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Experience of Chicagoland acute care hospitals in preparing for Ebola virus disease, 2014–2015

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ABSTRACT

During the 2014–2015 Ebola virus disease (EVD) outbreak, hospitals in the United States selected personal protective equipment (PPE) and trained healthcare personnel (HCP) in anticipation of receiving EVD patients. To improve future preparations for high-consequence infectious diseases, it was important to understand factors that affected PPE selection and training in the context of the EVD outbreak. Semistructured interviews were conducted with HCP involved with decision-making during EVD preparations at acute care hospitals in the Chicago, IL area to gather information about the PPE selection and training process. HCP who received training were surveyed about elements of training and their perceived impact and overall experience by email invitation. A total of 28 HCP from 15 hospitals were interviewed, and 55 HCP completed the survey. Factors affecting PPE selection included: changing guidance, vendor supply, performance evaluations, and perceived risk and comfort for HCP. Cost did not affect selection. PPE acquisition challenges were mitigated by: sharing within hospital networks, reusing PPE during training, and improvising with existing PPE stock. Selected PPE ensembles were similar across sites. Training included hands-on activities with trained observers, instructional videos, and simulations/drills, which were felt to increase HCP confidence. Many felt refresher training would be helpful. Hands-on training was perceived to be effective, but there is a need to establish the appropriate frequency of refresher training frequency to maintain competence. Lacking confidence in the CDC guidance, interviewed trainers described turning to other sources of information and developing independent PPE evaluation and selection. Response to emerging and/or high consequence infectious diseases would be enhanced by transparent, risk-based guidance for PPE selection and training that addresses protection level, ease of use, ensembles, and availability.

KEYWORDS

Ebola virus disease; healthcare personnel training; high-consequence infections; occupational health; personal protective equipment; qualitative research; standard precautions

Introduction

Though the last major threat of Ebola virus disease (EVD) in the United States occurred in 2014–2015, acute care hospitals must remain prepared to respond to outbreaks of high-consequence infections. Although classified as low global risk, the current EVD outbreak in the Democratic Republic of Congo (Congo), combined with the recurring emergence of high-consequence infections (e.g., Severe Acute Respiratory Syndrome [SAR], Middle East Respiratory Syndrome, 2009 H1N1 influenza), highlights the need for ongoing preparations.[1] Healthcare personnel (HCP) are particularly vulnerable to occupationally-acquired infection during outbreaks of emerging infectious diseases, including EVD and SARS owing, perhaps, to uncertainty about the route of transmission and necessary personal protective equipment.[2,3] After the infection of two HCP with EVD, for example, the Centers for Disease Control and Prevention (CDC) revised their recommendation for personal protective equipment (PPE) to eliminate skin exposure, though PPE guidance continued to be updated through 2016.[4,5]

The purpose of this study was to understand how acute care hospitals in the Chicago, Illinois area prepared for the 2014–2015 EVD outbreak, focusing on issues related to occupational health. More specifically, questions included: 1) how PPE ensembles were selected, 2) considerations for PPE acquisition and use, and 3) how training in the use of PPE ensembles

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and EVD patient care was developed and delivered. While there is a growing body of literature describing preparations for the 2014–2015 EVD outbreak, this study is unique because it allows comparison of experiences across different types of acute care hospitals (with different roles in the regional EVD plan), and between HCP who planned and received training.[6–9] The study objectives were achieved using semistructured interviews with HCP involved with EVD preparations, and surveying HCP who participated in training for the use of enhanced PPE ensembles for EVD.

Methods

Interviews of trainers/PPE selectors

Twenty-six of the 71 acute care hospitals in the Chicago area were selected for recruitment using a purposeful sampling strategy (Table 1). Hospitals were classified into categories based on their role in the regional EVD response plan (Ebola Treatment Center [ETC] or Ebola Assessment Center [EAC] and non-ETC/EAC), type, location, and size (small with <250 beds, medium with 250–500 beds, and large with >500 beds). In each category, if there were ≤ 4 hospitals, all hospitals were selected for recruitment; otherwise, four hospitals were randomly selected. Two hospitals were excluded from analysis because members of our research team were involved in EVD preparations at these hospitals.

Individuals were eligible for participation if they were employed at a Chicago area acute care hospital and participated in decision-making about PPE and/or contributed to the design or delivery of training during the 2014–2015 EVD outbreak. Participation in the interview was incentivized by a $30 gift card. Attempts were made to contact up to eight individuals (up to three phone calls and three e-mails each) at each hospital, starting with individuals in infection prevention or emergency management. One to three individuals were interviewed at each hospital between September 2016 and February 2017. When more than one individual participated from a hospital, attempts were made to identify people with different disciplinary training and/or role in EVD preparations.

A semistructured interview guide was prepared.[10,11] Questions and follow-up probes were organized into four domains: participant characteristics, institution organization and culture, training experiences, and experience with personal protective equipment. The interview guide is available in the online supplemental materials. Interviews were performed over the telephone, digitally recorded and transcribed. Interviews were periodically reviewed to evaluate saturation of question or topic and identify the need for further probes for clarity.[12]

A codebook for the interview transcripts was developed iteratively and validated by application to selected interviews by five investigators with tabulation of inter-rater reliability.[13] The final codebook is included in the Online Supplemental Materials. Final coding was performed on each interview transcript by two people, with a third adjudicated conflicting codes to select the five most relevant codes or subcodes for each response.

The focused conversation method was used for group analysis of coded text: Two analysis meetings were conducted focused on the objectives related to PPE and training, respectively.[14] The focused conversation method involves the group addressing a series of objective, reflective, interpretative, and decisional questions. More details are provided elsewhere, and the conversation guides are included in the Online Supplemental Materials.[15] Observations and themes identified in the focused conversation were further explored by identifying text that supported and challenged the findings, including identification of illustrative quotes.

Quantitative data from interviewed trainers is described at the hospital level by the percentages of hospitals interviewed.

Table 1. Trainer interview recruitment and enrollment.

Hospital Classification	Number of Hospitals			Number of Trainers Interviewed and Analyzed
	Identified	Targeted	Recruited	
Ebola Treatment Center	4	4	4	11
Ebola Assessment Center	2	2	1	1
Veterans' Administration Hospital	3	3	1 (1[A])	1
Other Academic Medical Center	1	1	0 (1[A])	0
Medium Urban Hospital	13	4	1	1
Small Urban Hospital	12	4	4	5
Large Suburban Hospital	2	2	1	4
Medium Suburban Hospital	18	4	2	3
Small Suburban Hospital	16	4	1	2
Total	71	26 (28*)	15 (17 *)	28

*Interview trainers at hospitals that employed study's investigators were excluded from analysis.

Survey of trainees

Referral sampling was used to recruit survey respondents. An online survey using Qualtrics XM (Seattle, WA) was distributed by the interviewed trainers to colleagues and through the State of Illinois Rapid Electronic Notification System from October 2016 to June 2017. Eligible respondents had received training in the use of PPE in the context of the 2014–2015 EVD outbreak. Survey respondents (trainees) were a different population than interviewees (trainers). The survey included 142 questions organized around six themes: 1) trainee characteristics, 2) PPE donning and doffing training received, 3) perceived impact of training, 4) training received regarding performing care activities while wearing PPE, 5) experience with specific types of PPE, and 6) experience with caring for suspected or confirmed EVD patients. Multiple choice answers were used to describe characteristics of the trainees and the training. Likert scales were used for perceived impact and experience. The survey was piloted by trainers and trainees within our research institution and iteratively adapted to the final version. The survey is available in online supplemental materials. Participation was incentivized by a $10 gift card.

The study was approved by the University of Illinois at Chicago Institutional Review Board, protocol # 2015-0900.

Results

Participant characteristics

Recruitment of trainers occurred from September 2016 to February 2017 and resulted in 28 interviewed trainers from 15 of the 26 (58%) hospitals identified for recruitment (Table 1). Trainers from additional hospitals were not recruited because preliminary review of transcripts suggested that saturation was achieved on most questions. Trainers broadly fell into the following categories: infection prevention (n = 12), emergency management (n = 8), education (n = 3), executive leadership (n = 2), biosafety (n = 1), and risk management (n = 1).

A total of 55 trainees completed the online survey between October 2016 and June 2017. Thirty-four (62%) surveyed trainees identified that they worked at academic or tertiary care centers, while the remaining surveyed trainees were from nonacademic urban/suburban hospitals (33%), VA hospitals 4%), and the fire department (2%). Surveyed trainees identified as nurses (n = 30), physicians (n = 7), other clinical personnel (n = 9), or nonclinical personnel (n = 9). The majority worked in an emergency department (44%), followed by interfacility transportation (13%).

Response to CDC guidance

Interviewed trainers from 14 hospitals identified the CDC as a source of information about PPE for use with EVD patients. CDC recommendations, however, were used with other resources including: biocontainment centers, expert consultants, in-house experts, and colleagues at other hospitals in the same healthcare network; occupational health agencies were rarely mentioned. Multiple resources were used in part owing to concern that initial CDC recommendations to use standard and contact precautions were "inadequate" or "unreliable."[16]

The evolution in CDC recommendations had significant implications: hospitals had to evolve with the recommendations, the changes decreased credibility of the personnel selecting PPE and delivering training and influenced HCP attitudes toward possible care of an EVD patient. One interviewed trainer explained that the changes from CDC "messed with our credibility." Another trainer described that changes from CDC resulted in training HCP on the use of three different PPE ensembles, which meant that "the caregivers weren't particularly happy." The overall delay in clear recommendations from CDC was felt to add "unneeded anxiety."

Impact of PPE shortages

Interviewed trainers from all hospitals indicated that inadequate PPE supply affected preparations when the CDC recommendations moved to the use of enhanced PPE ensembles.[5] The common theme was that trainers used what "we could get our hands on." Some hospitals initiated training with available equipment while waiting for preferred equipment, like powered air purifying respirators (PAPRs) and fluid-impermeable coveralls, to become available; others adapted or "cannibalized" equipment from specialty units (e.g., orthopedic surgery), such as surgical helmets with shrouds and longer gloves. Interviewed trainers from one hospital described the plan to use suits designed for hazardous materials (HAZMAT) response as a "last resort option" if they ran out of other PPE supplies. These strategies, however, could not overcome limitations in available PPE sizes, a challenge expressed by many interviewed trainers.

Limited supply of PAPRs was specifically identified by interviewed trainers from several hospitals, though

the majority of interviewed trainers described training with PAPRs. Some hospitals substituted shrouded surgical helmets for PAPRs because the helmets provided the same cooling effect as the airflow in PAPRs but included N95 respirators in the ensemble because the helmet does not provide respiratory protection. One interviewed trainer described that the hospital (non-ETC/EAC) did not have PAPRs and did not initially seek to acquire the highest levels of recommended PPE, including PAPRs, because they did not anticipate receiving an EVD patient. This was the only interviewed trainer that described the use of this type of risk-based decision making for PPE selection and training.

Some interviewed trainers from smaller hospitals felt that their hospitals were at a disadvantage relative to larger hospitals with respect to acquiring PPE. One interviewed trainer described, "We didn't have a lot of the resources that some of the bigger facilities did. […] We can't really compete with the big dogs if you will." Supply shortages were minimized among smaller hospitals that were part of a healthcare network, as interviewed trainers from networked hospitals described plans for just-in-time delivery of PPE and centralized patient care, which decreased the need for PPE stockpiling and training at the smaller hospitals.

Financial support for PPE acquisition

Interviewed trainers did not describe the cost of PPE as a limiting factor in preparations, and many cited worker safety as sole criteria for PPE selection. The resources were described in a carte blanche fashion: "we're buying the best for our employees," "the Cadillac of everything," and "I don't care what the price is we just have to do this." Interviewed trainers postulated reasons for the extent of financial support in both positive and negative terms. Positive expressions about the availability of financial resources centered on the organization's commitment to safety, "there was no hedging on the commitment of the organization for the safety of all of our employees across the board." Negative expressions centered on the organization's fear of failure, "I think they just got the money because no hospital wanted to be caught not doing anything about it."

PPE performance evaluation

Interviewed trainers from 47% of hospitals described evaluating and modifying PPE ensembles in ways characterized here as improvisation, and these activities were often described as involving the HCP who would provide care to EVD patients.

The impermeability of body coverings, including at junctions between pieces of PPE, was a common concern. Some interviewed trainers described finding it difficult to identify or evaluate fluid-impermeability ratings, describing a body covering as being made of "an impermeable-like type of material but, there's no signage or anything." Interviewed trainers from two hospitals described independently evaluating the permeability of PPE or the connections of PPE ensembles with surrogates for blood with water or Kool-Aid. An interviewed trainer described evaluating an ensemble to figure out, "How do we do this so that it doesn't leak around the edge of the Tyvek suit?" And, that after identifying a potential ensemble through a trial-and-error approach, the interviewed trainer said that staff answered the questions, "what do you think? can you get in? can you get out? how should we modify it? does this work?" Concerns extended to breaching PPE and contributed to decisions to use hooded PAPRs or shrouded surgical helmets in an attempt to prevent HCP from touching their face.

Perceptions of safety and risk

While interviewed trainers from 50% of the non-ETC/EAC hospitals felt they did not serve a population at risk for EVD, interviewed trainers from all hospitals described fear as common emotion among HCP. As one interviewed trainer described, " … [HCP] kept thinking about the nurse that was in Texas that seemed to have had all the protection that she needed but she still got exposed somehow." Fear led to decisions about PPE that some interviewed trainers characterized as "irrational." As one participant described, "[HCP] were not paying attention to the different risks between a wet and a dry patient. They heard Ebola, Ebola wet, highly contagious, everybody dies, and they wanted to be encased like a mummy." Another participant described specific requests from HCP who "said that they would refuse to take care of anybody unless they were provided with this absurd amount of protection […] not levels of PPE required or requested by the CDC … ."

Comfort and ease of use

Interviewed trainers described heat as the main factor affecting comfort during use of the enhanced PPE ensembles. Heat management motivated the use of PAPRs and shrouded surgical helmets, which move

cool air over the head of the wearer. These devices also have less impact on the visual field of the wearer than goggles or face shields. Interviewed trainers at a couple of hospitals indicated that suits for HAZMAT response were not preferred because they are hot and heavy and would be reserved for emergencies.

PPE selected

The final PPE ensembles selected at the different hospitals were quite similar, and were described by interviewed trainers as involving head-to-toe coverage consistent with the CDC recommendations for "no skin exposure".[5] The use of PAPRs and Tyvek coveralls or fluid-impermeable gowns were identified by interviewed trainers at 10 and 12 hospitals, respectively, including all ETCs. Head coverings (e.g., shrouds or hoods) were described by interviewed trainers at 4 of the 5 hospitals that did not use PAPRs. Interviewed trainers at 4 hospitals (2 ETCs), described the use of surgical helmets.

Who was trained

Interviewed trainers at 4 hospitals described training the majority of HCP at the hospital in PPE donning/doffing, regardless of whether they were expected to care for EVD patients. More commonly, interviewed trainers indicated that PPE donning/doffing training was limited to HCP anticipated to be in the patient care workflow. HCP in the emergency department were most frequently identified by interviewed trainers as recipients of PPE donning/doffing training (n = 14 hospitals interviewed), followed by environmental service workers (n = 9) and intensive care or isolation room workers (n = 5). Other HCP groups described by interviewed trainers as included in training were: laboratory, radiology, respiratory therapy, security, transportation, and emergency medical technicians.

Training for PPE donning/doffing

Training about donning/doffing PPE was described by interviewed trainers from all 15 hospitals. While a variety of training methods for PPE donning/doffing were described, interviewed trainers at the majority of hospitals interviewed indicated use of hands-on practice. This is consistent with surveyed trainees, 93% of whom reported receiving hands-on training in PPE donning and doffing in a group setting. Instructional videos about PPE donning and doffing were also identified frequently by interviewed trainers, and by 49% of surveyed trainees. Interviewed trainers from the majority of hospitals interviewed identified that existing staff participated in delivery of training about PPE donning/doffing. The staff most frequently identified included: infectious diseases clinicians and infection control personnel (53%), clinical educators (47%), and clinical staff (16%). Forty-percent of hospitals interviewed specifically described using a train-the-trainer model to distribute training.

All hospitals interviewed indicated that the ability of HCP to don/doff PPE was evaluated using observation, including return demonstration. Interviewed trainers at some hospitals described using check lists to aid observation or markers (glow germ or chocolate syrup) to evaluate self-contamination during PPE doffing. The vast majority of surveyed trainees (98%) received instructions on a specific order for donning/doffing PPE. Of the 52 surveyed trainees who indicated their ability to don/doff PPE was evaluated during training, 85% reported demonstration for trainer and 15% reported demonstration for a fellow trainee. No surveyed trainees reported taking a written quiz.

Training in patient care

Training in the care of EVD patients was described at 47% of hospitals interviewed, including the ETCs and EAC, while training in logistical protocols (intake procedures, communication protocols, etc.) were described at 73%. Surveyed trainees most frequently indicated that they received training in: cleaning patient care areas or spills (56%), transporting patients (55%), transportation of body fluids (36%), blood draw (22%), and emergency medical procedures (16%). One surveyed trainee wrote in that s/he was trained to *not* provide resuscitation to EVD patients. Five surveyed trainees indicated receiving training in the use of electronic devices, including: a Bluetooth stethoscope, telemedicine equipment, and/or iPads/tablets.

Simulations and/or drills of care activities and logistical protocols were described by interviewed trainers from the vast majority of hospitals and identified as opportunities to: increase the speed of response, increase the comfort and ease of HCP to use PPE (e.g., learning the "physical boundaries" imposed by the PPE), identify gaps in preparations, increase HCP confidence, and revise operating procedures. That is, the simulations were part of a continuous improvement process, rather than a summative assessment of HCP competency. HCP were viewed "as active learners and trainers because of their

Table 2. Responses to question on training methods and confidence in care.

Q36. What aspect of your training had the most positive impact on your confidence to care for an Ebola patient? (Rank the top 3)	Rank in Subject's Top 3 (n)	No Response	Valid Response Number for This Question
Hands-on activities in a group setting	39	0	55
Hands-on activities in an individual (one-on-one) setting	28		
Computer-based training	4		
Watching instructional video	11		
Provided training booklet	2		
Table top exercises	5		
Marker for self-contamination	8		
Trained observer	21		
A mock patient room (without tasks trainers or manikins)	8		
A simulation lab with task trainers (manikins)	10		
A patient care room	3		
Other	3		

contributions [to the care process] and what they had to say." Changes described as arising from simulations and drills included: installation of phones in patient rooms to improve communication, changes in staffing requirements, creation of a "all call" page of HCP who would respond to an EVD patient, and adoption of a risk tiered approach to PPE.

Two interviewed trainers from different hospitals described negative consequences of unannounced simulations involving mock patients. Specifically, fear among HCP during the simulation affected how they performed their work and/or resulted in emotional distress. In a hospital where the interviewed trainer noted the first drill was "incredibly stressful," the trainer described that a staff member in the patient room "panicked and tried to come out […] tried to take off his PPE and get out" during a drill.

Impact on trainees

Interviewed trainers described that fears were assuaged through "town hall" education and information sessions and through training. One interviewed trainer said town halls were used " … to keep people updated on what we learned through CDC […] because there was all sorts of […] misinformation going on." The impact of training, particularly simulation, reduced fear and led to revisions of the PPE ensembles. For example, an interviewed trainer from a hospital where HCP "wanted to be encased [in PPE] like a mummy" noted that preferences "started to change after like the 4th or 5th simulation where people were like, '[M]an, [I] can't work like this.'"

When asked to identify the three training modalities that had the greatest positive impact on their confidence to care for an Ebola patient, surveyed trainees most frequently identified: hands-on activities in group (n = 39) or individual settings (n = 28), trained observers (n = 21), instructional videos (n = 11), training in a simulated care area with (n = 10) or without task trainers (n = 8), and using markers for evaluation of self-contamination during PPE doffing (n = 8) (Table 2). The majority of surveyed trainees were very (52%) or moderately (31%) confident in their ability to don PPE and to doff PPE as instructed; and the majority (67%) reported that the presence of an observer would increase their confidence in doffing PPE as instructed. The majority of surveyed trainees were very (33%) or moderately (41%) confident in their ability to work as an individual or in a group to care for an EVD patient.

Skills maintenance

Interviewed trainers from the ETCs and two other hospitals reported that their hospital has performed some skill maintenance training since the outbreak ended (interview period September 2016 to February 2017). The value of skill maintenance was linked with the need to be "always prepared for things like Ebola" and/or a trend toward improved emergency management and business continuity planning. Barriers to skill maintenance training identified by interviewed trainers at ETCs included debate about who should be trained, and how frequently HCP should be trained. Interviewed trainers from non-ETC hospitals identified staff turnover as a barrier. The majority of surveyed trainees (58%) perceived a need for refresher training, but the perceived need for training differed with time since last training ($\chi^2 p < 0.001$). Among surveyed trainees who indicated a need for refresher training about patient care activities 48% wanted the training twice per year or more frequently, and 42% wanted the training annually.

Thirteen of the interviewed hospitals described some historical education on PPE, however many interviewed trainers described how EVD preparations made them aware of deficiencies in routine training

and use of PPE. Deficiencies included needed "clarification on how to don and doff", lack of experience with elements of the ensemble, limited training to only a subset of providers, lack of hands-on training, and lack of retraining after hire. Despite these identified gaps, interviewed trainers from only two hospitals indicated a change in routine training, specifically, new employee orientation was changed to include hands-on training in PPE donning/doffing.

Discussion

Hospitals in the Chicagoland area were resourceful in their occupational health preparations for the 2014–2015 EVD outbreak were able to select PPE ensembles they judged appropriate for the hospital's role in the regional EVD plan and trained HCP in the use of enhanced PPE ensembles and/or EVD patient care. Interviewed trainers at all hospitals interviewed indicated that at least some training involved enhanced PPE ensembles. This is consistent with the response that half of the non-ETC/EAC interviewed hospitals had some expectation of receiving an EVD patient, and with the federal policy recommending that all hospitals be able to provide care for an EVD patient for up to 24 hr.[17,18] Fortunately, only suspected EVD patients were treated in Chicagoland hospitals, so the ability of preparations to protect HCP from occupationally-acquired EVD was not tested. Our results, however, do not suggest that substantial changes in routine practices have occurred outside of ETCs that would ease preparations for the next outbreak of an emerging or high-consequence infectious disease of a similar scale, as limited refresher training is ongoing, and only two hospitals interviewed have modified routine training in the use of PPE. Interviewed trainers expressed the perception that the immediacy of the threat of a high-consequence infectious disease has decreased, which is likely a driver to decreased institutional commitment to preparedness activities, and failure to institutionalize changes resulting from lessons learned in the EVD preparations. In addition, with the 2018–2019 EVD outbreak in Congo at a low global risk, there has not been a response to initiate refresher training at non-ETCs.

Interviewed trainers were frequently critical of CDC guidance for PPE ensembles for care of EVD patients. The initial recommendations from the CDC for standard and contact precautions were perceived as inadequate, and repeated revisions created challenges for hospitals to acquire equipment and maintain trust with HCP. Lacking confidence in the CDC guidance, interviewed trainers described turning to other sources of information, particularly the biocontainment units and individuals perceived to be experts (in-house and external). Few interviewed trainers mentioned referencing occupational health agencies, such as the National Institute for Occupational Safety and Health and the Occupational Safety and Health Administration. This is disappointing as occupational health experts can contribute substantially to the prevention of infection among patients and HCP, and since the 2014–2015 EVD outbreak there has been movement to increase the availability of information about PPE from these and other federal occupational health agencies.[19–22] There remains, however, a need to provide further guidance on how to evaluate ensembles, not just individual pieces of PPE, for their level of protection against infectious diseases and for their comfort and usability.

In the face of PPE shortages and changing PPE guidance, most hospitals utilized multiple sources of information and improvised to select PPE ensembles that met their needs. This approach is consistent with the spirit of standard precautions. Standard precautions require HCP to perform specific behaviors (e.g., hand hygiene), select PPE and use work practices that are appropriate to the nature of anticipated contact with body fluids.[23] Application of standard precautions to the care of a symptomatic EVD patient leads to the enhanced PPE ensemble ultimately recommended by the CDC. More specifically, given the large volumes of body fluid emitted in late-stage EVD and the large number of sites where Ebola virus may initiate infection, it is necessary to protect the dermis, facial mucous membranes and (controversially) the respiratory tract from contact with patients' bodily fluids.[24–27] Furthermore, the high EVD mortality rate observed in Africa requires a precautionary approach to worker protection.[28] In this context, standard precautions would identify the need for fluid-impermeable PPE to protect the entirety of the dermis, the mucous membranes, and the respiratory tract. The lower rates of EVD mortality observed in the United States and Europe and improved understanding of virus shedding in the early stages of EVD could allow a change in the PPE ensemble under the standard precautions framework, such as the two-tier, symptom-based, PPE recommendations.[29,30]

The reliance on PPE to protect HCP from occupationally-acquired infectious diseases is unfortunate, as PPE is the lowest strategy in the hierarchy of controls. Research objectives for this study were focused on topics related to PPE, so other types of control

strategies employed were not explore with interviewed trainers, but a few surveyed trainees described receiving training in electronic devices to reduce patient contact, such as telemedicine equipment or Bluetooth™ stethoscopes. Since the 2014–2015 EVD outbreak, there has been evaluation of the environment and how it contributes to risk and can be optimized for protection of HCP.[31] There should be increased efforts to identify engineering and administrative controls to reduce pathogen emission and limit pathogen transport through the environment. Until that time, however, it is critical that HCP have access to and correctly use ensembles of PPE that effectively interrupt disease transmission.

Hands-on practice was the most common modality for training in PPE donning/doffing and EVD patient care activities described in our sample and was valued by trainees. Others have found that workers desire hands-on training about PPE donning and doffing, and this type of training is consistent with principles of adult education because it actively engages the worker in a realistic, relevant activity.[32–34] Hands-on training also offers opportunity for evaluation, which is particularly important when self-perceived proficiency is not correlated with performance, such as has been observed for doffing of PPE ensembles.[35] Hands-on training can provide real-time feedback to correct behaviors in the moment with observer interventions or surrogates for contamination.[36,37]

In this sample, skills maintenance training was limited and primarily occurred at ETCs. A barrier identified was debate over the appropriate frequency of training, though surveyed trainees who wanted refresher training, wanted it to occur 1–2 times annually. The annual interval for many occupational health trainings is driven by logistical concerns rather than evidence of skill retention. Training in complex activities like PPE donning/doffing may need to occur more frequently than annually.

This study is subject to a number of limitations. While this study used a stratified random sampling scheme to identify hospitals for recruitment of interviewed trainers to help ensure that varied experiences were represented, individuals declined to participate or were not responsive to recruitment efforts. Some individuals specifically cited negative experiences during the EVD preparations as a reason to not participate, which may have led to a bias in our sample towards individuals with positive experiences. However, all interviewed trainers described the period of the 2014–2015 EVD outbreak as extremely stressful, and some described negative experiences. Amongst our sample of interviewed trainers, however, there was consistency among responses, suggesting that saturation was reached for many of our questions, despite the modest sample size. The trainee survey was distributed through referral sampling, and received a small number of responses, but there is no reason to believe that interviewed trainers distributed the survey to a specific subset of potentially eligible colleagues. Given the limited sample size, inferences from the survey were limited, but findings were consistent with interviewed trainers. This mixed methods approach — an effort to triangulate the true experience of HCP involved in EVD preparations — is the strength of the research approach. By design, the study captured the experience in the Chicagoland area and was conducted after the conclusion of the 2014–2015 EVD outbreak. Thus, experiences described herein may be specific to Chicago and subject to recall bias.

A strength of our approach to this qualitative research was the use of multiple coders applying a codebook to interview transcripts and the focused conversation method for data analysis and interpretation. These methods ensured that the data were reviewed by multiple people from the research team through different disciplinary perspectives. Themes emerging from the focused conversation were verified by reviewing the interview text to identify supporting and challenging quotes and, to the extent feasible, tabulating quantitative information.

Conclusions

Though hospitals in the Chicagoland area were able to select PPE ensembles and train HCP to use these PPE ensembles while providing care to EVD patients, it is not clear that the preparations have resulted in lasting changes that will ease preparations for the next high-consequence infection outside of ETCs. Refresher training is essential for maintaining preparedness, and there is a need to determine, through research, a training interval that maintains skills while minimizing cost and administrative burden. Hospitals were able to improvise and identify other sources of information to guide PPE selection in the face of dissatisfaction with initial CDC recommendations, using an approach consistent with the philosophy of standard precautions. Occupational health agencies could and should fill the need for guidance for PPE selection and evaluation that is relevant to diverse infectious diseases, and acknowledge the need to consider: protection level, ease of use, ensembles, and availability. Such guidance could result from revisiting PPE

selection in the context of standard precautions and/or the development of a tool to guide decision making.

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Conflicts of Interest

The authors have no conflict of interest to disclose related to this manuscript.

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References

[1] **World Health Organization:** Ebola virus disease - Democratic Republic of Congo. Disease outbreak news: Update. Available at https://www.who.int/csr/don/13-December-2018-ebola-drc/en/ (accessed December, 2018).

[2] **Chevalier, M.S., W. Chung, J. Smith, et al.**: Ebola virus disease cluster in the United States - Dallas County, Texas, *MMWR*. 63:1087–1088 (2014).

[3] **Sepkowitz K.A., and L. Eisenberg:** Occupational deaths among healthcare workers. *Emerg Infect Dis. Jul. 11(7)*:1003–1008 (2014).

[4] **Department of Health and Human Services, CDC:** *Infection Prevention and Control Recommendations for Hospitalized Patients under Investigation (PUIs) for Ebola Virus Disease (EVD) in U.S. Hospitals*. Atlanta, GA: US CDC; 2016. Available at http://www.cdc.gov/vhf/ebola/healthcare-us/hospitals/infection-control.html (accessed December, 2018).

[5] **CDC:** *Tightened Guidance for U.S. Healthcare Workers on Personal Protective Equipment for Ebola*. CDC Online Newsroom. Available at https://www.cdc.gov/media/releases/2014/fs1020-ebola-personal-protective-equipment.html (accessed March, 2018).

[6] **Cummings, K., M. Choi, E. Esswein, et al.**: Addressing infection prevention and control in the first U.S. community hospital to care for patients with Ebola virus disease: Context for national recommendations and future strategies. *Ann. Intern. Med. 165(1)*:41–49.

[7] **Varma, J., D. Prezant, R. Wilson, et al.**: Preparing the health system to respond to Ebola virus disease in New York City, 2014. *Disaster Med. Public Health Prep. 11(3)*:370–374 (2017).

[8] **Phrampus, P., J. O'Donnel, D. Farkas, et al.**: Rapid development and deployment of Ebola readiness training across an academic health system: The critical role of simulation education, consulting and systems integration. *Simul. Heal. 11(2)*:82–88 (2016).

[9] **Lateef, O., B. Hota, E. Landon, et al.**: Chicago Ebola Response Network (CERN): A citywide cross-hospital collaborative for infectious disease preparedness. R.A. Weinstein, ed. *Clin. Infect. Dis. 61(10)*:1554–1557 (2015).

[10] **Mays N., and C. Pope:** Rigour and qualitative research. *BMJ. 311(6997)*:109–112 (1995).

[11] **Pope C., S. Ziebland, N. Mays:** Qualitative research in health care - Analyzing qualitative data (Reprinted from Qualitative Research in Health Care). *Br. Med. J. 320(7227)*:114–116 (2000).

[12] **Saunders, B., J. Sim, T. Kingstone, et al.**: Saturation in qualitative research: Exploring its conceptualization and operationalization. Available at https://doi.org/10.1007/s11135-017-0574-8 (accessed September, 2017).

[13] **Armstrong, D., A. Gosling, J. Weinman, and T. Marteau:** The place of inter-rater reliability in qualitative research: An empirical study. *Sociology. 31(3)*:597–606 (1995).

[14] **Stanfield, R.:** *The Art of Focused Conversation*. Gabriola Island, Canada: New Society Publishers, 2000, p. 222.

[15] **Fritzen-Pedicini, C., S. Bleasdale, M. Sikka, et al.:** Utilizing the focused conversation method in qualitative research: A team-based approach to data analysis and interpretation. *BMC Health Serv. Res. 19*(1):306 (2019).

[16] **Siegel, J.D., E. Rhinehart, M. Jackson, L. Chiarello**: 2007 *Guidelines for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings*. Available at http:/www.cdc.gov/ncidod/dhqp/pdf/isolation2007.pdf (accessed August, 2018).

[17] **Zibulewsky, J.:** The Emergency Medical Treatment and Active Labor Act (EMTALA): What it is and what it means for physicians. *Proc. Bayl. Univ. Med. Cent. 14*(4):339–346 (2001).

[18] **Centers for Disease Control and Prevention:** *Interim Guidance for U.S. Hospital Preparedness for Patients under Investigation (PUIs) or with Confirmed Ebola Virus Disease (EVD): A Framework for a Tiered Approach | Ebola Hemorrhagic Fever | CDC*. Available at https://www.cdc.gov/vhf/ebola/healthcare-us/preparing/hospitals.html (accessed April, 2018).

[19] **National Institute for Occupational Safety and Health:** *NIOSH Personal Protective Equipment Information (PPE-Info)*. Available at https://www.osha.gov/dsg/id/tab6.pdf (accessed August, 2018).

[20] **Verbeek, J., S. Ijaz, C. Mischke, et al.**: Personal protective equipment for preventing highly infectious diseases due to exposure to contaminated body fluids in healthcare staff (Review). *Cochrane Database Syst. Rev. 4*:CD011621 (2016).

[21] **Kilinc Balci, F.S.:** Isolation gowns in health care settings: Laboratory studies, regulations and standards, and potential barriers of gown selection and use. *Am. J. Infect. Control. 44(*1):104–111 (2016).

[22] **OSHA:** *Fact Sheet: PPE Selection Matrix for Occupational Exposure to Ebola Virus*. Washington, DC: U.S. Department of Labor, 2014.

[23] **The Hospital Infection Control Practices Advisory Committee, Centers for Disease Control and Prevention, Public Health Service, U.S. Department of Health and Human Services.:** Guideline for isolation precautions in hospitals Part II. Recommendations for isolation precautions in hospitals. *Am. J. Infect. Control. 24(*1*)*:32–52 (1996).

[24] **CDC**: *Ebola Viral Disease Outbreak — West Africa,* 2014. Available at https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6325a4.htm (accessed March, 2018).

[25] **Bausch, D.G., J.S. Towner, S.F. Dowell, et al.**: Assessment of the risk of Ebola virus transmission from bodily fluids and fomites. *J. Infect. Dis. 196(*S2*)*:S142–S147 (2007).

[26] **Brosseau, L.M., and R.M. Jones:** *Protecting health workers from airborne MERS-CoV — Learning from SARS*. Available at http:/www.cidrap.umn.edu/news-perspective/2014/05/commentary-protecting-health-workers-airborne-mers-cov-learning-sars (accessed March, 2018).

[27] **MacIntyre, R.C., A. Chughtai, H. Seale, G. Richards, and P. Davidson:** Uncertainty, risk analysis and change for Ebola personal protective equipment guidelines. *Int. J. Nurs. Stud. 52*:899–903 (2015).

[28] **Ngatu, N.R., N.J-M. Kayembe, E.K. Phillips, et al.**: Epidemiology of Ebola virus disease (EVD) and occupational EVD in health care workers in Sub-Saharan Africa: Need for strengthened public health preparedness. *J. Epidemiol. 27(*10*)*:455–461 (2017).

[29] **Connor, M.J., C. Kraft, A.K. Mehta, et al.**: Successful delivery of RRT in Ebola virus disease. *J. Am. Soc. Nephrol. 26(*1*)*:31–37 (2015).

[30] **CDC**. *Guidance on Personal Protective Equipment (PPE) to Be Used by Healthcare Workers during Management of Patients with Confirmed Ebola or Persons under Investigation (PUIs) for Ebola Who Are Clinically Unstable or Have Bleeding, Vomiting, or Diarrhea in U.S. Hospitals, Including Procedures for Donning and Doffing PPE | Ebola Hemorrhagic Fever*. Available at https://www.cdc.gov/vhf/ebola/healthcare-us/ppe/guidance.html (accessed March, 2018).

[31] **Zimring, C.M., Z. Matić, M.F. Wong Sala, et al.**: Making the invisible visible: Why does design matter for safe doffing of personal protection equipment? *Infect. Control. Hosp. Epidemiol. 39(*11*)*:1375–1377(2018).

[32] **Narra, R., J. Sobel, C. Piper, et al.**: CDC safety training course for Ebola virus disease healthcare workers. *Emerg. Infect. Dis. 23(*13*)*:S217–S224 (2017).

[33] **Doll, M., M. Feldman, S. Hartigan, et al.**: Acceptability and necessity of training for optimal personal protective equipment use. *Infect. Cont. Hosp. Epidemiol. 38(2)*:226–229 (2017).

[34] **Allar, P., and M. Frank-Cooper:** Use of remote video auditing to validate Ebola Level II personal protective equipment competency. *J. Contin. Educ. Nurs. 26*:244–246 (2015).

[35] **Fogel, I., O. David, C. Balik, et al.**: The association between self-perceived proficiency of personal protective equipment and objective performance: An observation study during a bioterrorism simulation drill. *Am. J. Infect. Control. 45(*11*)*:1238–1242 (2017).

[36] **Poller, B., S. Hall, C. Bailey, et al.**: 'VIOLET': A fluorescence-based simulation exercise for training healthcare workers in the use of personal protective equipment. *J. Hosp. Infect.* 229–235. Available at http://www.journalofhospitalinfection.com/article/S0195-6701(18) 30065-3/fulltext (accessed April, 2018).

[37] **Casanova, L.M., K. Erukunuakpor, C.S. Kraft, et al.**: Assessing viral transfer during doffing of Ebola-level personal protective equipment in a biocontainment unit. *Clin. Infect. Dis. 66(6)*:945–949 (2018).