



Importance of Hand Hygiene Compliance in Reducing Occupationally Acquired Infections for Emergency Departments and Emergency Medical Services

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Abstract

In the realm of frontline healthcare, where the well-being of both patients and healthcare workers hangs in the balance, there is a heightened vulnerability of healthcare workers (HCWs) to occupationally acquired infectious diseases (OAI), particularly evident during recent infectious disease outbreaks. Ethical principles in healthcare mandate that HCWs provide care regardless of the associated risks, leading them to be in close proximity to infected patients during triage and care provision. The unavoidable risk of OAI is exacerbated by insufficient protection, resources, training, and compliance, making HCWs, especially Emergency Department (ED) clinicians and Emergency Medical Service (EMS) providers, disproportionately affected during outbreaks. This paper emphasizes the crucial role of handwashing and hygiene in an infection control model for ED and EMS workers. We recommend the implementation of a range of strategies to enhance hand hygiene compliance. This proactive approach is essential to mitigate the daily risks HCWs face with OAIs. By investing in multimodal strategies, healthcare facilities aim to fortify the resilience of the healthcare system while providing enhanced protection for frontline workers. These individuals willingly risk their lives to ensure the well-being of others. Therefore, prioritizing improvements in hand hygiene compliance becomes a crucial step in safeguarding HCWs and reinforcing the overall effectiveness and robustness of the healthcare system.

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Introduction

Recent infectious disease outbreaks have highlighted the vulnerabilities of healthcare workers (HCWs) to occupationally acquired infectious diseases (OAI). As the ethical principles of healthcare dictate, patients must receive care no matter the risks presented by their illness or injury. This necessitates that HCWs be in close proximity to infected patients while triaging and providing care, thus placing them at a greater risk for a variety of infections. The risk for OAI is an unavoidable part of daily patient care, and HCWs often become the most affected populations during infectious disease outbreaks due to a lack of proper protection, resources, training, and compliance.¹ Both emergency department (ED) clinicians and Emergency Medical Service (EMS) providers are at an increased risk of exposure by being on the frontlines, often as the first contacts patients have with the medical system. HCWs are often the first to confront a new or emerging outbreak or even seasonal spikes in epidemics as patients who possess symptoms seek care for their illnesses. Particularly in the case of emerging or new outbreaks, HCWs, especially EMS providers and ED staff, may have interactions with index cases before baseline epidemiological data is known and before the

outbreak risk can be reported and communicated to the healthcare community as well as the general public, putting them at an increased risk for OAI. This paper will demonstrate the importance of handwashing and hand hygiene as part of an infection control model for ED and EMS workers and will provide recommendations to improve hand hygiene compliance to protect these HCWs from OAIs.

Background

Healthcare workers, including ED and EMS personnel, are frequently exposed to a variety of infectious diseases that have their own complicating transmission factors that require various levels of precaution. This paper explores risks, vulnerabilities, and compliance with infection prevention measures in light of novel emerging diseases like COVID-19. A study from the first four months of the COVID-19 pandemic in Wuhan (November 2019–February 2020) suggested that of 25,961 PCR-confirmed² COVID-19 diagnoses, 5.1 percent were HCWs.³ The estimated COVID-19 incidence using epidemiological data for denominators was higher in HCWs than in the general population.⁴ HCWs are particularly vulnerable to COVID-19 infections and other emerging infectious diseases due to close contact with infected patients and contaminated materials.⁵ SARS-CoV-2 was not the first coronavirus to spill over to humans and lead to global case counts. Previous coronavirus outbreaks have demonstrated extensive nosocomial transmission risks, including Severe Acute Respiratory Syndrome coronavirus (SARS) and Middle East Respiratory Syndrome coronavirus (MERS).⁶ The high incidence of nosocomial infections during these outbreaks is believed to be related to suboptimal infection control practices and the performance of aerosol-generating medical procedures.⁷ During the SARS epidemic in 2003, the World Health Organization (WHO) reported that, of the 8,098 total cases, 1,707 or 21 percent of the cases were HCWs.⁸ Similarly, 18 percent of all laboratory-confirmed cases of MERS-CoV from 2012 to June 2, 2018, were HCWs.⁹ WHO regularly reports on new cases of MERS, which have continued to lead to HCW and patient illnesses.¹⁰ According to official data analyzed in a 2021 study from several other published studies, there was a rate of 12–15 percent of nosocomial COVID-19 in patients reported around the world until May of 2020.¹¹ COVID-19 and other airborne respiratory illnesses are only some of the occupational hazards that healthcare workers face daily. In the later phases of the pandemic, rates around the globe were slightly reduced. For example, hospital-acquired infections (HAI) were reported in 7.4 percent of cases in Switzerland and 8.6 percent in Brazil.¹²

The probability of nosocomial transmission to healthcare workers depends on several factors including the availability of personal protective equipment (PPE), transmissibility and virulence of the pathogen, operating environment, and behavioral interventions, like hand hygiene. Each of these factors should be considered in infection prevention control (IPC) measures to best protect healthcare workers from infection while treating the most vulnerable in the community. When determining IPC measures, it is important to evaluate what is available to HCWs during an outbreak. Initial studies during the COVID-19 pandemic revealed low amounts of available supplies of PPE, hand hygiene products, and disinfection supplies for equipment and hospitals, all of which increased the risk of OAI.¹³

The safety of HCWs is crucial for healthcare systems to remain resilient in the emergence of an infectious disease, a seasonal epidemic, or in the event of a major global pandemic. OAI in these workers threaten to disrupt the entire healthcare system and its ability to treat the sick within our communities due to the loss of able-bodied HCWs, especially in the specialized climates of EMS and EDs. In 2020, more than 2,900 HCWs in the United States died as a result of the pandemic.¹⁴ WHO estimated that between 80,000 and 180,000 HCWs could have died from COVID-19 in the period between January 2020 to May 2021.¹⁵ COVID-19 deaths decreased significantly in the third year of the pandemic compared to the first two years, largely because most deaths in the first year occurred before the availability of vaccines, medical countermeasures, and renewed access to PPE.¹⁶

Personal Protective Equipment (PPE)

The emergence of SARS-CoV-2 has highlighted existing vulnerabilities within supply chains that put HCWs at risk and the need for correct application of appropriate measures and compliance for IPC. Viruses that transmit person-to-person through respiratory droplets and close contact require HCWs to evaluate aerosolization and exposure risks for patient treatment that may require close-contact care and procedures.¹⁷ In the event of severe respiratory infections, care such as intubation and nebulizer treatments necessitate contact with the healthcare system through EMS and EDs.¹⁸ An estimated 20–30 percent of SARS patients, pre-vaccine, required mechanical ventilation, and 10 percent of SARS patients died, with those deadly cases potentially having EMS or ED intervention before resuscitation efforts terminated.¹⁹ Aerosolization risk exposure assessments require stringent precautions in order to protect HCWs, including adhering to strict and proper PPE utilization. The U.S. Occupational Safety and Health Administration (OSHA) mandates that PPE be selected based on the specific hazards that are likely to be encountered during work. The selection of appropriate PPE must consider key factors including the type of hazard and the prospective routes of infection (inhalation, skin absorption, blood, ingestion, and eye or skin contact).²⁰

Access to and use of PPE, however, is not sufficient for protection from various pathogens, as proper donning and doffing is necessary for adequate protection and prevents potential contamination to the user. In addition, specific equipment such as respirators require fit-testing for individual use. ED clinicians and EMS providers often do not have the luxury of pre-patient diagnostic contact testing which places the decision on the providers to assess clinical symptoms to determine the level of PPE to wear. Typical ED and EMS precautions for general non-respiratory illnesses, such as car accidents or chest pain, will likely only result in the use of gloves.²¹ In contrast, more high-risk patients, such as those with respiratory complaints or infectious disease diagnoses, will necessitate respirators such as N95s and/or isolation gowns. The adoption of PPE in EMS has shifted towards more protection over the years, as the gloves that are commonplace on almost every EMS call now were not widely used throughout the system decades ago.²² The U.S. Centers for Disease Control and Prevention (CDC) recommends minimum precautions that apply to all patients, regardless of their suspected or confirmed infectious status, in all healthcare settings.²³ The suggested PPE protection is recommended for HCWs treating various types of patients. The appropriate use of PPE for adherence to standard

precautions includes the “use of gloves in situations involving possible contact with blood or body fluids, mucous membranes, non-intact skin, the use of protective clothing to protect skin and clothing during procedures or activities where contact with blood or body fluids is anticipated, and the use of mouth, nose, and eye protection during procedures that are likely to generate splashes or sprays of blood or other body fluids.”²⁴

Various methods, including standard operating procedures (SOPs) and standardized trainings, are meant to assist HCWs in assessing risk and selecting the appropriate PPE.²⁵ Early suggestions for PPE during the SARS-CoV-2 outbreak included all forms of precautions;²⁶ however, gloves, face shields, and respirators were the most important PPE to prevent OAI due to aerosolization and close-contact transmission routes. A national study by the Association for Professionals in Infection Control and Epidemiology (APIC) COVID-19 task force found in March 2020, soon after the emergence of SARS-CoV-2 in the United States, that face shields and respirators were the least available supplies, with only 13.6 percent and 18.2 percent of infection preventionists reporting sufficient supplies of face shields and respirators respectively.²⁷ Many infection preventionists (66.9 percent) reported sufficient hand soap, but far fewer had sufficient hand sanitizer (29.5 percent, $P < .001$), and only 45.4 percent had sufficient disinfection supplies.²⁸ The scarcity of PPE made HCWs more vulnerable to OAIs since they had to either forgo wearing PPE, reuse PPE, or make their own PPE.²⁹

Pathogen Transmission and Virulence

HCWs can potentially be exposed to various pathogens during their daily operations in patient care. They must consider various routes of transmission and potential exposure in their IPC practices. Transmission of infectious diseases within a healthcare setting requires the combination of three elements: source, host, and mode.³⁰ The source, known as a reservoir, must be present of an infectious agent(s), a susceptible host with a portal of entry receptive to the agent, and a mode of transmission for the agent to enter the host. Transmission routes will vary depending on the pathogen, and some routes may have more than one to consider. Some pathogens are transmitted “primarily by direct or indirect contact with an infected individual, (e.g., Herpes simplex virus [HSV], respiratory syncytial virus, Staphylococcus aureus), others by aerosol droplet, (e.g., influenza virus, B. pertussis) or airborne routes (e.g., M. tuberculosis).”³¹ There are also bloodborne virus pathogens that are transmitted via percutaneous or mucous membrane exposure. Contact transmission is the most common mode of transmission.³²

HCWs are taught that all body fluids, secretions and excretions, should be considered potential routes of exposure, and activities that create aerosols or put the HCW into close contact with a patient should be done with caution, considering the risk of nosocomial infection.³³ Universal precautions were developed to address the risk of bloodborne pathogens by treating all blood and bloody body fluids as infectious. Standard precautions, later developed by the CDC to leverage the major features of universal precautions and Body Substance Isolation (BSI), are a tenet of healthcare to help reduce the risk of the transmission of pathogens through body substances.³⁴ Standard transmission-based precautions can be applied to protect healthcare workers from known or unknown sources within hospitals or ambulances.

Hand Hygiene

The final tenet of OAI prevention is a common global health promotion process. This method of infection prevention serves as an important connection between PPE and the pathogen itself, bridging the protection gap that may be present in the utilization of PPE. Hand hygiene is a crucial precaution element to break the infection chain, reducing the risk of OAI (Table 1). The CDC lists hand hygiene as the most important measure to prevent the spread of infections and has it listed as the first standard precaution.³⁵ Hand hygiene with an alcohol-based solution is widely used throughout the world as the most simple, low-cost, and effective OAI prevention measure in lieu of soap.³⁶ The alcohol-based hand rubs denature certain surface proteins of enveloped viruses, inactivating them and preventing survival and spread, improving the antimicrobial efficacy and rate of compliance with hand hygiene.³⁷ A systematic review of alcohol-based hand rubs found that they removed microorganisms effectively, requiring less time, and thus less hand irritation than handwashing with soap or other antiseptics and water. The authors found that the availability of these alcohol-based solutions in HCWs' work environments with easily accessible supplies helped to increase compliance with hand hygiene among HCWs.³⁸ Various agents have been suggested as effective for hand hygiene in lieu of alcohol when handwashing stations are not available; this is especially important for EMS professionals who do not have access to stations in the field. These agents should be made available based on the potential exposure as seen in Table 1.

Table 1. Various Hand Hygiene Agents³⁹

Agent	Concentration	Best Uses	Advantages
Alcohol	60–95 percent ethanol, isopropanol, or n-propanol; gels, rinses, and foams	Germicidal activity against GP and GN bacteria and a variety of fungi; good use against EV	Fast acting, reduces bacteria counts
Chlorhexidine	0.5–4 percent	Good activity against GP bacteria, less activity against GN bacteria and fungi, minimal activity against mycobacteria	Non-allergenic, minimally affected by organic material presence; has significant residual activity
Iodine and iodophors	0.5–10 percent povidone-iodine	Bactericidal activity against GP, GN and some spore-forming bacteria; active against mycobacteria, viruses and fungi	Good antimicrobial activity in lower concentration formulations; less skin irritation and fewer allergic reactions with iodophors versus iodine
Plain soaps (non-medicated)	Bars, soaps, liquid	Can remove loosely adherent transient flora; Enveloped viruses and common bacteria	Removal of proteinaceous material such as blood

GP: Gram-positive, GN: Gram-Negative, EV: Enveloped viruses

While all components of infection control are important to decrease the risk of transmission, hand hygiene has been demonstrated to be a leading factor in preventing transmission in healthcare environments.⁴⁰ Relying heavily on PPE alone can become a risky solution, particularly when supplies and availability of PPE may be limited. Hand hygiene can be completed in as little as 20 seconds and is an inexpensive measure that can be addressed by an individual to reduce their exposure risk to OAIs. The ease of implementing regular hand hygiene and the ability to regulate compliance provides an easy and effective solution to OAI prevention failures.

The lack and variability of hand hygiene access and compliance in healthcare environments poses an elevated risk of OAI. The restrictive nature of emergency medical healthcare environments, including access to handwashing stations, is unlikely to change. However, through informed policy recommendations and uniform hand hygiene guidelines, necessary procedures can be enacted to reduce the risk of OAIs to frontline workers.

ED and EMS Factors that Reduce Compliance

The factors discussed above provide an important context for the vulnerabilities that exist; however, in order to decrease the risk of OAIs, there must be compliance across the healthcare system, particularly in EDs and EMS. Of particular importance is the role of hand hygiene compliance. Numerous environmental, institutional, behavioral, and clinical factors have been suggested as reasons for lower hand hygiene compliance in healthcare settings (Table 2). While the rates are low across the healthcare industry, both EDs and EMS are distinct sectors that complicate the ability to remain compliant.⁴¹ Previous hand hygiene studies have often focused on inpatient locations such as intensive care units with failure rates around 60 percent.⁴² Still, few have investigated the rates of failure in the less structured and more chaotic environments that can be present in the ED or EMS. ED and EMS HCWs are subject to a unique set of institutional and human-behavior based factors that can limit hand hygiene compliance. The urgent nature of the work, as well as the potential limited availability of handwashing measures in the field, complicate the ability of HCWs in the emergency sector to remain fully compliant with hand hygiene precautions. Relatively few studies have investigated hand hygiene compliance in these environments. However, limited studies have shown hygiene compliance in the ED to be as low as 29 percent internationally⁴³ and 38 percent in United States' EMS systems.⁴⁴

Table 2. Factors That Affect Hand Hygiene Compliance ⁴⁵

Environmental/Institutional/Behavioral	Clinical Factors
<ul style="list-style-type: none"> • Wearing Gloves • Lack of knowledge about protocols • Lack of promotion of positive benefits of hand hygiene • Personal beliefs about lack of risk of health care activities • Sinks are inconveniently located or not available • Lack of hand hygiene supplies • Lack of role models for staff • Forgetfulness of staff • Lack of institutional priority • Lack of sanctions for non-compliance 	<ul style="list-style-type: none"> • Hand hygiene causing delays in patient care • Understaffing and overcrowding

One approach may be to apply data from patient-centered studies to key HCW populations. A New Jersey hospital system enacted an electronic hand hygiene compliance monitoring system to track compliance based on the WHO's "5-Moments for Hand Hygiene,"⁴⁶ which promotes hand hygiene at five distinct times during healthcare delivery, and the CDC hygiene standards in an effort to reduce HAIs.⁴⁷ The system uses monitors on point-of-care hand sanitizer and soap dispensers to monitor compliance.⁴⁸ The DebMed System software assesses real hand hygiene event data (actuation events recorded by monitored dispensers) by juxtaposing it with an evidence-based estimate of overall hand hygiene opportunities, relying on the WHO's 5 Moments.⁴⁹ These computations serve as the reference point for establishing a Hand Hygiene Compliance Index (HHCI) for the 5 Moments.⁵⁰ Since 2015, participating units across the entire healthcare system have had increases of nearly 70 percent in overall hand hygiene compliance, with the system sustaining a 57 percent improvement overall. Currently, the entire system, composed of seven hospitals, is nearing 90 percent compliance, while the main hospital, Morristown Medical Center, is nearly at 100 percent compliance. The increased compliance has yielded a 47 percent decrease in catheter-associated urinary tract infections, a decrease of 58 percent in surgical site infections, a decrease in C-difficile of 64 percent, and an 82 percent decrease in Methicillin Resistance Staph Aureus blood infections.⁵¹ This decrease in the infection rate of HAIs from an increase in hand hygiene compliance in a healthcare system suggests the importance of hand hygiene in preventing OAI.

The constant flow of patients in and out of the ED with various acuity levels causes frequent distractions and interruptions that may be barriers to infection control activities.⁵² A study conducted in an urban, academic ED in Massachusetts with more than 57,000 annual visits found numerous complications for hand hygiene compliance within its EDs.⁵³ The ED hand hygiene compliance differed from non-ED hand hygiene compliance studies throughout healthcare institutions.⁵⁴ The ED had 45 private treatment spaces and 17 hallway treatment spaces, of which 25 private and 11 hallway spaces were being prescribed as high visibility

on the basis of proximity to a nursing station. The ED had 146 alcohol-based hand hygiene dispensers and 45 sinks. Within the study, the same traditional indicators for poor hand hygiene compliance among HCWs, including glove use and the HCW role, were found in addition to ED-specific predictors based on layout characteristics, including hallway bed location and patient location in an observational unit.⁵⁵ Unlike inpatient units, the variable volume and emergent needs of patients often mandate that additional bed space be made available in an ED. Hallway patient location was found to be the strongest predictor of poor hand hygiene compliance in the study.⁵⁶ The lower hand hygiene compliance for patients in hallway locations indicates that environmental factors such as the location of hand hygiene supplies and work-related factors such as crowding have major impacts on hand hygiene compliance in EDs.

A study of a 1,100-bed ED at Methodist Hospital of Indiana in Indianapolis, a facility that conducts tertiary care and is part of a teaching hospital, found that handwashing occurred at an overall frequency of only 32.3 percent.⁵⁷ The study suggested the “large number of patient contacts, simultaneous management of multiple patients, high illness acuity, and severe time constraints” to be potential factors for poor compliance with hand hygiene in the ED, even though there were accessible handwashing stations. The study found that handwashing after clean activities averaged only 18.4 percent but was 59.8 percent for dirty and gloved contacts.⁵⁸ The study defined clean contact as activities in which patient contact occurred, and in which there was contact with materials that were associated with patients but were not known to be contaminated with patient secretions. The presence of viruses on surfaces can be an exposure risk if there is unprotected contact without hand hygiene following the contact. Glove use was also shown to diminish compliance with handwashing by as much as 25 percent in another study, which is further discussed in this section.⁵⁹ This behavioral factor may be based on HCW’s perception that gloves are an alternative option to handwashing, based on a belief that the alternative would save time in an ED setting where the number of distinct contacts with each patient is high.⁶⁰

A rebuild of an 800-bed referral hospital in the United Kingdom included a decrease in the distance from clinical activity to sinks from 30 meters to no more than 5 meters and often much less.⁶¹ This improved accessibility to sinks did not lead to an improvement in handwashing compliance, suggesting there are other critical factors that must be addressed in hand hygiene models to ensure a reduction in OAI.⁶² Low hand hygiene compliance has been shown to be attributed to workloads within EDs.⁶³ Contributing factors from a study of low hand hygiene compliance in a 40-bed ED of a 475-bed academic hospital in Toronto, Canada, were high and unpredictable patient volumes, increasing acuity in the presenting patients, overcrowding of the ED, insufficient staffing, and an associated lack of time.⁶⁴ With a variable volume consistent within the United States and variable nurse-to-patient ratios throughout the shift, these factors can be generalizable to the United States, serving as a platform from which to make improvements.⁶⁵ EDs additionally face challenges in which presenting patients may not have had any laboratory-confirmed results to identify positive presentation of infectious diseases to dictate the need for various types of PPE.

Similar to EDs, hygienic behavior has infrequently been studied in pre-hospital emergency care settings. There are no sinks in the back of ambulances within the United States, or generally around the globe, complicating hand hygiene compliance in an EMS environment.⁶⁶ A study of 1,494 EMS providers across the United States found that only 33 percent of providers reported

cleaning their hands following invasive procedures, and 16 percent reported they never cleaned their hands following invasive procedures. This was accompanied by only 52 percent of respondents reporting wearing gloves with every patient contact.⁶⁷ Studies have found that after patient care, a significant number of EMS providers have a heavy bacterial load on their hands (77 percent) and only 24 percent of providers perform hand hygiene in between patients, increasing the potential for exposure.⁶⁸ EMS providers frequently have contact with multiple patients per day with varying health conditions and medical needs at the time of patient contact. Unlike the cleaner environments of a hospital setting, EMS providers often contact patients in their homes or other social environments such as restaurants or parks.

There remains a gap in the expansive studies of the OAI risk factors within these pre-hospital environments in the United States. A German study, however, which hygienically and microbiologically examined the “handwashing area, equipment for artificial respiration, insufflation, intubation, aspiration, intravasal catheterization, blood-pressure measurement, and sterile materials storage” in 44 ambulances, found that blood pressure cuffs and stethoscopes had the highest areas of contamination.⁶⁹ In high-volume areas, it is unlikely that multi-use items will be disposed of due to the cost inhibition.⁷⁰ This can pose an additional source of continued contamination outside of immediate patient contact should decontamination not be done adequately—a concern in the fast-paced environments of EMS.⁷¹

While EMS providers in the United States receive mandatory annual OSHA training on bloodborne pathogens, there remains a gap in training on the logistics and importance of protocols for IPC and decontamination, which is necessary for infectious disease containment.⁷² EMS training focuses on swift and effective patient care, but lacks the comprehensive training needed to conduct an extensive patient history assessment, which “could result in an inaccurate diagnosis where early symptoms of an emerging or re-emerging [infectious disease] could be mistaken for a routine influenza-like illness.”⁷³ Only 1.3 percent of the national EMS education standards and curricula competencies are allocated to address the complex nature of infectious diseases, placing EMS providers at risk. EMS practitioners are often the first HCWs to evaluate patients and are frequently required to assess and treat patients without advanced notice of diagnosis. Ebola Virus Disease was incorrectly marked as airborne by “17.3% of Frontline-level respondents [with] similar percentages found in the airborne category for other viral hemorrhagic fevers,” and 14.6 percent of frontline-level respondents incorrectly marked anthrax as transmitted via human-to-human contact.⁷⁴ These gaps in infection control training can lead to increased unease within EMS providers when responding to patients who are potentially infected with transmissible diseases, reducing the response framework’s ability to respond to and control an infectious disease outbreak.⁷⁵

Traditional hospital-based hand hygiene methods are complicated, and there is no easy method that is directly applicable to an EMS setting. EMS providers often work in non-sterile environments where invasive procedures may occur in the pre-hospital setting, which further increases the potential for exposure and OAI. Ambulances may contain hand hygiene supplies such as hand sanitizers, but there is an overall access issue during patient triage.⁷⁶ While hand hygiene solutions can be available in the cabinets, the foaming solutions or liquid hand sanitizers are often not wall-mounted at access points, leading to a further decrease in compliance. These EMS and ED-specific factors increase the vulnerabilities and risks of OAI from the already elevated general risk of HCWs, suggesting a need for a comprehensive approach to hand hygiene improvement strategies.

Available Approaches for Hand Hygiene Compliance

Hand hygiene practices reflect attitudes, behaviors, and beliefs, which must all be addressed to increase HCWs' hand hygiene compliance. A multimodal strategy is necessary to increase handwashing compliance and reduce OAIs in the complex environment of healthcare. Multimodal strategies for hand hygiene have consistently been shown to be more successful in improving rates of adherence than single interventions.⁷⁷

The WHO's multimodal hand hygiene improvement strategy includes five key components necessary for sustained and significant improvement in compliance.⁷⁸ The five components are system change, training and education, evaluation and feedback, reminders in the workplace, and institutional safety climate. The system change component ensures that the necessary infrastructure is in place to allow HCWs to practice hand hygiene. The two major requirements of system change are access to continuous water supply, soap, and towels as well as readily accessible alcohol-based hand hygiene supplies at the point of care. The improvement strategy must also include regular training on the importance of hand hygiene, leveraging the "5 Moments for Hand Hygiene."⁷⁹ The training should include discussing and displaying correct procedures for hand rubbing and washing for all HCWs. Following the first two components, it is important to have monitoring of hand hygiene practices and infrastructure. This evaluation and feedback will include an inquiry into the perceptions and knowledge of HCWs and feedback on compliance and correct practices for staff so they can make changes if needed. The improvement strategy also calls for reminders in the workplace to prompt HCWs about the importance of hand hygiene and to remind HCWs of the indications and procedures for the performance of hand hygiene. The final component requires that institutions create a safety climate in which the environment for HCWs precipitates awareness about safety issues while guaranteeing compliance with and consideration of hand hygiene improvement at all levels within the institution. This includes active participation at the individual and institutional levels, self-efficacy to make the improvements, and partnerships with various outside organizations to promote improved compliance.⁸⁰

Multimodal approaches have been shown to be successful in the context of EDs.⁸¹ One specific study was conducted from May–September 2013 in an ED in the Netherlands with an average of 21,000 annual visits. The ED had 23 beds: three resuscitation rooms, 19 beds, and one triage room. Approximately 1,000 opportunities for hand hygiene were evaluated among 57 ED nurses and physicians. Compliance with hand hygiene increased significantly from baseline from 18 percent to 41 percent after the first week of education, reminders, and regular feedback and stabilized to 50 percent and 46 percent after the second and third weeks, respectively.⁸² This study found success with an intervention strategy that addressed knowledge (education), awareness (performance feedback), action control (reminders), and social influences (role models) in a team-directed strategy that included both individual providers and the institution itself.⁸³ Although there are no identical studies in the EMS space, the lessons learned from the ED can be applied to the EMS environment, which contains many of the same vulnerabilities for OAI. While WHO recommendations are critical to a successful infection prevention system, some gaps can be addressed through focused interventions within EDs and EMS.

Discussion and Recommendations

EDs and EMS should leverage the WHO's multimodal strategy to increase hand hygiene improvement to reduce the vulnerabilities that place HCWs at an increased risk for OAI. Actions that consider all five focus areas would be needed to address the complex human, environmental, and institutional factors within these specialties that place them at an increased risk for OAI compared to other HCWs. Integrated within the multimodal strategy, the 5 Moments for Hand Hygiene can be a valuable tool to help influence system change through easy-to-remember reminders for HCWs.

Integrated Infection Control Teams

Hospitals frequently have infection control teams, but greater focus should be placed on OAI prevention, and the infection control team model should be expanded to EMS, which typically do not have dedicated infection control teams. These infection control teams should be responsible for providing evaluation and feedback to ensure that there is compliance with hand hygiene measures. Developing tools for compliance analysis, assessment of HCW knowledge, and self-efficacy can further refine the focus of these teams for their respective providers. This is especially critical for EMS workers who "have limited time in their national curricula devoted to highly infectious disease identification and containment."⁸⁴ The infection control teams should also be responsible for installing visible and accessible workplace reminders, including WHO's "5 Moments for Hand Hygiene" posters, posters on handwashing, and hand hygiene reminders on screensavers. This would be especially important for EMS, which has less space to place reminders in the back of the ambulance but still requires some prompting to engage in hand hygiene when in the field.

EDs and EMS must also work collaboratively to share patient information and alert staff to any precautions that must be taken at patient transfer if they are available. This collaboration also requires a reporting and communication structure. By increasing collaboration and education, EMS can specifically increase their ability to quickly and accurately recognize the presenting symptoms of an infectious disease, which can assist downstream resources in preparing for an appropriate response.⁸⁵ Improved collaboration between the two services can also promote the dissemination of evidence-based knowledge about handwashing and infection prevention. Through this collaboration, there should also be hand hygiene compliance tracking, education, and training, as well as increased access to hand hygiene supplies. Promoting a safety climate where each service holds the other accountable by providing feedback and reminders can promote systemic changes, which are essential. The operational separation between EMS and EDs in many locations throughout the United States prevents EMS providers from accessing the comprehensive training resources available to hospital providers.

Accessible and Easy-to-Use Hand Hygiene Supplies

In the chaotic environments of EDs or in the field where EMS providers work, handwashing stations or available hand hygiene supplies need to be placed in a way that providers can easily use them. While it is not possible to immediately provide handwashing stations in ambulances, there still exists a need for hand hygiene supplies such as hand sanitizer or other antiseptic hand rubs to be available and easily accessible at ambulance entry doors. Handwashing stations should also be available to EMS providers within the hospital to allow them to be compliant with full hand hygiene following the transfer of a patient or decontamination of their equipment.

EDs have been shown to have unique institutional features that limit the compliance of hand hygiene. While crowding and understaffing within departments continue to be issues, providing staff to support the influx and acuity of patients would allow more time to complete hand hygiene.⁸⁶

Training Programs

Access to hand hygiene materials alone does not increase compliance.⁸⁷ Due to the variations among state licensures, a cohesive and comprehensive model must be adopted through the national curricula to promote mandatory infectious disease standards and training, increasing EMS provider knowledge and readiness for infectious disease response.⁸⁸ The national EMS curricula should collaborate with infection control professionals to develop training modules about infectious disease and OAI prevention, increasing the allotment for this critical training from the minimal 1.3 percent currently in the curricula. The training should be completed in collaboration with the CDC and WHO to ensure an alignment of recommendations for EMS personnel.⁸⁹ It is necessary to include the other measures of the multimodal strategy. Training for EMS and EDs is necessary to advise providers that there is no one-size-fits-all approach to hand hygiene or decontamination. There must be annual training to ensure providers are reminded of the importance of hand hygiene and best practices. This must include a demonstration of understanding the indicators for hand hygiene and a demonstration of proper practices. There have been studies suggesting that interactive education programs combined with the availability of hand hygiene products increase compliance with hand hygiene. Additional programs that included positive role modeling of proper hygiene behaviors and utilization of performance indicators also remarkably improved compliance.⁹⁰ A study in the United States suggested that embedding hand hygiene within a stronger institutional safety climate while optimizing staffing levels dedicated to OAI prevention would improve compliance and safety.⁹¹ A coordinated campaign to improve awareness of the risks of non-compliance with hand hygiene in association with the WHO's global campaign can begin to change the safety culture within EDs and EMS. Without a culture change that promotes and mandates hand hygiene compliance, the availability of hand hygiene products and handwashing stations alone will be insufficient, leaving our frontline HCWs at risk for OAI.

Additionally, in various fields, including the emergency response space, it is common for services to regularly exchange data and insights regarding injuries, illnesses, and fatalities stemming from the duties of responders.⁹² The firefighting sector, in particular, actively disseminates information on near-misses to extract valuable lessons. This practice allows departments worldwide to glean insights from these incidents, facilitating the implementation

of necessary adjustments to prevent similar situations in the future.⁹³ The National Fire Fighter Near-Miss Reporting System is a voluntary reporting system where firefighters can document hazards, near-misses, injuries, and deaths.⁹⁴ A similar reporting system could be implemented in the healthcare sector, particularly for EMS and EDs. By recording and sharing occupational adverse incidents, healthcare professionals can learn from each other's experiences, implement preventive measures, and reduce the risks associated with OAIs to protect healthcare workers.

Conclusion

ED providers, EMS professionals, and all healthcare workers often face numerous diseases during their lifesaving work.⁹⁵ One of the major constraints in the understanding of OAIs, especially in EMS and EDs, is the limited number of studies and available data that can be leveraged to address the vulnerabilities. For example, the largest nosocomial outbreak of SARS occurred in Hong Kong, with an attack rate of 41 percent of hospital inpatients.⁹⁶ There is no detailed description of the response, which hinders the ability for corrective action in Hong Kong and the infection control community at large to collaborate on best practices.⁹⁷ Even less research and data are available regarding EMS-based OAIs and the infection control procedures implemented, proving a major gap in the protection of some of the most vulnerable and critical HCWs. An additional, unexplored potential contributing factor in EMS may be the differences in training and education among full-time, part-time, and volunteer staff. Research must include comprehensive evaluations of the impacts of low hand hygiene compliance as an explicit factor in OAI while also investigating the challenges of EMS and ED providers. This data can then be applied to address systematic changes to improve compliance and prevent exposures. In addition, there is a large gap in legislative protections for HCWs that could mandate data collection and analysis to find gaps and vulnerabilities. For instance, only after legislation was passed by the New Jersey State Senate and Assembly in December of 2020 were hospitals, surgery centers, long-term care facilities, hospice centers, and home healthcare agencies required to report the incidence of COVID-19 cases and fatalities among their employees to the Department of Health.⁹⁸ This should be expanded across the country and include other pathogens to better protect our HCWs from OAI.

The infection prevention infrastructure within the United States is necessary to protect frontline workers. By applying the recommendations at the state level, public health departments can leverage their traditional funding to help establish healthcare IPC approaches in the United States as a model that can be adopted worldwide to promote greater protection of our healthcare workers from OAI. EMS and ED staff are crucial parts of a critical infrastructure who are constantly strained in steady-state conditions and even more so during epidemics and pandemics. The COVID-19 pandemic has highlighted vulnerabilities within our IPC systems, particularly across EMS and EDs. These systems and their personnel are in a constant cycle of exposure risk for OAIs until we address the known IPC and training/awareness gaps. While protection will require the proper use of PPE in the context of the pathogen, limitations in the availability of PPE, as seen during the COVID-19 pandemic, mandate that hand hygiene is the most important but most underused precaution measure. An investment in multimodal strategies for hand hygiene compliance can have a three-fold impact on IPC compliance, decreases in nosocomial transmission risk, and reducing OAIs to improve the resilience of our healthcare system and protection of our frontline workers who put their lives on the line so that others may live.

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