Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Chapter 7

Making the case for biopreparedness in frontline hospitals: a Phoenix case study

Saskia Popescu
Schar School of Policy and Government - Biodefense, George Mason University, Arlington, VA, United States

Hospitals and healthcare facilities are the frontlines for identification, isolation, and defense against infectious disease outbreaks. Improper or substandard infection prevention and control (IPC) efforts directly facilitate the spread of disease within a community through delayed identification, isolation, and treatment of the patient, which prevents downstream public health efforts from responding to the case, not to mention the risk of transmission to staff. Infection control failures in hospitals were responsible for 31% of global Middle East Respiratory Syndrome Coronavirus (MERS-CoV) cases since December 2016 [1]. The two nosocomial (healthcare-associated) cases of Ebola virus disease (EVD) in nurses caring for a patient in Dallas, Texas, were the result of poor infection control practices and administrative support. When the first imported case of Ebola was identified within a hospital in the United States of America (U.S.), the spread of the disease to healthcare workers revealed substandard infection control practices that were common within the U.S. healthcare system. More recently, the novel coronavirus, SARS-CoV-2, which causes COVID-19, has shown a propensity for transmission in healthcare settings. Many states, like New York, California, and Washington have been severely impacted by the virus. One in particular, Arizona has been especially hard hit with COVID-19, proving to be one of the hotspots internationally with a 25% positive rate and a seriously strained healthcare system during a rapid surge in June and July 2020 [2]. Arizona’s experience as a COVID-19 hotspot emphasizes the importance of this topic and sets the stage for this chapter’s focus on a hospital system within Phoenix, AZ, and its efforts to prepare for biological events well before the pandemic. From over 90,000 healthcare worker infections worldwide, or the rampant transmission of the disease throughout long-term care facilities, COVID-19 is the latest example of how healthcare represents a unique vulnerability in the United States’ biodefense [3].
Infection control failures also result in harmful economic outcomes, as was seen in the healthcare-associated cases of Severe Acute Respiratory Syndrome coronavirus (SARS-CoV) in Toronto, Ebola in Dallas, Texas, and MERS-CoV in Seoul, South Korea. The 2003 SARS-CoV outbreak spread throughout Toronto healthcare facilities and resulted in a $1 billion price-tag for quarantine efforts that were attempted as a control measure but ultimately cost in terms of tourism and domestic economy [4,5]. Treating an Ebola patients in the United States is estimated to have cost $1.16 million for two patients; and this figure does not account for nosocomial transmission and IPC failures that required additional contact-tracing and widespread environmental disinfection [6]. The inadequate IPC practices in Dallas, TX, resulted in two nurses becoming infected, a lawsuit, and severe financial loss for the hospital. In fact, the lawsuit states that the nurses at the Dallas hospital reported that the hospital administration failed to follow basic IPC principles, provide adequate training or personal protective equipment (PPE), and even resisted nursing demands for proper isolation of the patient [7]. Despite spending $60 billion on biodefense efforts since 2001 to protect against high-consequence diseases [8], a single Ebola patient resulted in significant infection prevention and control failures, economic damage to the hospital, lawsuits from staff, and fear within the United States [9]. The United States has the resources and capabilities to adequately defend against infectious disease threats and yet a single cluster of Ebola cases exposed a wholly vulnerable and deeply compromised level of healthcare biopreparedness.

The healthcare industry within the United States is unique, as it relies on primarily private entities. This is a unique approach to healthcare in industrialized countries, like the Bismarck model in Germany or the National Health Insurance model of Canada. Countries like the United Kingdom utilize the Beveridge model, which provides healthcare for all citizens and is financed by the government through taxes [10]. The United States is unique in that it spends a considerable amount on healthcare per person and has elements of several different models. In their 2020 Hospital Statistics, the American Hospital Association reported that there are 6146 hospitals in the United States, of which 5198 are community hospitals and 209 federal hospitals [11]. Moreover, there are 924,107 staffed beds across all US hospitals and over 36 million admissions with a total expense for all US hospitals exceeding $1.1 trillion. As the majority of US hospitals are private entities and ultimately determine their own level of biopreparedness, this creates a fractured approach to healthcare readiness for biological threats. A 2018 report by the Office Inspector General (OIG) of the U.S. Department of Health and Human Services assessed hospital readiness to emerging infectious disease threats following the 2013–16 Ebola outbreak [12]. The surveyed hospital administrators reported a higher level of preparedness but noted that emergency preparedness personnel often lacked the specialized knowledge required for infectious disease threats. Moreover, administrators noted that it was difficult
to integrate procedures specific to emerging infectious diseases, specifically IPC, into emergency plans and that responding to such events was out of the comfort zone for emergency preparedness coordinators. As a result of these vulnerabilities and to better ensure a prepared healthcare system, the US sought to build a tiered approach at a national level.

**The current tiered system in response to special pathogens**

The eleven patients treated for Ebola in the United States revealed the challenges and risks associated with providing medical care to patients infected with special pathogens. Advanced medical settings translate to more invasive medical practices, which inherently puts healthcare workers at risk. In late September 2014, a traveler from Liberia would change the face of American healthcare preparedness. On September 20, 2014, Thomas Duncan traveled from Liberia where he was exposed to Ebola virus disease, to Dallas, Texas and would later seek treatment on September 25, 2020 [13]. As a result of treating Duncan, US hospitals went into overdrive to meet the needs and expectations of identifying and caring for a potential Ebola patient. These efforts were exhausting in terms of staff and resources, and fundamentally the level of preparedness was considered unsustainable in the long-term. Between the costs of waste management, extremely high PPE needs, or staff-to-patient ratio necessary, it quickly became apparent that the existing processes were not sustainable. In response, the Department of Health and Human Services was provided funds to develop a regional approach to hospital management of patients with Ebola virus disease. In collaboration with the United States Centers for Disease Control and Prevention (CDC), they developed a state and jurisdictional-based tiered hospital approach. Hospitals in the higher tiers receive funding through the Hospital Preparedness Program. These included frontline facilities, Ebola assessment hospitals, and Ebola treatment centers [14]. Frontline facilities are acute care hospitals — including emergency departments and urgent care clinics — and their guidance is to be able to rapidly identify and triage a patient with relevant exposure and signs and symptoms. The name was quickly expanded to refer to Ebola and special pathogens treatment centers. Frontline facilities are expected to be able to properly isolate suspected patients and patients under investigation (PUI), potentially coordinate with state and local public health authorities for testing, and manage the patients for roughly 12–24 h until they could be transferred to an Ebola assessment or treatment facility.

The next tier, Ebola assessment hospitals, are acute care hospitals that are prepared to receive and isolate a patient under investigation and care for them until an Ebola diagnosis can be confirmed or ruled out. These hospitals are expected to have the diagnostic capabilities to transport specimens, staffing for the patient, proper PPE, waste management, and infection control training.
Ebola assessment hospitals are expected to provide up to 96 h of evaluation and care for patients under investigation. If a patient is found to have Ebola, the assessment hospital is expected to prepare transport for the patient to an Ebola treatment center. Fifty-five hospitals were initially designated as Ebola treatment centers, meaning that they had the capabilities to treat patients confirmed to be infected with Ebola. Ebola treatment centers are expected to have a multidisciplinary team of clinical and non-clinical members ready to respond, ongoing training, laboratory protocols, and a designated space for possible point-of-care testing.

In 2015, the Office of the Assistant Secretary for Preparedness and Response, expanded the special pathogen hospital tiers to also include a regional network tier. This revision designated 9 of the 64 Ebola Treatment Centers — those with the greatest capacity — as Ebola and Other Special Pathogens Centers [15]. In 2017, an additional hospital was elevated to this tier, leaving 63 hospitals as Ebola Treatment Centers. The Special Pathogens Centers are expected to maintain competencies and capabilities to accept a suspected or diagnosed patient within 8 h of notification, as well as conducting drills quarterly. For hospitals, the voluntary designation as an Ebola treatment center is prestigious, but also comes with substantial cost and ultimately, public association with highly infectious diseases.

The goal of the tiered system approach was to alleviate the burden of high-consequence pathogen readiness for US hospitals and to create a specialized framework to ensure that all hospitals had a basic level of preparedness, while a select few were specialized and could fully manage infected patients. The considerable risk for transmission during hospitalization and medical care, especially in more advanced healthcare settings, was a serious gap identified in the 2013–16 Ebola outbreak [15]. Much of the literature does note that these failures would likely happen again, as preparedness for high-consequence pathogens is not a hospital norm [12,16].

However, there are inherent gaps in this approach. First, frontline hospitals, which represent the majority of hospitals in the United States, are widely neglected and knowledge is centralized in those higher tiers. Funding prioritizes state and regional treatment centers and assessment hospitals, with the expectation being that frontline hospitals manage their own efforts. As the aforementioned OIG report reveals, special pathogen preparedness does not represent a key initiative for many frontline healthcare facilities. The second issue relates to the volume of hospital beds within the biocontainment units. Most facilities report 2–4 beds, which equates to roughly 300 beds across the United States. Should there be a large-scale event that requires more hospital capacity for patients with special pathogens, this will become a significant roadblock to care. Lastly, there is a considerable challenge in financing these hospitals. Frontline hospitals must provide their open support for special pathogens efforts. From education to training, this falls upon them to prioritize and make a financial investment in high-consequence disease preparedness.
These efforts are not insignificant financial investments and the work around the 2013–16 Ebola outbreak sheds light on such monetary hurdles. While there is little information on the actual costs related to US hospital response to Ebola, there is even less for the hospitals that were considered frontline. Some estimates suggest the average amount spent by hospitals on combined supply and overtime labor costs was $80,461 (n = 133; 95% confidence interval, $56,502 – $104,419) and that small hospitals spent larger amounts on staff overtime costs per 100 beds than large hospitals [17]. Building a biocontainment unit is quite expensive as well. The mean cost to build such a unit is roughly $1.2 million, which likely means many hospitals are dependent upon federal funding for developing these additional measures [14]. Unfortunately, the funding for assessment hospitals and treatment centers expired in May of 2020, with the future of federal funding for every tiered hospital outside of the ten regional facilities, in limbo [18].

While the tiered hospital approach to special pathogens is a step in the right direction, there are considerable gaps in US hospital biopreparedness that ultimately rely on hospital administrators to prioritize readiness. Maintaining biopreparedness across US hospitals is complex as there are few regulatory requirements that require hospitals to invest in emergency preparedness and no requirements related to infectious diseases. The resulting situation is one in which hospitals can meet regulatory guidelines without investing a single dollar in infectious disease preparedness. While hospitals will prepare for influenza season by purchasing additional personal protective equipment and vaccines, unless hospital administrators view biopreparedness as a worthwhile investment, such endeavors for other pathogens are unlikely to be pursued. Maintaining preparedness for low probability but high consequence diseases, like Ebola or SARS-CoV, can be costly and with many competing priorities, it is not surprising that many facilities report dwindling attention to such biological threats.

Maintaining preparedness — a vulnerability

The 2018 OIG report also points to the challenges of maintaining readiness as competing priorities do little to encourage healthcare administrators to continually invest in costly preparedness resources. Even hospitals that opt to invest in biopreparedness report continued opportunities for improvement. A recent assessment of the New York City hospital emergency department’s response to patients potentially infected with highly contagious or special pathogens revealed considerable gaps, even among hospitals classified as Ebola treatment centers. From December 2015 through May 2016, 49 New York City hospitals participated in 95 drills regarding measles and MERS-CoV scenarios. 39% of hospitals failed at least one drill and there were considerable infection prevention failures. Patients were appropriately masked and isolated in 78% of drills and infection control measures occurred more frequently when
travel history was obtained (88% vs. 21%) [19]. The focus on travel history as a precursor for initiating masking and isolation reveals a major weakness: a dependence on international travel to consider advanced isolation for patients, which requires the healthcare worker to ask and the patient to be forthcoming. Ultimately, they found that infection prevention practices were poor, with correct hand hygiene performed 36% of the time, and only 16% of staff showing patients how to perform hand hygiene. Moreover, in 80% of the drills that required patient isolation, the proper isolation signage was only posted on the patient’s room 70% of the time and staff wore the correct PPE 74% of the time [19]. These failures indicate not only suboptimal infection control compliance, but point to a continued lack of preparedness for infectious disease threats, whether they be rare or more common infections. The internal priorities of each hospital administration likely vary, but researchers have found that a majority of IPC programs reported a lack of administrative commitment to additional resources once an outbreak has ended [16]. While there are now designated hospitals to treat patients with special pathogens and many infection preventionists report that their facilities are more prepared, this survey was completed in 2015 and it is questionable if hospitals are still maintaining such efforts.

Addressing this vulnerability through a six-hospital system in Phoenix, AZ

Despite this stark reality, in 2018, a Phoenix-based healthcare system opted to invest in high-consequence disease preparedness. From performing a gap analysis to the creation of a subcommittee with key stakeholders, this was an endeavor that required considerable administrative support and financial investment.

Nestled across the metropolitan area of Phoenix, Arizona, exists a five-, soon to be six-hospital system with over 100 outpatient clinics and offices. The second largest hospital system in the state and the city of Phoenix, it includes three level-one trauma centers, representing a significant portion of the healthcare resources in Phoenix. In spite of the considerable investment during the Ebola response from 2014 to 2016, general biopreparedness had grown stagnant and there were no exercises planned for the immediate future.

In late 2018 though, following a shift in leadership and staffing within the IPC program, there was a renewed interest in assessing and improving overall infectious disease preparedness within the hospital system. All of the hospitals within the system fell in the category of frontline hospitals within the tiered special pathogens hospital program, meaning that the expectation was that they should be able to identify, isolate, and inform of any suspected patients with a special pathogen. Moreover, the expectation was these hospitals would have the capability to care for such patients for 24 h. The hospital system is also categorized as a non-profit, private health system and is not affiliated with
state or federal hospitals. There are roughly 1340 in-patient beds across the system, including multiple intensive care units, a neonatal intensive care unit, several oncology units, and a military partnership for emergency preparedness. Early on, it was decided that investing in biopreparedness also meant investing in infection prevention efforts, as enhanced measures build upon foundational practices.

**Gap analysis**

The first step in addressing vulnerabilities was to establish a gap analysis to understand the existing state of readiness within the hospital system. Staff had not received training for high-consequence disease response since 2014 and that training was specific to Ebola. Since this was the most recent training and education provided, it was decided that Ebola would be used as the test-scenario in the gap analysis. The analysis included questions based on guidance from the CDC for the management of PUI as well as algorithms created by the Arizona Department of Health Services in 2014.

While relatively broad, the gap analysis aimed to assess processes and knowledge starting in the Emergency Department admission and triage process. The survey of staff mimicked what the admission of a PUI and the role of various departments and stakeholders. Staff within the emergency department were asked a range of questions that tested their knowledge of response algorithms, communication, which patient rooms were to be used, PPE, and waste management, among other relevant processes. Those surveyed included emergency department staff, nurses, and physicians, laboratory personnel, environmental services, materials management, security, facilities, IPC specialists, and also included a review of the electronic medical records system.

The gap analysis involved 44 components and ultimately identified several considerable gaps within the system [20]. The emergency department staff represented the biggest vulnerability. Staff were questioned on how they would respond to a febrile patient with a travel history to an Ebola-affected region. While there was a travel screening question asked in triage, staff did not commonly ask about recent international travel if the patient presented with symptoms that were not consistent with an infectious etiology. Intake staff within the emergency departments were aware of the importance of documenting travel history but no staff at any of the facilities could speak to how they would respond if a patient had a relevant travel history and symptoms that could indicate EVD or another high-consequence pathogen. Of those surveyed staff, 60% were able to vocalize a proper communication strategy but only 20% noted that the process involved contacting an infection preventionist.

Staff were aware of an algorithm for response but could not speak to its location. Across all staff, there lacked an ability or comfort in skills to don and doff the appropriate PPE and all requested additional training. A majority of
staff were able to indicate the designated rooms for patients under investigation, but only 80% were airborne infection isolate room (AIIR) or negative pressure, and all spaces required the construction of an ante-room or containment zone to block off the area and allow for enough space for PPE donning, doffing, and patient care within a designated, sectioned area. Only one hospital had a non-negative pressure room designated for a patient under investigation and staff vocalized that this was chosen due to the direct route from triage to the room, thus minimizing exposure during transport.

In terms of personal protective equipment, each hospital had been provided with enhanced equipment for the Ebola response in 2014, in the form of a cart that was a repurposed code cart. This cart included the necessary PPE, directions for donning/doffing, and overall guidance for patient assessment. When evaluated, none of the hospital staff could vocalize the location of the PPE, with 80% of the carts being held within a locked room in the basement location of materials management. There was no clear ownership of the cart and responsibility for ensuring it was stocked with non-expired goods represented a consistent administrative failure. Each party thought it was managed by another department, which rendered the carts inaccessible, out of date, and often with limited supplies.

Beyond the emergency departments, medical management for PUIs represented a significant hurdle as there was no specific plan for the care of patients and treatment was dependent on healthcare workers volunteering. Moreover, there were no plans for the transfer of a PUI from the hospital to another should they require a higher level of care. All guidance related to Ebola response outside of the designated carts was in binders within the IPC department and had not been reviewed since 2014. Fortunately, the systems for acquiring additional PPE within 24 h were in place. Interestingly, the existing waste management containers and contracts for Ebola-associated waste were considered to still viable. However, upon further review, the contracts were no longer valid. Laboratory staff were able to communicate the process and materials necessary for shipping samples to the CDC or state laboratory, as well as point-of-care testing equipment for use within the patient’s room. There were no specific plans to incorporate security services into the process to ensure limited access to PUIs and the care area. Lastly, a survey of infection preventionists revealed that a majority felt they could mostly manage PUIs but required a refresher of the materials, as they had not reviewed processes for several years. Moreover, the infection preventionists all asked for additional training to ensure they were effective as subject matter experts during the care of PUIs.

Overall, the gap analysis found considerable vulnerabilities but none that were particularly surprising given the time that had passed since 2014 efforts. The next phase though would prove to be the most challenging — establishing a network-wide subcommittee and attacking the list of opportunities.
Development of a high-consequence disease subcommittee

Following the findings of the gap analysis, it was determined that to respond to each opportunity, a large, multi-disciplinary high-consequence disease (HCD) subcommittee would be established across the healthcare system. Ultimately, without the support of hospital leadership, this would not have been possible. Operationalized and managed by the IPC program, members/key stakeholders included infection prevention, laboratory, medicine, nursing, human resources, information technology (IT), environmental services, facilities and environmental controls, education, emergency department and critical care, supply chain, and emergency preparedness.

The subcommittee began meetings on a monthly basis and presented both the gap analysis but also the objectives and goals — to enhance preparedness for high-consequence diseases across the hospital system. Based on quarterly goals, these included addressing vulnerabilities identified within the gap analysis, creating educational and training sessions for frontline staff, establishing a drill timeline, and building PPE kits for each healthcare campus. It was determined early on, that while there was a critical and timely need to educate frontline staff, the subcommittee’s efforts would focus on sustainable preparedness as a key goal.

The first priority within the HCD subcommittee was to communicate to key stakeholders what high-consequence diseases were and why they posed a risk to the continuity of care within the healthcare system. Providing the findings of the gap analysis allowed stakeholders to have a role and responsibility within the subcommittee and ultimately, deliverable action items. The HCD committee established goals and monthly meetings that focused on specific topics within the readiness of the healthcare system and having stakeholders report on their efforts (e.g., facilities and the testing of barriers to create anteroom-containments outside of designated HCD patient rooms for the doffing of PPE). Each meeting focused on providing updates regarding work completed and highlighted on a specific stakeholder’s work to address the vulnerabilities.

In conjunction with this work, one of the infection preventionists was identified as the point person for supporting such efforts based upon their background in biopreparedness. From this, a HCD plan was developed as a point of reference to incorporate guidance, resources, and processes should a patient with a high-consequence disease be treated. The plan focused on two key approaches to HCD readiness: the i3 strategy (identify, isolate, and inform) and presenting three potential forms of high-consequence pathogens (i.e., viral hemorrhagic fevers, airborne organisms, and Disease X). The presentation of the three high-consequence disease categories was intended to help guide response efforts for staff based on disease transmission mechanisms and the respective response efforts required. Moreover, the inclusion of Disease X was an effort to acknowledge that there will likely be an emerging
infectious disease in the future with a response that will be characterized by evolving guidance and response measures. The inclusion of Disease X in this strategy proved to be quite helpful during the early weeks of the COVID-19 outbreak.

The HCD plan was created to document the process changes identified within the gap analysis, but also to act as a singular reference for response efforts. The plan was made available online within an internal webpage and included a range of information, from CDC guidance on waste removal and disposal, to the steps required for donning and doffing PPE, lists of individuals to include in notifications, a reference guide, and lists of the designated HCD rooms within each emergency department and what the anteroom-containment barriers looked like. The goal of the plan was to ensure all the CDC-supported guidance was available in a single document to avoid confusion, delay, and missteps. Guidance documents from the Occupational Safety and Health Administration and the National Ebola Training and Education Center were also included and enhanced the HCD plan by ensuring its utility and applicability to the health systems. Moreover, pieces from each key stakeholder (e.g., laboratories) were updated to match the internal processes and provide detailed guidance that was relevant to the hospital system, compared to overarching, non-specific guidance from CDC. Lastly, the plan also established a goal of creating a Provider Response Team, which would be a voluntary team of nurses, physicians, and respiratory therapists who would undertake additional training and provide the majority of care for PUI to relieve frontline staff. One of the most important goals within the plan and the subcommittee was to provide HCD training (i.e., an overview of HCDs, internal processes, enhanced PPE training) for over 90% of the emergency department staff and urgent care providers (i.e., nurses, physicians, and respiratory therapists). The decision was made to focus the PPE section of the HCD training on enhanced PPE for Ebola and other viral hemorrhagic fevers, as it was the most complicated and utilized the least by healthcare workers. Isolation precautions for airborne diseases, like MERS-CoV, rely on PPE and isolation precautions that staff are more comfortable with, such as N95 masks and airborne isolate rooms. Prior to initiating this training though, it was critical to establish up-to-date PPE kits and ensure there was a continued supply chain.

**Enhanced personal protective equipment kits**

One of the first tasks of the HCD subcommittee was to ensure the supply of enhanced PPE as existing stocks were incomplete, inaccessible, or outdated. The infection preventionist HCD coordinator worked with the system-level supply chain to establish a list of necessary PPE and the volume that should be made accessible to each hospital campus for both training and actual patient care.
Surprisingly, this task proved to be challenging as much of the attention to Ebola enhanced PPE had diminished over the years and there was no longer such a keen interest from manufacturers. There were considerable challenges associated with finding appropriate surgical hoods, testing full-body suits versus gowns, and identifying the most universal-fitting, fluid impermeable boot covers. These challenges proved to be time-consuming and resulted in delays. Based on financial stewardship and training capacity for staff, it was decided to use N95 masks instead of powered air-purifying respirators. The identification, testing, and acquisition of equipment for enhanced PPE kits proved one of the more challenging endeavors despite considerable support from the hospital’s supply chain director. In the end, it took over six months to identify the necessary PPE materials so that they could be built into kits for each campus. It was determined that each hospital would receive 60 kits – with 5 readily kits available in both the emergency and urgent care departments.

Harnessing the power of the electronic medical records

During this time, efforts to utilize electronic medical records (EMR) were made a priority. A sub-group of the HCD subcommittee, including members from IPC and IT, worked to refine an existing tool within the EMR that inquired about international travel upon admission. The work of this group allowed for modifications based on ongoing outbreaks and a better, more real-time alert for medical providers. Alerts were created in coordination with the EMR team and IPC, and were alerted providers of relevant outbreaks going on around the world. These alerts, known as a Best Practice Advisory (BPA) drew from CDC travel alerts determined to be Level 2 or higher. Upon answering a question regarding the history of international travel within 28 days, admitting staff would be prompted to indicate where the patient had traveled. If they noted that the patient traveled to an area with an existing alert (e.g., Wuhan City – COVID-19), a BPA would appear and alert the medical provider. Staff could then choose to order isolation precautions or acknowledge the BPA, which would then mute it. If the BPA was acknowledged, it would no longer alert that provider but would continue to alert others. Further, should the patient become febrile during their admission, it would re-prompt the BPA for medical providers. Within the BPA, it was noted to communicate with IPC and provided their contact information. The BPA alerts though were dependent upon the admitting provider indicating which country the patient had traveled to, which required additional education and communication efforts to ensure this step was not missed. The goal of the alert was to notify staff of existing outbreaks that they might consider both infection prevention efforts, but also diagnostics. Should a patient have a travel history to an area of an outbreak, the hope was that the BPA would encourage healthcare workers to isolate the patient to determine symptoms and risk for infection.
Environmental controls

A core component to preparedness and response for infectious disease events in a healthcare setting is that of engineering controls. The ability to build the anteroom-containments outside of designated HCD rooms and ensuring negative pressure is an easily forgotten task. One of the first tasks within the subcommittee was to ensure that all AIIR were functioning and maintaining true negative pressure, which required evaluation by a third-party vendor. Such efforts across multiple hospitals are neither easy nor inexpensive. Fortunately, the utility of AIIR extends beyond HCD efforts, and making the case for their evaluation was not difficult. Each hospital had at least one AIIR within the emergency department that would serve as the location for the care of a HCD patient with an airborne infection. However, if a patient was under investigation for a viral hemorrhagic fever, the room might change based upon the need for an anteroom-containment and other unique patient care components like a private bathroom.

A second component relating to environmental controls was the ability to rapidly build anteroom-containments outside of the designated HCD rooms. Those specific rooms were chosen in conjunction with emergency department directors, IPC specialists, and facilities, to ensure the best space was selected based on negative pressure, private bathrooms, continuity of care within the emergency department, and ease of patient transfer. As not all AIIR were designed to have private bathrooms, it was decided that should a patient with a viral hemorrhagic fever present to the hospital, it was ideal to have a private bathroom versus negative pressure, as the risk for healthcare workers was higher in removing human waste from a bedside commode than of aerosol-generating procedures. Such decisions required the consideration of varying risk categories and were not made lightly but represent the limitations that exist in many frontline hospitals. Ultimately, it was decided to work toward converting these designated rooms to negative pressure within the next year.

Once the designated room was chosen for a potential viral hemorrhagic fever patient, the infection preventionists at each hospital worked with the emergency department director and facilities to establish drills to build an anteroom-containment outside the space. These tests were conducted to ensure that materials were available, determine the time required for construction, and take photographs for inclusion into the plans as a source of reference. Coined “the barrier build,” these drills acted as valuable teaching moments for not only the staff in the emergency department but also those facilities engineers helping to build the anteroom-containment. As each hospital and emergency department is unique, it was important to account for the variances that might impact patient care and staff safety.
Network-wide communication

During the establishment of the HCD subcommittee, it was determined that network-wide communication of their efforts should be provided to all facilities in the system. To this end, a logo was developed by the communications and marketing departments to help staff identify efforts that were associated with the HCD group. Further, on several occasions, the infection preventionists at each hospital campus would present at campus-wide meetings on the subcommittee, its efforts, and upcoming training opportunities.

Network-wide awareness of the HCD efforts was an important factor in not only ensuring support, but also for ensuring awareness among thousands of employees. Moreover, this provided an opportunity to discuss the PPE that was selected and ordered, and the approach of having a small “grab and go” supply in the emergency department with additional kits available elsewhere. Additional communication was provided by the IPC network director to hospital leadership as a means to fostering support for staffing training efforts. Updates on the HCD subcommittee were also provided at the bi-monthly meetings of the IPC committee.

Training — where to begin?

At a network level there was a desperate need to address HCD education and training but ambiguity about where to begin these trainings. The goal was to ensure all frontline staff had experience with enhanced Ebola PPE, could speak to relevant processes (e.g., i3), and locate additional materials. Thus, it was decided that instructional lectures would not only discuss what HCDs were but also the differences in response measures and isolation precautions. It was also decided that trained infection preventionists acting as the instructors would discuss the support system for those caring for patients and the plan to incorporate response teams for relieving frontline staff. This was the time to reinforce patient safety measures while ensuring staff felt supported by both processes and the HCD subcommittee efforts. Additionally, after instruction, staff would spend time learning to don and doff enhanced Ebola PPE and also perform routine tasks while wearing PPE to experience the limitations in dexterity and challenges of common medical movements.

The training was developed by IPC specialists and based upon lessons learned from 2014 efforts, experiences at the CDC, and resources made available via the National Ebola Training and Education Center. Feedback on the training was provided from nursing educators and frontline staff. Continuing education credits were also made available through the hospital’s nursing education program. Furthermore, it was decided that the training would be provided at each hospital campus and urgent care clinic, limited to 90 min (i.e., a 20 min lecture, 60 min for PPE donning/doffing, and 10 min for questions), and provided in the morning and evenings to account for morning
and night shifts and to ensure that attendance would limit disruptions to healthcare services. The expectation was that infection preventionists would provide the training, as would nursing educators who attended training at the Center for Domestic Preparedness and went through additional training with IPC.

Perhaps the most challenging aspect of education and training was ensuring staff attendance. As this curriculum was not finalized until the fall of 2019, ensuring frontline staff attendance during a severe respiratory virus season was not ideal. There were challenges in ensuring staff attendance as it was not mandated from nursing leadership but rather encouraged. IPC had to work closely with nursing and medical leadership at each hospital to ensure support and administrative push to ensure 90% of frontline staff received training. Competing priorities and a heavy educational burden on nursing staff meant that HCD training was not a major priority for many. Moreover, since this training was not a regulatory requirement, it was often left to the discretion of the emergency department director to promote and enforce attendance.

An unanticipated real-world drill

In the middle of the HCD subcommittee efforts, a unique situation occurred—a patient presented with gastroenteritis and travel history to the Democratic Republic of the Congo, which at the time was experiencing an outbreak of Ebola. In the fall of 2019, a patient came presented to the emergency department reporting recent travel history and signs and symptoms consistent with the screening criteria recommended by the CDC. At this point on the high-consequence disease preparedness efforts, the subcommittee had been established, met a handful of times, and PPE kits were being ordered. The only operational aspect though was the BPA alert within the electronic medical record system.

Still, the patient was rapidly isolated and the IPC team was notified. While most of the PPE for Ebola was outdated or inaccessible, the ongoing work of the infection preventionists at that hospital campus meant that PPE kit samples provided to the hospital prior to purchasing were available for use. By luck, the two infection preventionists at the campus had recently been training on Ebola PPE donning and doffing steps because of attendance at a training at the CDC. The infection preventionists guided the facilities team to build an anteroom-containment around an AIIR within the emergency department, allowing staff to doff PPE inside the anteroom-containment according to CDC guidelines. Over the course of the next 24 h, the patient was evaluated and cared for by a single nurse on 12-h shifts. The IPC team stayed with the medical providers to ensure they had a PPE assistant to guide donning and doffing efforts. There were delays in establishing communication with the local and state
public health entities and challenges in determining what laboratory testing would be provided both internally and externally to determine the clinical state of the patient. Overall, the challenges in identifying and isolating the patient ultimately did not prove to be the weak points in response, but rather the coordination with local public health authorities and determining what tests laboratory staff felt comfortable performing despite public health officials feeling the patient was of low-risk for Ebola. Ultimately, the patient was found to have a common diarrheal illness and public health authorities felt he was of low-risk due to the geographical area of his travel abroad and the work he was doing. Roughly 30 h after his admission, he was discharged from the hospital.

An after-action review of the event proved to be helpful in terms of opportunities for improvement. Several key lessons were learned, mostly with regard to laboratory and waste management considerations. The determination of what laboratory tests could be safely completed in the hospital versus what the health department requested proved disorienting. Moreover, there was generalized confusion across all sectors regarding what labs needed to be drawn for Ebola testing and the transportation process. As a result of these issues, extensive work was done with the hospital systems’ laboratories to determine and establish protocols for what could be completed if the patient was of a greater risk category, but also establish point of care testing protocols. In terms of waste management, the previous contracts from 2014 were no longer viable and while the patient was ultimately determined not to be of risk for Ebola, had the waste required true decontamination efforts consistent Category A waste, it would have required an entirely new contract and thus a delay in waste remediation. Other smaller stresses were apparent during the event, such as information management and security around the area as paramedics and non-hospital employees in the emergency department sought to obtain information. While these were stressful lessons learned at the time, they proved extremely helpful for building better response and preparedness efforts.

**COVID-19 — a test of existing efforts**

In early 2020, news of a novel acute respiratory condition in Wuhan, China, began to prompt concern internationally. Within a matter of weeks, the first case of the disease now called COVID-19, caused by the novel coronavirus SARS-CoV-2, was identified in the United States. Hospitals across the country went on alert and worked to prepare for potential cases as tens of thousands were identified in the Chinese epicenter of Wuhan. Fortunately, the existing HCD infrastructure within the healthcare system had laid the groundwork for response efforts within the hospital system. Early on, there was network-wide communication regarding the outbreak, symptoms, i3 efforts, guidance for testing based on CDC criteria for PUI, and communication resources.
Within 2 days of the first case in the United States, the aforementioned communication was sent to staff and leadership. Infection preventionists at each campus were rounding in the emergency departments to ensure they were informed and prepared to identify and isolate potential patients. Daily nursing huddles ensured IPC efforts could provide instant updates and answer questions promptly. During this time there was concern regarding international PPE supplies, so the HCD subcommittee worked with supply chain stakeholders to acquire more masks and conduct daily assessments of supply levels. A new and enhanced BPA was created via the electronic medical record team to screen for not only travel to the relevant areas, but also send alerts that briefly explained the outbreak, the need for isolation precautions, symptoms, CDC criteria for testing, and instruction to call IPC immediately. This BPA was available for both inpatient and outpatient admitting documentation. If triggered, the BPA would allow providers three options — order isolation precautions, determine the patient did not meet criteria (i.e., no symptoms, etc.), or defer for chart review but would continue to alert until cleared. The EMR team was also able to tie the BPA alert to a text message and email that would be sent to the entire IPC team. This rapid alert ensured all cases were reviewed by an infection preventionist, but also that a more proactive response could be established, which helped frontline staff to feel more supported.

The following week and with the first COVID-19 case identified in Arizona, weekly meetings were established with an expanded HCD subcommittee attendee list. Meetings initially lasted 2 h to provide an overview of the situation and updates from each stakeholder (e.g., supply chain, updates on AIIR functionality, etc.), but these were reduced to 45 min to address weekly progress and needed resources. Shortly after it was announced that there was a case identified in Phoenix, AZ, several hospitals became inundated with not only close contacts of the case, but also worried individuals as well. This proved to be challenging for both frontline staff and IPC but was beneficial as it provided educational opportunities and opportunities to establish a better response. Several meetings were scheduled daily to establish working groups to address everything from communication to testing and surge capacity efforts. As community transmission became apparent in early March 2020, it was decided that more IPC rounding and education were required. Managing PPE supply strains also proved to be difficult and communication regarding the re-use and extended use of N95 masks was made a priority. Ultimately, it was found that the existing HCD subcommittee efforts and infrastructure helped lay the groundwork for COVID-19 response and as a result, attendance for the HCD training skyrocketed during this time.

The efforts of the HCD subcommittee would not be possible without the dedicated members, but also the support of the IPC director and those dedicated infection preventionists. While such efforts should not be dependent upon the passion and dedication of a select few, without their steadfast desire to enhance preparedness and response, these efforts would not be possible. The
decision to focus resources and efforts on biopreparedness helped to ensure that a rapid system-wide response to COVID-19 was possible. The investment in hospital preparedness for biological threats should be seen as an investment in not only infection prevention and patient safety, but a reduction in vulnerabilities to unanticipated infectious disease events. As public health and healthcare are uniquely intertwined and intrinsically reliant on each other, these efforts helped not only strengthen this relationship, but reduce the burden when COVID-19 cases surged in the United States in June and July of 2020.

In truth, no hospital system is fully prepared for a pandemic and the nuances that come with it. COVID-19 was no different, but efforts to enhance readiness and reduce the strain in healthcare yielded benefits that trickled into public health. A hospital more prepared is one that can help reduce community cases by avoiding hospital-associated infections in patients and staff alike. Focus on enhancing laboratory capacity internally eased the burden of local labs and sped up patient notification, while focusing on PPE utilization and sustainable approaches helped keep healthcare workers safe and the hospital operational. Enhancing alerts and diagnostic capacity translated to faster reporting to local health departments, which helps speed up contact-tracing. All of these initiatives not only build internal readiness and response to biological events but also strengthen local public health and help reduce pressures on those critical resources.

References

[1] World Health Organization. WHO MERS-CoV global summary and assessment of risk. Geneva: WHO; 2017.
[2] Popescu S. Arizona reopened too fast. In: Epidemiologists knew it, but we couldn’t stop it. The Washington Post; July 20, 2020.
[3] Mantovani C. Over 90,000 health workers infected with COVID-19 worldwide: nurses group. Reuters; May 06, 2020.
[4] Gupta AG, Moyer CA, Stern DT. The economic impact of quarantine: SARS in Toronto as a case study. J Infect 2005;50:386–93.
[5] Keogh-Brown MR, Smith RD. The economic impact of SARS: how does the reality match the predictions? Health Pol 2008;88:110–20.
[6] Sun LH. Cost to treat Ebola in the U.S.: $1.16 million for 2 patients. The Washington Post; November 18, 2014.
[7] Brown T. Dallas nurses say infection control ignored in Ebola care. Medscape; October 15, 2014.
[8] Hayden EC. Biodefence since 9/11: the price of protection. Nature 2011;477:150–2.
[9] Isidore C, Alesci C. Dallas hospital hit by Ebola losing patients and money. CNN Money; October 17, 2014.
[10] Wallace LS. A view of health care around the world. Ann Fam Med 2013;11:84.
[11] American Hospital Association. 2020 fast facts on U.S. Hospitals. Chicago: AHA; 2020.
[12] U.S. Department of Health and Human Services Office of Inspector General. Hospitals reported improved preparedness for emerging infectious diseases after the Ebola outbreak. U.S. Department of Health and Human Services; October 16, 2018.
Berman M, Brown D. Thomas Duncan, the Texas Ebola patient, has died. The Washington Post; October 08, 2014.

Herstein JJ, Biddinger PD, Kraft CS, Saiman L, Gibbs SG, Smith PW, et al. Initial costs of Ebola treatment centers in the United States. Emerg Infect Dis 2016;22:350–2.

World Health Organization. Ebola health worker infections. 2020. www.who.int/features/ebola/health-care-worker/en. [Accessed 20 July 2020].

Morgan DJ, Braun B, Milstone AM, Anderson D, Lautenbach E, Safdar N, et al. Lessons learned from hospital Ebola preparation. Infect Contr Hosp Epidemiol 2015;36:627–31.

Smit MA, Rasinski KA, Braun BI, Kusek LL, Milstone AM, Morgan DJ, et al. Ebola preparedness resources for acute-care hospitals in the United States: a cross-sectional study of costs, benefits, and challenges. Infect Contr Hosp Epidemiol 2017;38:405–10.

Popescu S. Outbreaks of lethal diseases like Ebola and the Wuhan coronavirus happen regularly. The US government just cut funding for the hospitals that deal with them. Bulletin of the Atomic Scientists; January 22, 2020.

Foote MM, Styles TS, Quinn CL. Assessment of hospital emergency department response to potentially infectious diseases using unannounced mystery patient drills — New York City, 2016. MMWR 2017;66:945–9.

Popescu S, Leach R. Identifying gaps in frontline healthcare facility high-consequence infectious disease preparedness. Health Secur 2019;17:117–23.