

EMS=emergency medical services; EPHPP=Effective Public Healthcare Panacea Project quality assessment tool

*Selection bias grading is assessed as either[33]:

Strong = Selected individuals are very likely to be representative of the target population and there is greater than 80% participation

Moderate = The selected individuals are at least somewhat likely to be representative of the target population and there is 60 - 79% participation

Weak = The selected individuals are not likely to be representative of the target population, there is less than 60% participation or selection is not described

†Confounders domain is assessed as either[33]:

Strong = Will be assigned to those articles that controlled for at least 80% of relevant confounders

Moderate = Will be given to those studies that controlled for 60 – 79% of relevant confounders

Weak = will be assigned when less than 60% of relevant confounders were controlled or control of confounders was not described

Evidence Table C-10. Results of studies investigating how workforce practices to recognize and prevent infectious diseases by demographic characteristics of the EMS/911 workforce (Guiding Question 2/3a)

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Glaser, 2011[27]	Age	Vaccine Uptake	Influenza Vaccine	Influenza	NR	Got vaccine: 39.6 years; Did not: 37.1 years p<0.03
Glaser, 2011[27]	Gender, Male	Vaccine Uptake	Influenza Vaccine	Influenza	NR	Percent of events: 55.5%, p<0.0001
Glaser, 2011[27]	Gender, Female	Vaccine Uptake	Influenza Vaccine	Influenza	NR	Percent of events: 45.8%, p<0.0001
Glaser, 2011[27]	Race, Black	Vaccine Uptake	Influenza Vaccine	Influenza	NR	OR: 0.46
Gregory, 2021[30]	Age, 29-38 years	Vaccine Uptake	Received a COVID-19 vaccine	SARS-Cov-2	2584	aOR: 1.31 (95% CI: 0.99 to 1.72), Ref <28 years vs 29-38 years)
Gregory, 2021[30]	Age, 39-50 years	Vaccine Uptake	Received a COVID-19 vaccine	SARS-Cov-2	2584	aOR: 1.56 (95% CI: 1.17 to 2.08), Ref <28 years vs 39-50 years)
Gregory, 2021[30]	Age, >51 years	Vaccine Uptake	Received a COVID-19 vaccine	SARS-Cov-2	2584	aOR: 2.22 (95% CI: 1.64 to 3.01), Ref <28 years vs >51 years)
Gregory, 2021[30]	Gender, Male	Vaccine Uptake	Received a COVID-19 vaccine	SARS-Cov-2	2584	aOR: 1.26 (95% CI: 1.01 to 1.58), Ref Female vs Male)

aOR=adjusted odds ratio; CI=confidence interval; N=sample size; NR=not reported; OR=odds ratio

Evidence Table C-11. Results of studies investigating workforce practices to recognize and prevent infectious diseases by workforce characteristics of the EMS/911 workforce (Guiding Question 2/3b)

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Halbrook, 2021[28]	Not Applicable	Vaccine Uptake	COVID-19 Vaccine uptake	SARS-COV2	465	Percent with events: 87.5%
Halbrook, 2021[28]	Not Applicable	Vaccine Uptake	COVID-19 Vaccine uptake	SARS-COV2	858	Percent with events: 96%
Hubble, 2011[29]	Vaccinated	Vaccine Uptake	Influenza Vaccine	Influenza	107	Percent with events: 35.5%
Hubble, 2011[29]	Vaccinated	Vaccine Uptake	Influenza Vaccine	Influenza	70	Percent with events: 54.3%
Hubble, 2011[29]	Vaccinated	Vaccine Uptake	Influenza Vaccine	Influenza	424	Percent with events: 50%
Gregory, 2021[30]	Setting	Vaccine Uptake	Received a COVID-19 vaccine	SARS-Cov-2	2584	aOR: 1.36 (95% CI: 1.08 to 1.70), Ref Rural vs Urban/suburban)

aOR=adjusted odds ratio; CI=confidence interval; N=sample size; OR=odds ratio

Evidence Table C-12. Results of studies investigating workforce practices to recognize and prevent infectious diseases by practice characteristics of the EMS/911 workforce (Guiding Question 2/3c)

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Glaser, 2011[27]	Not Applicable	Vaccine Uptake	Influenza Vaccine	Influenza	9559	n with events: 5469
Glaser, 2011[27]	Not Applicable	Vaccine Uptake	Influenza Vaccine	Influenza	1053	n with events: 362
Harris, 2010[10]	Not Applicable	Practice	Recap needles, never	NR	NR	63 v. 48 OR: ref
Harris, 2010[10]	Not Applicable	Practice	Recap needles, seldom	NR	NR	9 v. 12 OR: 1.75 (95% CI: 0.68 to 4.49) Ref: Recap needles, never
Harris, 2010[10]	Not Applicable	Practice	Recap needles, most of the time	NR	NR	3 v. 22 OR: 9.63 (95% CI: 2.72 to 34) Ref: Recap needles, never
Harris, 2010[10]	Not Applicable	Practice	Recap needles, always	NR	NR	3 v. 23 OR: 10.1 (95% CI: 2.85 to 34.5) Ref: Recap needles, never
Harris, 2010[10]	Not Applicable	Practice	Dispose of needles in marked container, always	NR	NR	68 v. 92 OR: 0.96 (95% CI: 0.4 to 2.32) Ref: Dispose of needles in marked container, most of the time
Harris, 2010[10]	Not Applicable	Practice	Dispose of needles in marked container, most of the time	NR	NR	10 v. 13 OR: ref
Harris, 2010[10]	Not Applicable	Practice	Dispose of other contaminated material in marked container, always	NR	NR	51 v. 93 OR: 0.24 (95% CI: 0.11 to 0.52) Ref: Dispose of other contaminated material in marked container, most of the time, sometimes, and seldom
Harris, 2010[10]	Not Applicable	Practice	Dispose of other contaminated material in marked container, most of the time, sometimes, and seldom	NR	NR	27 v. 12 OR: ref
Harris, 2010[10]	Not Applicable	Practice	Wear gloves for all calls, always	NR	NR	69 v. 188 OR: 1.75 (95% CI: 0.81 to 3.79) Ref: Wear gloves for all calls, most of the time
Harris, 2010[10]	Not Applicable	Practice	Wear gloves for all calls, most of the time	NR	NR	9 v. 43 OR: ref
Harris, 2010[10]	Not Applicable	Practice	Use of face mask (TB), always	NR	NR	71 v. 151 OR: 4.86 (95% CI: 1.44 to 16.4) Ref: Use of face mask (TB), most of the time, seldom, and never
Harris, 2010[10]	Not Applicable	Practice	Use of face mask (TB), most of the time, seldom, and never	NR	NR	3 v. 31 OR: ref
Harris, 2010[10]	Not Applicable	Practice	Use of protective device for performing resuscitation, always	NR	NR	80 v. 209 OR: 17.3 (95% CI: 1.04 to 28.8) Ref: Use of protective device for performing resuscitation, most of the time and seldom

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Harris, 2010[10]	Not Applicable	Practice	Use of protective device for performing resuscitation, most of the time and seldom	NR	NR	0 v. 22 OR: ref
Hubble, 2011[29]	Vaccinated	Vaccine Uptake	Influenza Vaccine	Influenza	303	n with events: 161
Hubble, 2011[29]	Not Applicable	Vaccine Uptake	Influenza Vaccine	Influenza	566	n with events: 281
Grant, 2021[9]	Not Applicable	Practice	No PPE worn, pre-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 40.8%
Grant, 2021[9]	Not Applicable	Practice	No PPE worn, post-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 8.9%
Grant, 2021[9]	Not Applicable	Practice	Gloves worn, pre-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 48%
Grant, 2021[9]	Not Applicable	Practice	Gloves worn, post-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 53.2%
Grant, 2021[9]	Not Applicable	Practice	Surgical mask worn, pre-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 13%
Grant, 2021[9]	Not Applicable	Practice	Surgical mask worn, post-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 50.8%
Grant, 2021[9]	Not Applicable	Practice	N-95 mask worn, pre-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 13%
Grant, 2021[9]	Not Applicable	Practice	N-95 mask worn, post-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 49%
Grant, 2021[9]	Not Applicable	Practice	Eye protection worn, pre-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 13%
Grant, 2021[9]	Not Applicable	Practice	Eye protection worn, post-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 30.1%
Grant, 2021[9]	Not Applicable	Practice	Gown worn, pre-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 2%
Grant, 2021[9]	Not Applicable	Practice	Gown worn, post-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 7.9%
Grant, 2021[9]	Not Applicable	Practice	No PPE worn, pre-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 4.7%
Grant, 2021[9]	Not Applicable	Practice	No PPE worn, post-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 3.8%
Grant, 2021[9]	Not Applicable	Practice	Gloves worn, pre-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 91.1%
Grant, 2021[9]	Not Applicable	Practice	Gloves worn, post-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 88%
Grant, 2021[9]	Not Applicable	Practice	Surgical mask worn, pre-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 10.1%

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Grant, 2021[9]	Not Applicable	Practice	Surgical mask worn, post-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 23%
Grant, 2021[9]	Not Applicable	Practice	N-95 mask worn, pre-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 27%
Grant, 2021[9]	Not Applicable	Practice	N-95 mask worn, post-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 85%
Grant, 2021[9]	Not Applicable	Practice	Eye protection worn, pre-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 30.1%
Grant, 2021[9]	Not Applicable	Practice	Eye protection worn, post-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 65%
Grant, 2021[9]	Not Applicable	Practice	Gown worn, pre-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 10.1%
Grant, 2021[9]	Not Applicable	Practice	Gown worn, post-shelter in place order (self reported)	SARS-Cov-2	1231	Percent with events: 28.9%
Grant, 2021[9]	Not Applicable	Practice	No PPE worn (self reported)	SARS-Cov-2	526	n with events: 6
Grant, 2021[9]	Not Applicable	Practice	Surgical or N-95 mask worn (self reported)	SARS-Cov-2	526	Percent with events: 91.4%
Grant, 2021[9]	Not Applicable	Practice	N-95 mask worn (self reported)	SARS-Cov-2	526	Percent with events: 65%
Grant, 2021[9]	Not Applicable	Practice	Eye protection worn (self reported)	SARS-Cov-2	526	Percent with events: 81.5%
Grant, 2021[9]	Not Applicable	Practice	Gown worn (self reported)	SARS-Cov-2	526	Percent with events: 57.9%
Gregory, 2021[30]	Not Applicable	Vaccine Uptake	Received a COVID-19 vaccine	SARS-Cov-2	2584	aOR: 1.03 (95% CI: 0.73 to 1.46), Ref HS/GED vs Some college)
Gregory, 2021[30]	Not Applicable	Vaccine Uptake	Received a COVID-19 vaccine	SARS-Cov-2	2584	aOR: 1.26 (95% CI: 0.87 to 1.84), Ref HS/GED vs Associates)
Gregory, 2021[30]	Not Applicable	Vaccine Uptake	Received a COVID-19 vaccine	SARS-Cov-2	2584	aOR: 1.72 (95% CI: 1.19 to 2.47), Ref HS/GED vs >=Bachelors)
Gregory, 2021[30]	Not Applicable	Vaccine Uptake	Received a COVID-19 vaccine	SARS-Cov-2	2584	aOR: 1.31 (95% CI: 0.97 to 1.76), Ref Fire vs Private)
Gregory, 2021[30]	Not Applicable	Vaccine Uptake	Received a COVID-19 vaccine	SARS-Cov-2	2584	aOR: 1.15 (95% CI: 0.82 to 1.62), Ref Fire vs Government non-fire)
Gregory, 2021[30]	Not Applicable	Vaccine Uptake	Received a COVID-19 vaccine	SARS-Cov-2	2584	aOR: 1.53 (95% CI: 1.04 to 2.24), Ref Fire vs Government non-fire)
Gregory, 2021[30]	Not Applicable	Vaccine Uptake	Received a COVID-19 vaccine	SARS-Cov-2	2584	aOR: 1.16 (95% CI: 0.80 to 1.69), Ref Fire vs Other)
Rebmann, 2012[32]	Experiment	Vaccine Uptake	Vaccine uptake in H1N1 vaccine	H1N1	14	n with events: 14

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Rebmann, 2012[32]	Control	Vaccine Uptake	Vaccine uptake in H1N1 vaccine	H1N1	251	Percent with events: 66.8%
Rebmann, 2012[32]	Not Applicable	Vaccine Uptake	Vaccine uptake in influenza vaccine	Influenza	7	n with events: 7
Rebmann, 2012[32]	Not Applicable	Vaccine Uptake	Vaccine uptake in influenza vaccine	Influenza	258	Percent with events: 75.6%

CI=confidence interval; HS=high school; GED=Graduate Equivalency Degree; n=number of participants; N=sample size; OR=odds ratio; Ref=reference; TB=tuberculosis

Evidence Table C-13. Results of studies reporting effectiveness on how workforce practices recognize and prevent infectious diseases of EMS/911 workforces (Guiding Question 2/3d)

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Brown, 2021[26]	Not Applicable	Incidence	PCR test	SARS-COV2	NR	1.17/10,000 person days IRR: 1.64 (95% CI: 0.22 to 12.26) Ref: Cohort 3 (COVID-19 encounter, NO AGP procedure, NOT during infectious window)
Brown, 2021[26]	Not Applicable	Incidence	PCR test	SARS-COV2	NR	0/10,000 person days IRR: 0 (95% CI: 0.0 to 1.5) Ref: Cohort 3 (COVID-19 encounter, NO AGP procedure, NOT during infectious window)
Brown, 2021[26]	Not Applicable	Incidence	PCR test	SARS-COV2	NR	0.71/10,000 person days Ref
Brown, 2021[26]	Not Applicable	Incidence	PCR test	SARS-COV2	NR	0.46/10,000 person days IRR: 0.64 (95% CI: 0.30 to 1.36) Ref: Cohort 3 (COVID-19 encounter, NO AGP procedure, NOT during infectious window)
Harris, 2010[10]	Not Applicable	Incidence	Needlestick	Any type of blood-borne exposure	110	n with events: 9 (%) OR: 1.49 (95% CI, 0.44 to 5.04) Ref: Recap needles, seldom, most of the time, and always
Harris, 2010[10]	Not Applicable	Incidence	Needlestick	Any type of blood-borne exposure	71	n with events: 4
Harris, 2010[10]	Not Applicable	Incidence	Needlestick	Any type of blood-borne exposure	158	n with events: 12 (%) OR: 1.8 (95% CI, 0.22 to 14.6) Ref: Recap needles, seldom, most of the time, and always
Harris, 2010[10]	Not Applicable	Incidence	Needlestick	Any type of blood-borne exposure	23	n with events: 1
Harris, 2010[10]	Not Applicable	Incidence	Needlestick	Any type of blood-borne exposure	142	n with events: 6 (%) OR: 0.2 (95% CI, 0.06 to 0.64) Ref: Recap needles, seldom, most of the time, and always
Harris, 2010[10]	Not Applicable	Incidence	Needlestick	Any type of blood-borne exposure	39	n with events: 7

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Harris, 2010[10]	Not Applicable	Incidence	Needlestick	Any type of blood-borne exposure	143	n with events: 12 (%) OR: 2.95 (95% CI, 0.17 to 52.2) Ref: Recap needles, seldom, most of the time, and always
Harris, 2010[10]	Not Applicable	Incidence	Needlestick	Any type of blood-borne exposure	15	n with events: 0
Harris, 2010[10]	Not Applicable	Incidence	Needlestick	Any type of blood-borne exposure	174	n with events: 14 (%) OR: 1.72 (95% CI, 0.09 to 31.0) Ref: Recap needles, seldom, most of the time, and always
Harris, 2010[10]	Not Applicable	Incidence	Needlestick	Any type of blood-borne exposure	9	n with events: 0
Harris, 2010[10]	Not Applicable	Incidence	Needlestick	Any type of blood-borne exposure	153	n with events: 12 (%) OR: 1.11 (95% CI, 0.23 to 5.24) Ref: Recap needles, seldom, most of the time, and always
Harris, 2010[10]	Not Applicable	Incidence	Needlestick	Any type of blood-borne exposure	28	n with events: 25
Miramonti, 2013[31]	Not Applicable	Prevalence	Nasal colonization of MRSA	MRSA	152	% with events: 5.3%
Miramonti, 2013[31]	Not Applicable	Prevalence	Nasal colonization of MRSA	MRSA	134	% with events: 4.5%
Miramonti, 2013[31]	Not Applicable	Prevalence	Nasal colonization of MRSA	MRSA	89	% with events: 5.6%
Miramonti, 2013[31]	Not Applicable	Prevalence	Nasal colonization of MRSA	MRSA	45	% with events: 2.2%
Newberry, 2021[16]	Not Applicable	Prevalence	IgG seroprevalence test	SARS-COV2	227	n with events: 3 (1.3%) Ref
Newberry, 2021[16]	Not Applicable	Prevalence	IgG seroprevalence test	SARS-COV2	90	n with events: 5 (5.6%) RR: 4.2 (95% CI: 1.03 to 17.22) Ref: Full PPE during exposure
Newberry, 2021[16]	Not Applicable	Prevalence	IgG seroprevalence test	SARS-COV2	18	n with events: 2 (11.1%) RR: 8.41 (95% CI: 1.5 to 47.12) Ref: Full PPE during exposure
Newberry, 2021[16]	Not Applicable	Incidence	PCR test	SARS-COV2	227	n with events: 3 (1.3%) Ref

Author, Year	Subgroup	Outcome Category	Outcome	Infectious Disease	N	Results
Newberry, 2021[16]	Not Applicable	Incidence	PCR test	SARS-COV2	90	n with events: 2 (2.2%) RR: 1.68 (95% CI: 0.29 to 9.9) Ref: Full PPE during exposure
Newberry, 2021[16]	Not Applicable	Incidence	PCR test	SARS-COV2	18	n with events: 0 (0%)
Orellana, 2016[17]	Handwashing	Prevalence	Nasal colonization of MRSA	MRSA	NR	OR: Daily hand hygiene frequency: 3.41 (less frequent) p = 0.036
Orellana, 2016[17]	Handwashing	Prevalence	Nasal colonization of MRSA	MRSA	NR	OR: Frequency of hand hygiene after glove use: 5.18 (less frequent) p = 0.0065

AGP= aerosol generating procedures; CI=confidence interval; IgG= Immunoglobulin G; IRR=incidence rate ratio; MRSA=Methicillin-resistant Staphylococcus aureus; n=number of participants; N=sample size; OR=odds ratio; PCR=polymerase chain reaction; PPE=personal protective equipment; RR=risk ratio

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Appendix D. Gray Literature Search Results

Table D-1. Summary of the gray literature search

Organization	Site	Date of Search	# of Results	# Included
Assistant Secretary for Preparedness and Response	https://www.phe.gov/about/aspr/Pages/default.aspx	11/18/2021	244	3
Centers for Disease Control and Prevention	www.cdc.gov	11/18/2021	41	3
National Institutes of Health	https://www.nih.gov	11/22/2021	920	0
Infectious Diseases Society of America	https://www.idsociety.org/	11/22/2021	229	0
Society for Healthcare Epidemiology of America	https://shea-online.org/search/	12/9/2021	46	0
Association for Professionals in Infection Control and Epidemiology	https://apic.org/	12/10/2021	93	2