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

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

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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.

The list of Key Informants who provided input to this report follows:

[Will be provided in final report]

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 non-financial conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential non-financial conflicts of interest identified.

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

Structured Abstract

Objectives. To summarize current evidence on exposures to infectious pathogens in the emergency medical services (EMS)/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 emergency medical technicians, 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 October 2021 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/911 workforce.

Results. Eighteen observational studies reported on the epidemiology of infections in the EMS/911 workforce and 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. Providers certified in Advanced Life Support have a high risk for blood and fluid exposure, and EMS workers had a higher risk of hospitalization or death from SARS-CoV-2 than firefighters. Nine 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/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/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 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/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/911 infectious disease issues would be strengthened by 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 workforce. EMS/911 workers have contact with the public and 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 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 workers. In addition, first responders, including telecommunicators, are often in a communal work environment with shared eating and sleeping spaces. EMS workers 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/911 workforce and on interventions or practices for preventing, recognizing, and controlling occupationally-acquired infectious diseases in that workforce. 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/911 workforce?
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/911 workforce 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/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/911 workforce?

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 October 7, 2021. We included studies of the EMS/911 workforce conducted in the United States. We included studies that evaluated the effectiveness of an EMS/911 workforce practice that had a comparison group. We did not include studies that evaluated fire fighters or police personnel whose roles were not primarily related to medical care.

Results

In the published literature, we found 24 studies that met our inclusion criteria. Eighteen were observational studies examining the characteristics, incidence, prevalence, and/or severity of occupationally-acquired infectious diseases and related exposures in the EMS/911 workforce. Nine observational studies reported on the characteristics and effectiveness of infection prevention and control (IPC) practices in the EMS/911 workforce. 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/911 workforce 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/911 workforce, 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 firefighters, 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 in Advanced Life Support (ALS) had an increased risk of blood exposure, fluids exposure, and needlesticks when compared to workers certified 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 nine observational studies on characteristics and effectiveness of IPC practices in the EMS/911 workforce, 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 while another study demonstrated that aerosol-generating procedures (AGPs), even with full PPE, were associated with SARS-CoV-2 diagnosis. However, only one EMS provider 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 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/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/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/911 workforce. A moderate amount of evidence also exists on the characteristics and effectiveness of IPC practices in the EMS/911 workforce, 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/911 workforce. 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 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 workers often have contact with multiple patients per day, in home, ambulance, and hospital environments, while 911 telecommunicators have varying degrees of contact with EMS responders. 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 workers and 911 telecommunicators.[1] For the purposes of this technical brief, the EMS/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] In Nevada, EMS workers wore gloves during 56% of activations, washed hands after 27% of patient encounters, and disinfected equipment 31% 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% 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 workers via blood-borne exposure. EMS workers 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 vis blood-borne exposure, and many EMS providers are required to be vaccinated against it. Yet, studies have shown that EMS workers frequently do not follow recommendations for minimizing the risk of needle stick injuries.[8]

The EMS/911 workforce also is 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 workers (including 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 workers 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 providers, 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 requested this technical brief for the purpose of summarizing the evidence on: exposures to and incidence/prevalence/severity of infectious diseases in the EMS/911 workforce; and interventions for preventing, recognizing, and controlling occupationally-acquired infectious diseases in the EMS/911 workforce. This brief should be useful to policy makers, researchers, and managers in the EMS field in making decisions about how to minimize the risk of infectious diseases in the EMS/911 workforce. The technical brief should help to identify future research needs by identifying research questions that have not been addressed in the literature.

Guiding Questions

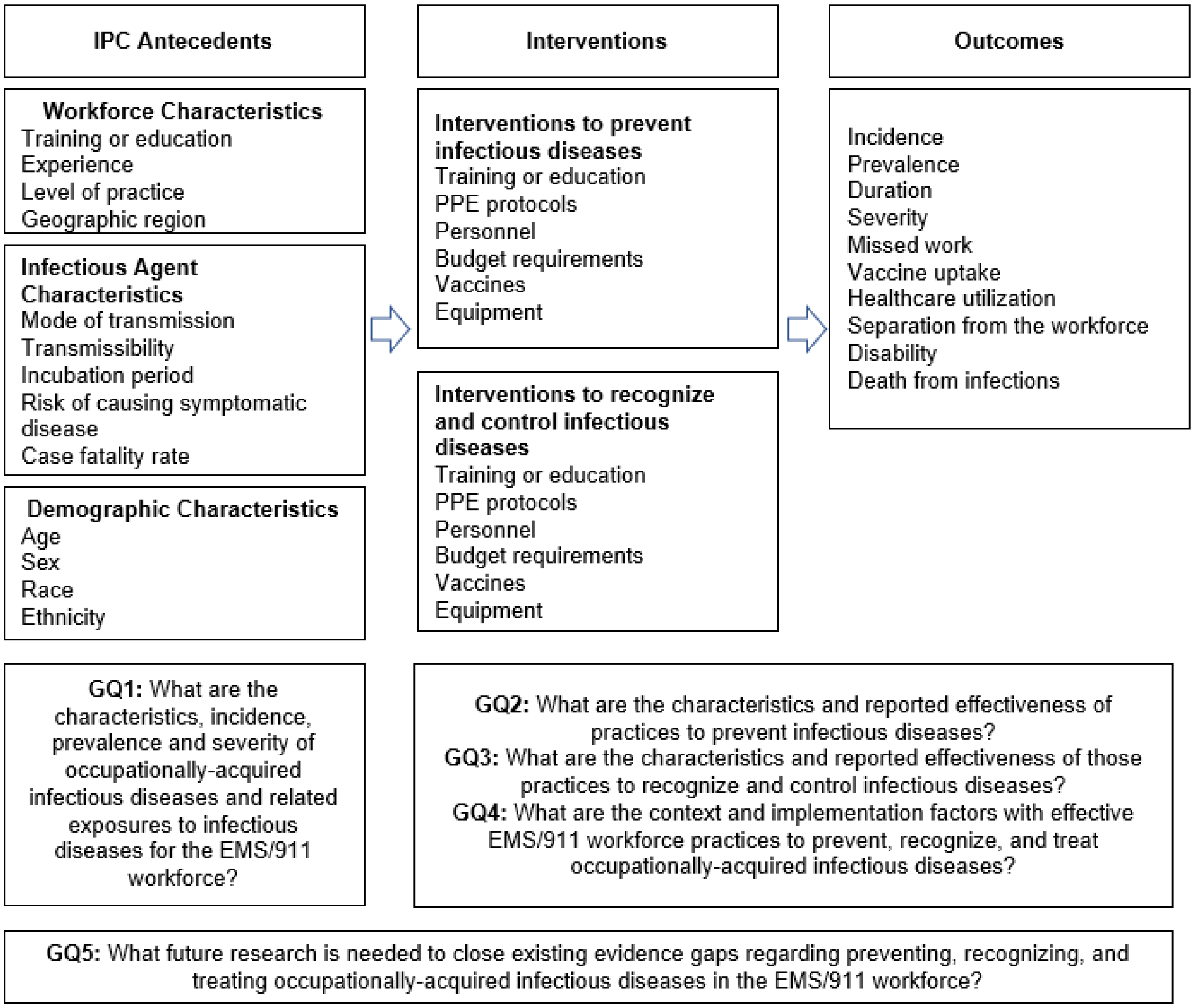
1. What are the **characteristics, incidence, prevalence, and severity of occupationally-acquired infectious diseases and related exposures** for the EMS/911 workforce?
    a. How do the incidence, prevalence, and severity of infectious diseases and related exposures vary by *demographic characteristics* (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 etc.)?
    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/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/911 workforce 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/911 workforce?
    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/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/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/911 workforce?

For Guiding Question (GQ) 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 workers. The EMS workforce includes the responding health care 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/911 workers



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

Methods

Discussions with Key Informants

We recruited a panel of external experts on emergency medical technicians, state-level EMS leadership, and programs relevant to EMS personnel. We also engaged representatives of professional societies in infectious diseases and emergency medicine: National Registry of Emergency Medicine Technicians, 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, National Institute for Occupational Safety and Health, and the Centers for Disease Control and Prevention (CDC). The external experts provided advice on how we answered each of our 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 October 7, 2021. We limited the search to the last 15 years because older studies have little relevance to modern IPC practices. 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). We included studies if they provided original data on the GQs.

Table 1. Inclusion and exclusion criteria

	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*	• Fire fighters 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
Comparison	• Any comparison group (for studies that evaluate the effectiveness of an EMS/911 workforce practice)	• Studies without a comparison group (for studies that evaluate the effectiveness of an EMS/911 workforce practice)
Outcomes	• Incidence	• NA

	• Prevalence • Duration • Severity • Missed work • Healthcare utilization • Separation from the workforce • Disability • Death from infections	
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; 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 or 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 IPC protocols pertinent to the EMS/911 workforce 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.

Results

We first present the results from the Key Informant interviews. We then present the results of the published literature search, organized by 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 EMS/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 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 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/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/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 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 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

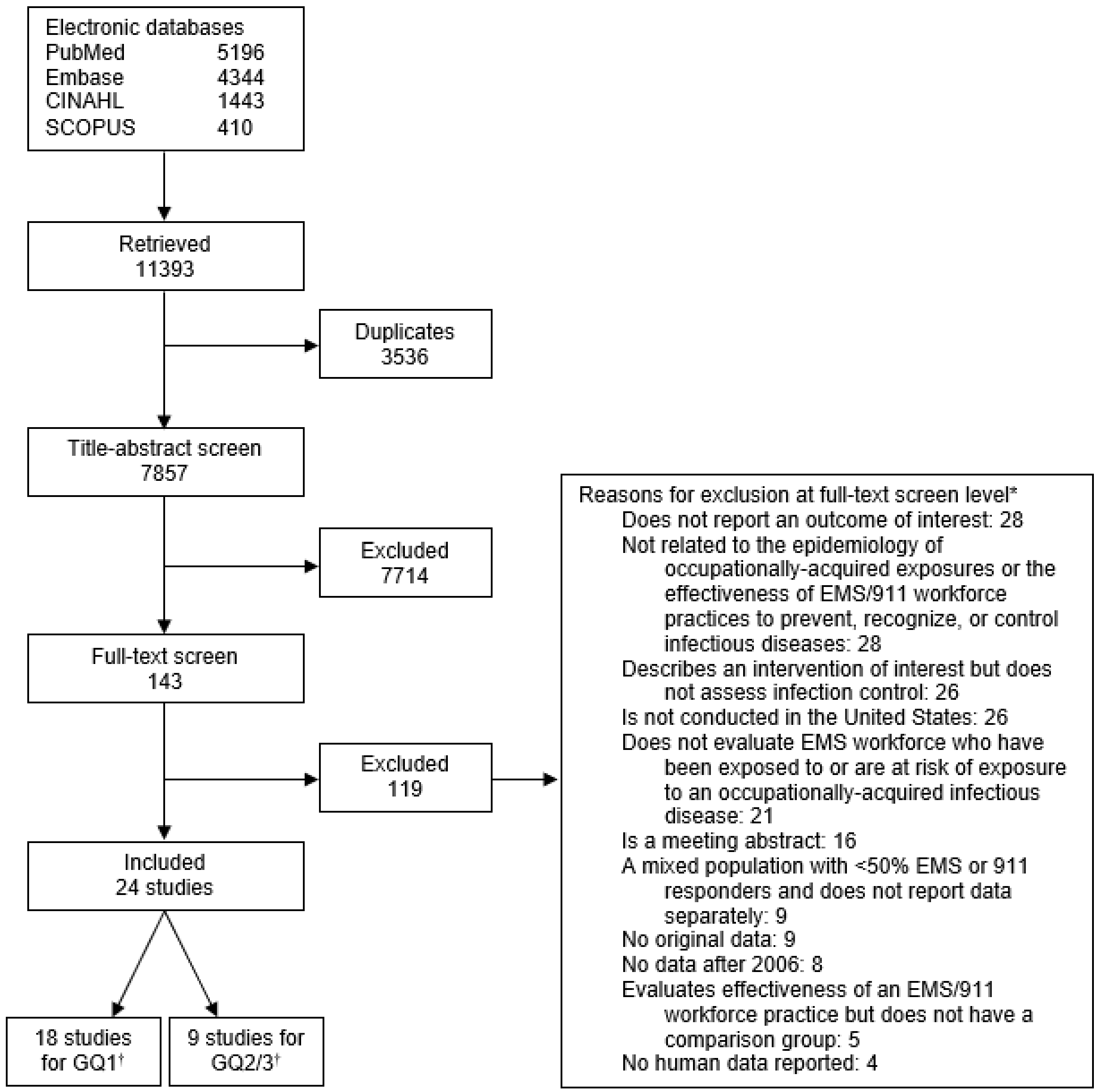
The Key Informants reported that studies on this topic used observational methods with serious limitations. Although they agreed with looking for studies of interventions using a comparison group, they noted that studies using the local community as a comparison group would require careful consideration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

Results of the Published Literature Search

We retrieved 7857 unique citations (Figure 2). After screening abstracts and full-text, we included 24 studies (N=88,658 participants).[8, 11-33] The list of excluded articles is in Appendix B. Evidence tables are provided in Appendix C.

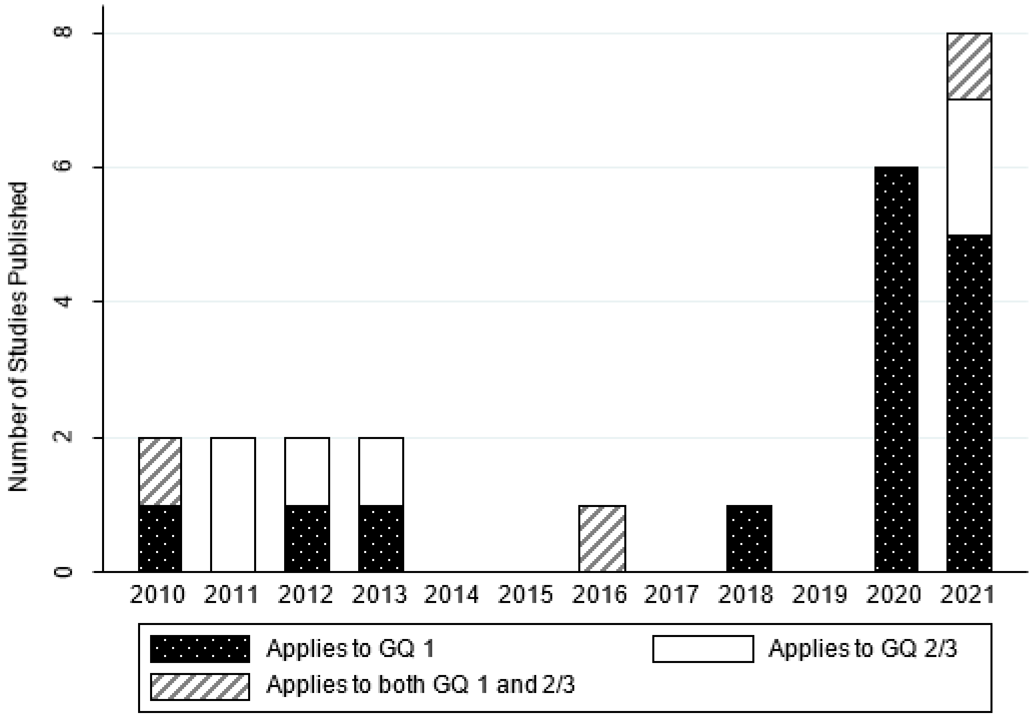
Fifteen studies applied to GQ 1 only,[11-17, 19, 20, 23, 25, 29, 30, 32, 33] six studies applied to GQ 2/3 only,[18, 21, 22, 24, 27, 31] and three studies applied to both GQ 1 and GQ 2/3.[8, 26, 28] Fourteen studies were published in 2020 or later (Figure 3). Many of the studies published in 2020 or later assessed the prevalence of COVID-19.

Figure 2. Results of literature search



* Articles could be excluded for more than one reason.
† Three 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/911 Workforce

Characteristics of Studies

Of the 18 studies included for GQ 1, 14 were cross-sectional studies,[8, 11, 13-16, 20, 23, 25, 26, 28, 30, 32, 33] three were retrospective cohort studies,[12, 17, 19] and one was a prospective cohort study.[29] The majority, 10, were set in urban areas,[13, 14, 17, 19, 20, 28-30, 32, 33] with the remaining conducted in multiple settings (six studies)[8, 11, 12, 23, 25, 26] and unclear settings (two studies).[15, 16] 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] three in the West,[12, 28, 30] one in the Southwest,[11] 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 on GQ 1 had weak study designs, given that 14 of the 18 studies were cross-sectional. As shown in Table 2, 89% of the studies on GQ 1 were somewhat or very likely to include individuals likely to be representative of the target population. However, only half of the studies reported that 80% 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 three did not, and two 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/911 workforce

	Cross-sectional studies n (%) N = 14	Prospective cohorts n (%) N = 1	Retrospective cohorts n (%) N = 3
Q1. Are the targeted individuals likely to be representative of the target population?			
Very likely	10 (71.4%)	1 (100%)	3 (100%)
Somewhat likely	2 (14.3%)	0	0
Not likely	1 (7.1%)	0	0
Can't tell	1 (7.1%)	0	0
Q2. What percentage of targeted individuals agreed to participate?			
80-100% agreement	5 (35.7%)	1 (100%)	3 (100%)
60-79% agreement	1 (7.1%)	0	0
Less than 60% agreement	3 (21.4%)	0	0
Can't tell	5 (35.7%)	0	0
Q3. Did the study report any data on the validity of the tests of interest			
Yes	11 (78.6%)	0	2 (66.7%)
No/can't tell	1 (7.1%)	1 (100%)	1 (33.3%)
Self-report	2 (14.3%)	0	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/911 workforce reported in all studies that met our inclusion criteria. Most of the studies reported prevalence rates, most frequently focusing on SARS-CoV2. Few studies reported incidence rates, and no incidence rates were reported for infections other than SARS-CoV2. 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-CoV2.

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

Author, Year	Outcome Category	Infectious Disease	Outcome	n/N	% with Outcome (95% CI)*
Webber, 2018[34]	Prevalence	Hepatitis C	Positive tests from 2000-2012	151/11374	1.3 (1.1, 1.6)
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)
Orellana, 2016[26]	Prevalence	MRSA	Nasal colonization of MRSA	13/280	4.6 (2.7, 7.8)
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)
Firew, 2020[23]	Prevalence	SARS-CoV-2	Self-report COVID 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)
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)
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)
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)
Weiden, 2021[32]	Prevalence	SARS-CoV-2	Prevalence of COVID	5175/14290	36.2 (35.4, 37.0)
Murphy, 2020[12]	Incidence	SARS-CoV-2	Diagnosis of COVID 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)
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)
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)
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)
Halbrook, 2021[31]	Healthcare utilization	SARS-CoV-2	COVID-19 vaccine uptake	407/465	87.5 (84.2, 90.2)
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)
Weiden, 2021[32]	Healthcare utilization	SARS-CoV-2	Hospitalization due to COVID	62/14290	0.4 (0.3, 0.6)

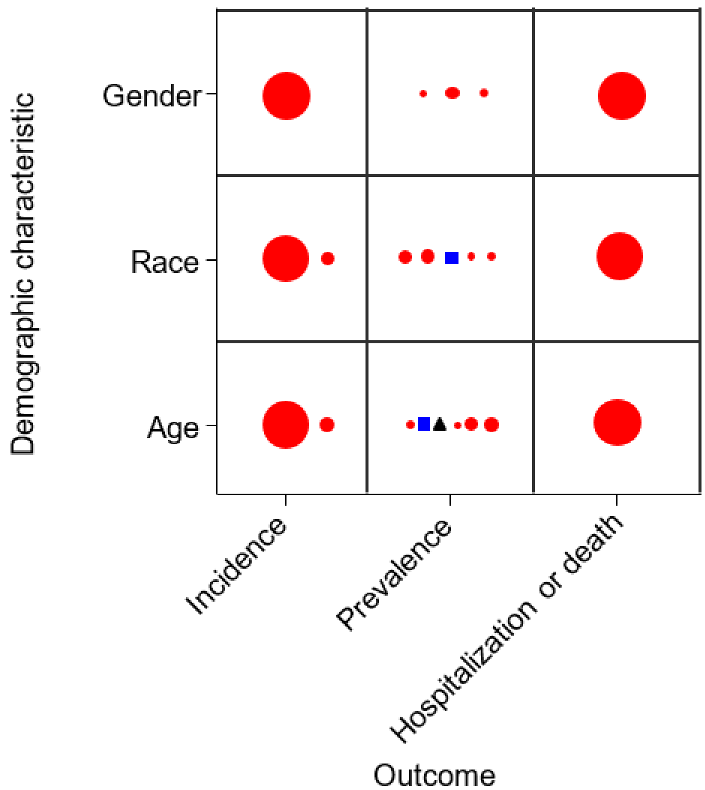
CI=confidence interval; COVID-19=coronavirus disease 2019; EMS=emergency medical services; MRSA=methicillin-resistant Staphylococcus aureus; n/N = number of people experiencing an event/number of people; SARS-CoV-2=severe acute respiratory syndrome coronavirus 2
* Confidence intervals were computed using 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/911 workforce by demographic characteristics

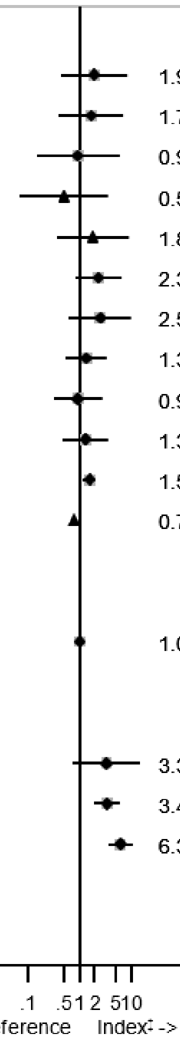


Each study is represented by a shape. The size of the shape is proportional to the sample size. Red circles represent studies of SARS-CoV-2 exposures; black triangles represent studies of MRSA exposures; blue squares represent studies of hepatitis C exposures. The placement of each shape within each 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/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/911 workforce based on age*†

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



CI=confidence interval; EMS=emergency medical services; MRSA=methicillin-resistant Staphylococcus aureus; NR=not reported; PCR=polymerase chain reaction; RR=rate ratio; SARS-CoV-2=severe acute respiratory syndrome coronavirus 2

*Incidence outcomes designated with triangles.

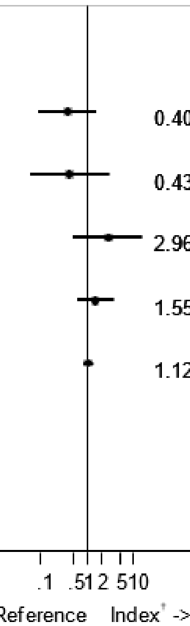
† Tarabichi 2021 is not included in the figure because it reported the mean age among those who were seropositive for SARS-CoV-2 (50.1 years) and the mean age among those who were negative (43.8 years).[13]

‡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 crossed one.

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

Author, Year	Index Group	Reference Group	Outcome Type	Outcome	n/N Comparison	n/N Reference	RR (95% CI)
SARS-COV2							
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)

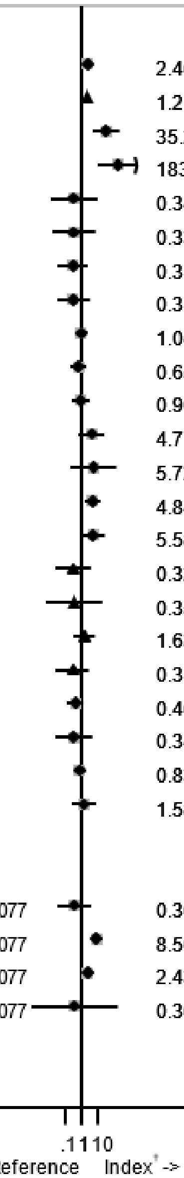


CI=confidence interval; ELISA=enzyme-linked immunosorbent assay; EMS=emergency medical services; NR=not reported; RR=rate ratio; RT-PCR=real-time polymerase chain reaction; SARS-CoV-2=severe acute respiratory syndrome coronavirus 2
*Incidence outcomes designated with triangles.
† Numbers less than 1 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/911 workforce based on race

Author, Year	Index Group	Reference Group	Outcome Type	Outcome	n/N Comparison	n/N Reference	RR (95% CI)
SARS-COV2							
Weiden, 2021	Non-white	White	Healthcare Utilization	Hospitalization or death	NR	NR	2.46 (1.34, 4.51)
Weiden, 2021	Non-white	White	Incidence	Positive diagnosis	NR	NR	1.21 (1.06, 1.38)
Tarabichi, 2021	Black, Non-Hisp	White, Non-Hisp	Prevalence	IgG & IgM ELISA seroprevalence	5/21	8/200	35.23 (5.24, 237.07)
Tarabichi, 2021	Other, Hisp	White, Non-Hisp	Prevalence	IgG & IgM ELISA seroprevalence	3/10	8/200	183.66 (10.69, 3155.46)
Tarabichi, 2021	Other	White, Non-Hisp	Prevalence	IgG & IgM ELISA seroprevalence	0/10	8/200	0.34 (0.01, 9.24)
Tarabichi, 2021	White, Hisp	White, Non-Hisp	Prevalence	IgG & IgM ELISA seroprevalence	0/12	8/200	0.33 (0.02, 7.05)
Tarabichi, 2021	White, Other	White, Non-Hisp	Prevalence	IgG & IgM ELISA seroprevalence	0/27	8/200	0.31 (0.04, 2.73)
Caban-Martinez, 2020	Black	White	Prevalence	IgG seroprevalence test	0/9	15/154	0.31 (0.03, 3.19)
Caban-Martinez, 2020	Hisp	White	Prevalence	IgG seroprevalence test	15/149	15/154	1.04 (0.49, 2.20)
Caban-Martinez, 2020	Non-Hisp	White	Prevalence	IgG seroprevalence test	3/48	15/154	0.65 (0.21, 2.03)
Caban-Martinez, 2020	Other	White	Prevalence	IgG seroprevalence test	3/34	15/154	0.90 (0.26, 3.17)
Newberry, 2021	Asian	White	Prevalence	IgG seroprevalence test	3/78	8/594	4.71 (0.73, 30.23)
Newberry, 2021	Black	White	Prevalence	IgG seroprevalence test	1/26	8/594	5.72 (0.22, 152.17)
Newberry, 2021	Hisp	White	Prevalence	IgG seroprevalence test	9/192	8/594	4.84 (1.58, 14.80)
Newberry, 2021	Other	White	Prevalence	IgG seroprevalence test	4/93	8/594	5.58 (1.05, 29.55)
Newberry, 2021	Asian	White	Incidence	PCR test	0/78	6/594	0.32 (0.03, 3.93)
Newberry, 2021	Black	White	Incidence	PCR test	0/26	6/594	0.35 (0.01, 19.22)
Newberry, 2021	Hisp	White	Incidence	PCR test	3/192	6/594	1.63 (0.35, 7.51)
Newberry, 2021	Other	White	Incidence	PCR test	0/93	6/594	0.31 (0.03, 3.26)
Vieira, 2021	Asian	White	Prevalence	IgG seroprevalence test	1/60	46/827	0.46 (0.14, 1.48)
Vieira, 2021	Black	White	Prevalence	IgG seroprevalence test	0/11	46/827	0.34 (0.03, 4.66)
Vieira, 2021	Hisp	White	Prevalence	IgG seroprevalence test	8/174	46/827	0.83 (0.40, 1.71)
Vieira, 2021	Other	White	Prevalence	IgG seroprevalence test	2/25	46/827	1.58 (0.28, 8.87)
Hepatitis C							
Webber, 2018	Asian	White	Prevalence	Positive test from 2000-2012	0/60	115/10077	0.36 (0.03, 3.97)
Webber, 2018	Black	White	Prevalence	Positive test from 2000-2012	21/546	115/10077	8.50 (3.95, 18.28)
Webber, 2018	Hisp	White	Prevalence	Positive test from 2000-2012	15/682	115/10077	2.43 (1.19, 4.93)
Webber, 2018	Other	White	Prevalence	Positive test from 2000-2012	0/9	115/10077	0.36 (0.00, 171.35)



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

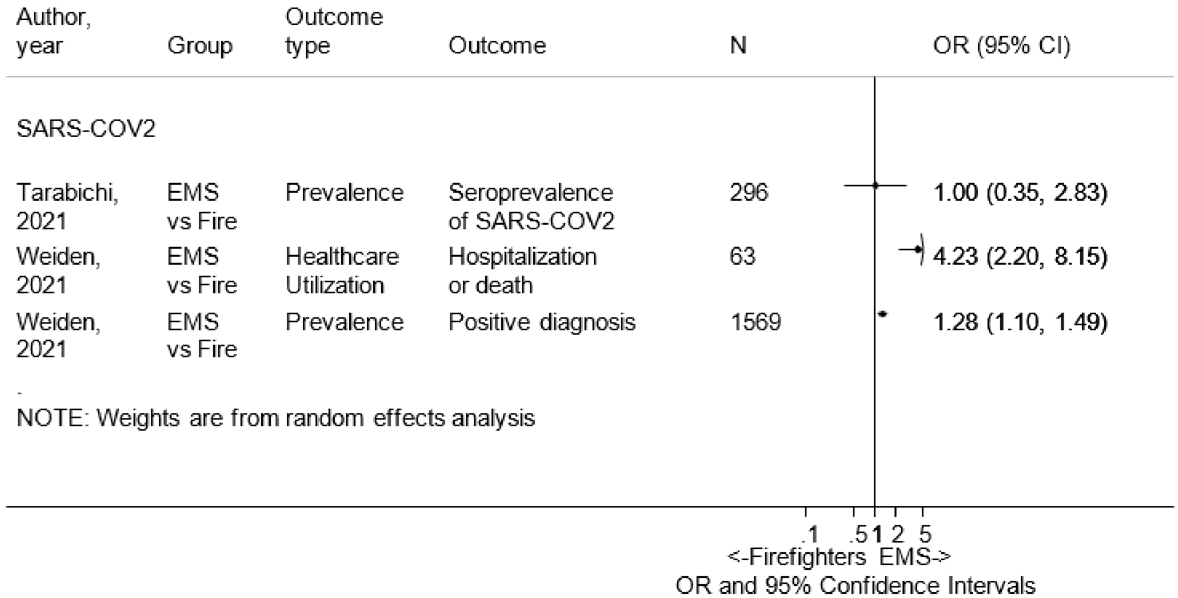
*Incidence outcomes designated with triangles.

† 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

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

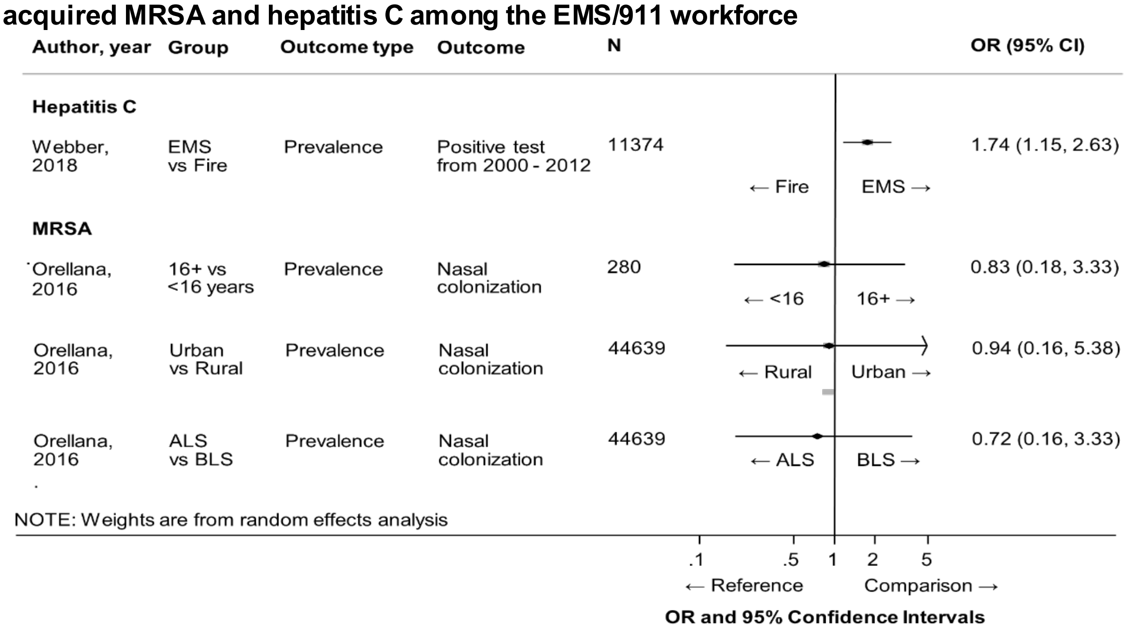
Figure 8. Differences in prevalence and healthcare utilization of occupationally-acquired SARS-CoV-2 among the EMS/911 workforce



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 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]

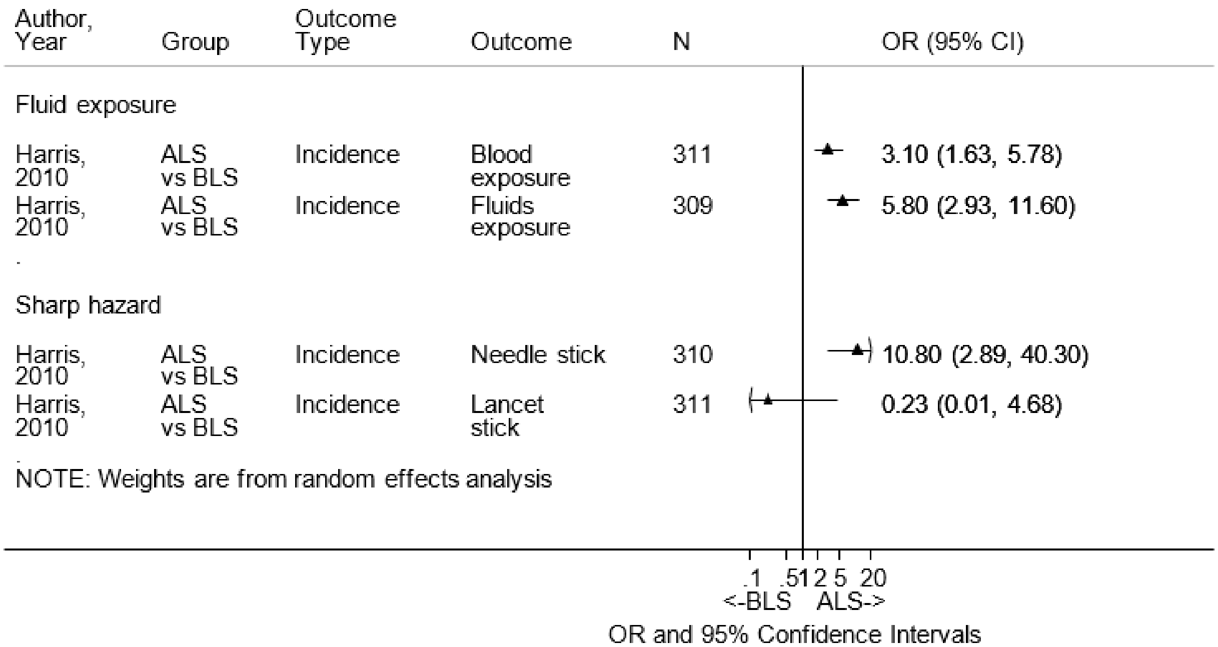
Figure 9. Differences in incidence, prevalence, and healthcare utilization of occupationally-acquired MRSA and hepatitis C among the EMS/911 workforce



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/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/911 Workforce Practices to Prevent, Recognize and Control Infectious Diseases

Characteristics of Studies

Nine studies were identified as being relevant to GQ 2/3.[8, 18, 21, 22, 24, 26-28, 31] All studies were observational studies with a concurrent comparison group; seven studies were prospective cohorts[8, 21, 22, 26-28, 31] and two were retrospective cohorts.[18, 24] Five were in urban settings[22, 24, 27, 28, 31] and four were in multiple settings.[8, 18, 21, 26] 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. Six studies included both EMS workers and firefighters involved in medical care[8, 18, 22, 24, 28, 31] and three studies only focused on EMS workers.[21, 26, 27] The total study sample size ranged from 186 to 10,612 EMS/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 9 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 33% of the studies reported that 80% or more of workers selected to participate ultimately agreed to participate (see Table 4). Regarding potential selection bias, only 2 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/911 workforce practices to prevent, recognize, and control infectious diseases

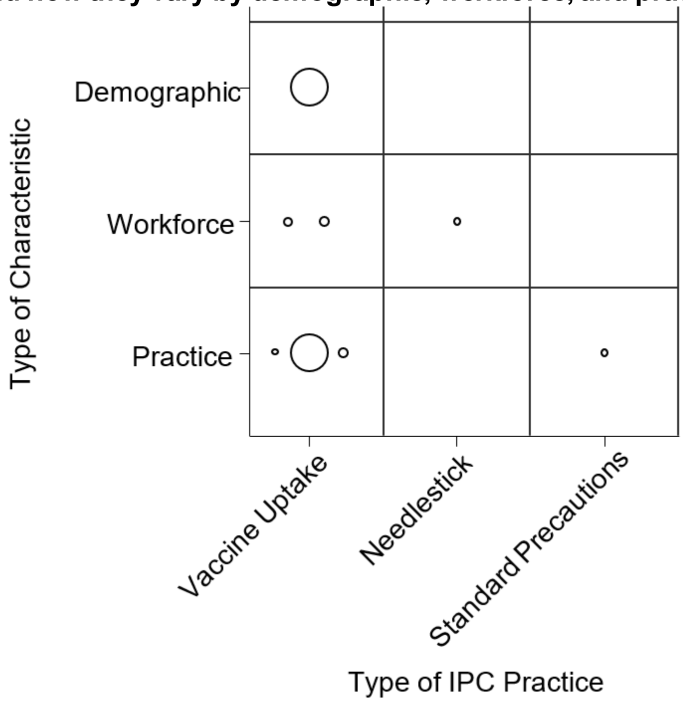
	N (%) **N=9**
Q1. Are the individuals selected to participate in the study likely to be representative of the target population?	
Very likely	5 (55.6%)
Somewhat likely	4 (44.4%)
Q2. What percentage of selected individuals agreed to participate?	
80-100% agreement	3 (33.3%)
60-79% agreement	2 (22.2%)
Less than 60% agreement	1 (11.1%)
Can't tell	3 (33.3%)
Q3. Were there important differences between groups prior to the intervention?	
Yes	1 (11.1%)
No	2 (22.2%)
Can't tell	6 (66.7%)

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/911 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

GQ2/3a: Differences by Demographic Characteristics

One study reported on how an IPC practice varied by demographic characteristics.[24] 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.

GQ2/3b: Differences by Workforce Characteristics

Three studies addressed how IPC practices varied by workforce characteristics.[8, 21, 31] Two studies evaluated vaccine uptake.[21, 31] 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]

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 EMS workers, who are more likely to be volunteers, were also at lower risk for needle stick than ALS-certified workers. BLS-certified 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 EMS workers.[8] Specifically, ALS-certified EMS workers were more likely than BLS-certified 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 EMS workers were also more likely to always recap needles (unadjusted OR 10.1; 95% CI 2.85 to 34.5), despite CDC and Occupational Health and Safety (OSHA) recommendations to not recap needles.

GQ2/3c: Differences by Practice Characteristics

Three studies examined the association of vaccine uptake with practice characteristics, including the incorporation of training into practice, implementation of a vaccine clinic, or presence of a mandatory vaccine policy.[21, 22, 24] No studies directly examined how use of IPC practices varied by available budget to support the practice.

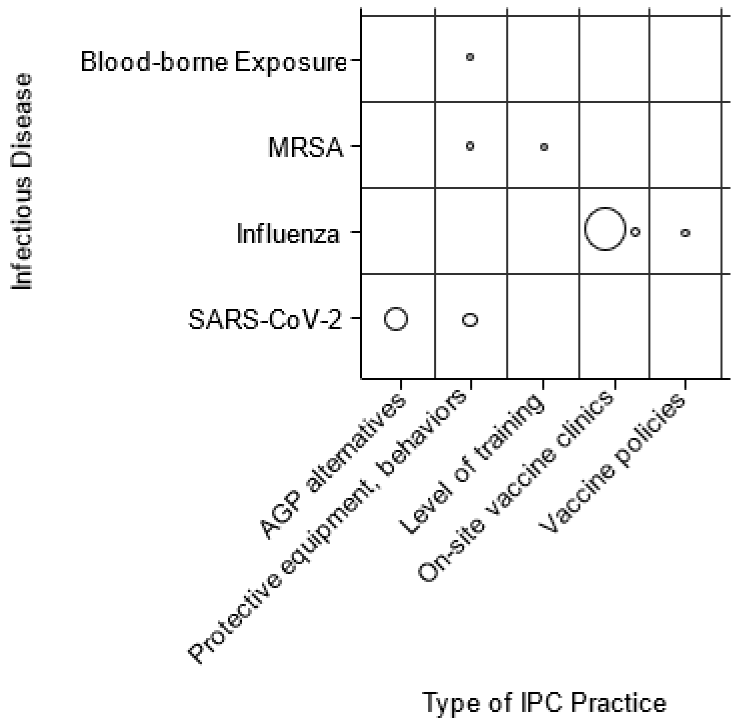
Vaccine Uptake

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% of participants reporting mandatory vaccine policies also reported being vaccinated while those who did not have a mandatory vaccine policy reported a 66.8% vaccination rate for H1N1 influenza (unadjusted $p<0.01$) and a 75.6% vaccination rate for seasonal influenza (unadjusted $p<0.001$).[22]

GQ2/3d: Reported Effectiveness of EMS/911 Workforce Practices to Prevent, Recognize, and Control Infectious Diseases

Eight studies reported on the effectiveness of preventing infectious diseases among the EMS/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/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/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 provider 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% (5,746 out of 9,559) during a targeted, active, and dedicated vaccine program in a bio-preparedness drill as compared to 34.4% (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/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 providers 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 providers 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 providers 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 providers 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 providers tested positive for COVID-19 by polymerase chain reaction (PCR), although 11 of these had never had a documented patient exposure. Of the remaining providers, 18 had a COVID-19 patient encounter but did not develop infection within the exposure window of 2-14 days, and only one provider 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/ 911 workforce infection control practices. This included seven documents from the Department of Health and Human Services (HHS), 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/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/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.35 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/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.[36] 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***.[35]

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.[37] 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.[38] The third document from HHS highlights several considerations including use of ***respiratory protection*** and ***use of non-pharmaceutical interventions (NPIs)***.[39]

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.[38] Important topics relevant to the EMS/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 providers, 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.[39] 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.[40] Of direct relevance to the ***EMS/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,[41] none were found to provide distinct breakdowns for the EMS workforce.

GQ 4: Context and Implementation Factors of Studies with Effective EMS/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*.[42]

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.[43] Of relevance to the EMS/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/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/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 health care 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 EMS/911 Workforce

We found 18 observational studies on the characteristics, incidence, prevalence, and/or severity of occupationally-acquired infectious diseases and related exposures in the EMS/911 workforce (GQ 1). Fourteen of the studies were published in the last 2 years (Figure 3), and most of them focused on SARS-CoV-2. Thus, much of the evidence on occupationally-acquired infections in the EMS/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/911 workforce, except for one study that reported an increased prevalence of hepatitis C in older versus younger EMS/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% CIs were very wide because of the low numbers of Black or Hispanic EMS/911 workers in the study.

Only four studies reported on how occupationally-acquired infectious diseases and related exposures differ by EMS/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 ALS versus BLS-certified EMS workers, and the authors reported that ALS-certified EMS workers had an increased risk of blood exposure, fluids exposure, and needle sticks.[8] Another study found no difference in 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/911 Workforce

We found nine observational studies on the characteristics and effectiveness of IPC practices in the EMS/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***[44] 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.

One study examined the real-world implementation and effectiveness of a MEGG protocol which included appropriate masks, eye protection, gown, and gloves at the beginning of the COVID-19 pandemic in Washington state.[18] Brown reported that AGP procedures, even with full

PPE, were associated with SARS-CoV-2 diagnosis. This finding was limited by having only one EMS provider developing COVID-19 infection during 8,582 person-days at risk while in PPE and performing 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]

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 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/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/911 workforce. Another particular challenge in EMS research is the multiple different levels of providers in systems and even 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 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 providers 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 providers 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/911 workforce as well as studies of the effectiveness of IPC practices in the EMS/911 workforce. The epidemiologic studies of incidence, prevalence, and severity of infections are representative of the target population of EMS/911 workers in the U.S., 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/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 one was 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 transmission, but this study was limited by sample size. The representativeness of these workforce practices would appear to be similar to nationwide practices, however no published evidence was found to support this. Also, no study of COVID-related on-site vaccine clinics or mandates was reported.

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/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/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/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

A review of the reported data in this technical brief demonstrates that the EMS/911 workforce is 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 workers. In addition, EMS personnel 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/911 workforce. No studies were found on vaccine mandates for SARS-CoV-2.

Future Research Needs

This technical brief has identified many gaps in the evidence on the epidemiology of occupationally-acquired infections and the effectiveness of IPC practices in the EMS/911 workforce. More research is needed on the effectiveness of diverse types of IPC interventions for the full range of occupationally-acquired infections in the EMS/911 workforce. 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; and 4) Studies of multi-component strategies for improving vaccine uptake by targeting predisposing, enabling, and reinforcing factors.

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, and a more extensive analysis of how the effectiveness of interventions differs according to the characteristics of the targeted workforce and their practice setting. 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.

Conclusions

A moderate amount of evidence exists on the incidence, prevalence, and severity of occupationally-acquired infections in the EMS/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/911 workforce, with a few exceptions. A moderate amount of evidence exists on the characteristics and effectiveness of IPC practices in the EMS/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
NPI	Non-pharmaceutical interventions
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