ORIGINAL RESEARCH

Comparing Training Techniques in Personal Protective Equipment Use

Richard J. Salway, MD, MScDM;[1,2] Trenika Williams;[3] Camilo Londono;[4] Patricia Roblin, MS;[4] Kristi Koenig, MD;[5] Bonnie Arquilla, MD[4]

1. New York Health and Hospitals, Office of Quality and Safety, New York, New York, USA
2. Kings County Hospital Center, Department of Emergency Medicine, Brooklyn, New York USA
3. Geisel School of Medicine at Dartmouth, Hanover, New Hampshire USA
4. SUNY Downstate College of Medicine, Brooklyn, New York USA
5. Center for Disaster Medical Sciences, University of California – Irvine School of Medicine, Irvine, California USA

Correspondence:
Richard James (RJ) Salway
451 Clarkson Avenue
Kings County Hospital Center
Department of Emergency Medicine
Brooklyn, New York 11203 USA
E-mail: dr.salway@gmail.com

Conflicts of interest/funding: This manuscript was supported by a grant from the US Department of Health and Human Services (HHS) Hospital Preparedness Program (HPP) and Public Health Emergency Preparedness (PHEP) aligned Cooperative Agreements (the HPP Grant and the PHEP Grant, respectively) for the purpose of building and sustaining New York City's public health and health care preparedness capabilities. The authors have no conflicts of interest.

Keywords: disasters; emergencies; emergency medicine; personal protective equipment; preparedness; training

Abbreviations:
CBRN: chemical, biological, radiological, nuclear
EM: Emergency Medicine
EPT: Emergency Preparedness Team
HAZMAT: hazardous material
OSHA: Occupational Safety and Health Administration
PAPR: Powered Air Purifying Respirator
PGY: post-graduate year
PPE: personal protective equipment

Abstract

Introduction: Physicians' management of hazardous material (HAZMAT) incidents requires personal protective equipment (PPE) utilization to ensure the safety of victims, facilities, and providers; therefore, providing effective and accessible training in its use is crucial. While an emphasis has been placed on the importance of PPE, there is debate about the most effective training methods. Circumstances may not allow for a traditional in-person demonstration; an accessible video training may provide a useful alternative.

Hypothesis: Video training of Emergency Medicine (EM) residents in the donning and doffing of Level C PPE is more effective than in-person training.

Null Hypothesis: Video training of EM residents in the donning and doffing of Level C PPE is equally effective compared with in-person training.

Methods: A randomized, controlled pilot trial was performed with 20 EM residents as part of their annual Emergency Preparedness training. Residents were divided into four groups, with Group 1 and Group 2 viewing a demonstration video developed by the Emergency Preparedness Team (EPT) and Group 3 and Group 4 receiving the standard in-person demonstration training by an EPT member. The groups then separately performed a donning and doffing simulation while blinded evaluators assessed critical tasks utilizing a prepared evaluation tool. At the drill's conclusion, all participants also completed a self-evaluation survey about their subjective interpretations of their respective trainings.

Results: Both video and in-person training modalities showed significant overall improvement in participants' confidence in doffing and donning PPE equipment ($P < .05$). However, no statistically significant difference was found in the number of failed critical tasks in donning or doffing between the training modalities ($P > .05$). Based on these results, the null hypothesis cannot be rejected. However, these results were limited by the small sample size and the study was not sufficiently powered to show a difference between training modalities.

Conclusion: In this pilot study, video and in-person training were equally effective in training for donning and doffing Level C PPE, with similar error rates in both modalities. Further research into this subject with an appropriately powered study is warranted to determine whether this equivalence persists using a larger sample size.

Salway RJ, Williams T, Londono C, Roblin P, Koenig K, Arquilla B. Comparing training techniques in personal protective equipment use. *Prehosp Disaster Med.* 2020;35(4): 364–371.

Introduction

There has been an increased emphasis on hospital preparedness for chemical/biological/radiological/nuclear (CBRN) incidents in the preceding 20 years. Management of these incidents requires personal protective equipment (PPE) utilization to ensure the safety of victims, facilities, and providers; therefore, providing effective and accessible training in its use is crucial.[1] These concerns have largely been driven by real and perceived threats of terrorism, though accidental hazardous material (HAZMAT) incidents are far more common.[2,3] Concerns have been heightened by the 2014 and 2018-2019 outbreaks of Ebola virus disease in Africa.[4] While this emphasis has been accompanied by increased

Received: November 9, 2019
Revised: January 20, 2019
Accepted: January 28, 2019

doi:10.1017/S1049023X20000564
© World Association for Disaster and Emergency Medicine 2020.

https://doi.org/10.1017/S1049023X20000564 Published online by Cambridge University Press

government funding in the United States, such as that available through the Weapons of Mass Destruction Act of 1996, there is concern that hospitals and health care professionals are no more prepared now than previously.[5-8] In addition, it is difficult to measure preparedness. Considerable disagreement remains about the manner to best train and prepare health care providers.[6]

Personal protective equipment has an important role to play in the evaluation and treatment of patients with suspected exposure to HAZMAT, though more effective methods of exposure control exist.[4,9] Many of the challenges with PPE are thought to arise from the health care provider's ability to consistently choose the right type and size, as well as use it correctly.[3,10,11] There have been attempts to standardize the types or levels of PPE by both national organizations (including the Centers for Disease Control and Prevention [CDC; Atlanta, Georgia USA], the Occupational Safety and Health Administration [OSHA; Washington, DC USA], and the American College of Emergency Physicians [ACEP; Irving, Texas USA]) and by hospital systems.[12-16] While OSHA mandates that first receivers in hospitals receive a certain amount of PPE training, no gold standard method is dictated.[13]

Most hospitals perform a standard, annual in-person demonstration, or may occasionally use video or slide presentations.[17] However, multiple studies have also demonstrated the effectiveness of more interactive "hands-on" training methods, ranging from computer simulation to self-directed workbooks.[18-22] Kang, et al state that "evidence shows that traditional learning methods (eg, watching educational videos, learning PPE guidelines) are inferior to immersive learning methods, including active learner involvement using simulations that include feedback on performance."[17]

Nevertheless, emergency situations demanding the immediate use of PPE may not allow for the use of these more immersive methods. If a CBRN incident occurs in the middle of the night, there may not be a qualified staff member available to demonstrate to health care providers the proper application of PPE. Other training methods may be necessary.

The goal of this pilot study was to compare the effectiveness of video training versus in-person training of 20 Emergency Medicine (EM) residents in the donning and doffing of PPE.

Methods

Study Design and Setting

This was a randomized, controlled pilot trial set in the emergency department of an urban acute care hospital in central Brooklyn, New York (USA) with 376 in-patient beds and >68,000 annual emergency department visits. The study design was submitted to the State University of New York (SUNY) Downstate (Brooklyn, New York USA) Institutional Review Board and was exempted from full committee review (Protocol 1248482-1).

Description

A convenience sample of subjects was chosen from EM residents in attendance at their weekly educational conference. Twenty residents were stratified by their post-graduate year (PGY) level (two through five) and then randomized into four distinct groups, with the same number of each PGY residents in each group to minimize the possible effect of previous training exposure. The EM residents not in attendance at the conference were excluded.

Group 1 and Group 2 acted as the experimental groups and were shown a nine-minute video presentation created by the Emergency Preparedness Team (EPT), which can be provided upon request to the corresponding author. The video demonstrated EPT personnel performing the correct donning and doffing of Level C PPE, which included Tychem CPF 3 chemical-resistant coveralls with attached butyl gloves (DuPont; Midland, Michigan USA); rubber boots; and a Powered Air Purifying Respirator (PAPR) device. Prior to viewing the video, one random member of each group was provided with supplies and instructions to create a donning/doffing checklist based on the video to be used during the drill itself.

Group 3 and Group 4 were taken to a separate location and served as the control groups. They received an approximately ten-minute in-person demonstration on the correct donning and doffing of the same PPE by the same member of the EPT featured in the video demonstration. They were also asked to create a checklist to use during the drill.

The four groups were then taken to separate locations and provided with the abovementioned PPE. Within each group of five residents, one was designated to actually perform the donning/doffing procedure, two were assigned to physically assist with the procedure, one was responsible for reading the checklist and making sure it was followed, and one was providing general assistance, as needed.

Each group then performed the donning procedure while being observed by evaluators. Once completed, the individual in the PPE passed through an active decontamination shower room as an additional assessment of the integrity of the applied PPE. The individual then returned to the previous area and began the doffing process with the rest of the group.

Study Endpoints

The primary study endpoint was the completion of the doffing process by all four groups.

Evaluation and Data Collection

Sixteen PGY 1 residents were designated as independent evaluators. They had received in-person PPE training separately the day prior and were trained on their roles in this drill at that time. Eight of the evaluators were assigned to the donning process and eight of the evaluators were assigned to the doffing process. The evaluators were then further sub-divided so that two evaluators were assigned to each of the four groups during each process. The evaluators were blinded to the type of training their particular group had received. Donning evaluators were given a donning evaluation tool while the doffing evaluators were responsible for evaluating the doffing process (Figure 1 and Figure 2). These evaluation tools were then collected for analysis by the EPT.

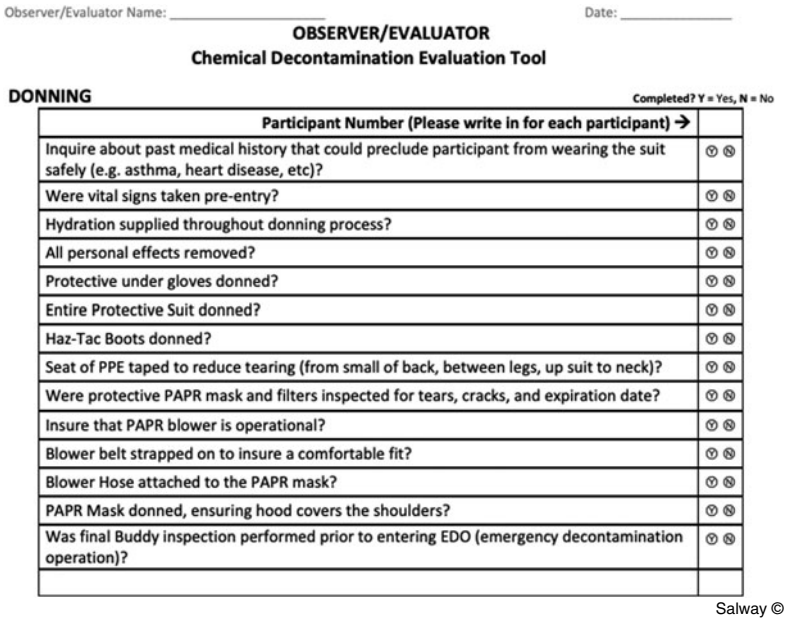
Following the drill, a group debriefing ("hot wash") session was performed with all the drill participants, evaluators, and the EPT. Written and verbal feedback was elicited at this time. The 20 drill participants were given a brief survey concerning the drill utilizing a five-item Likert scale (Figure 3). This survey was intended to assess the participants' confidence in donning/doffing both prior to and after their respective trainings, as well as other subjective aspects of the trainings.

Results

Donning

During the donning process, each of the four groups were evaluated on 14 critical protocol tasks (Figure 1). These tasks were designed

https://doi.org/10.1017/S1049023X20000564 Published online by Cambridge University Press



Observer/Evaluator Name: _____ Date: _____

OBSERVER/EVALUATOR
Chemical Decontamination Evaluation Tool

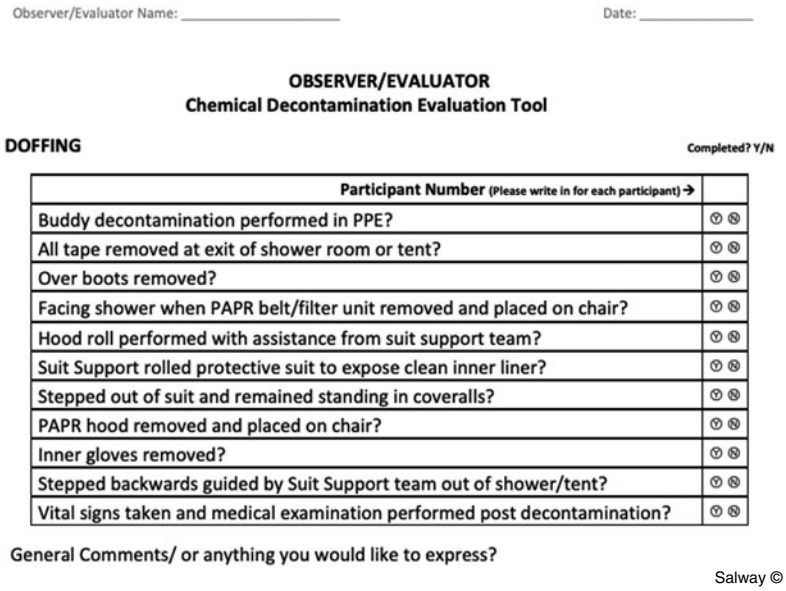
DONNING

Completed? Y = Yes, N = No

Participant Number (Please write in for each participant) →	
Inquire about past medical history that could preclude participant from wearing the suit safely (e.g. asthma, heart disease, etc)?	Y N
Were vital signs taken pre-entry?	Y N
Hydration supplied throughout donning process?	Y N
All personal effects removed?	Y N
Protective under gloves donned?	Y N
Entire Protective Suit donned?	Y N
Haz-Tac Boots donned?	Y N
Seat of PPE taped to reduce tearing (from small of back, between legs, up suit to neck)?	Y N
Were protective PAPR mask and filters inspected for tears, cracks, and expiration date?	Y N
Insure that PAPR blower is operational?	Y N
Blower belt strapped on to insure a comfortable fit?	Y N
Blower Hose attached to the PAPR mask?	Y N
PAPR Mask donned, ensuring hood covers the shoulders?	Y N
Was final Buddy inspection performed prior to entering EDO (emergency decontamination operation)?	Y N

Salway © 2020 Prehospital and Disaster Medicine

Figure 1. Donning Evaluation Tool.
Abbreviations: PAPR, Powered Air Purifying Respirator; PPE, personal protective equipment.



Observer/Evaluator Name: _____ Date: _____

OBSERVER/EVALUATOR
Chemical Decontamination Evaluation Tool

DOFFING

Completed? Y/N

Participant Number (Please write in for each participant) →	
Buddy decontamination performed in PPE?	Y N
All tape removed at exit of shower room or tent?	Y N
Over boots removed?	Y N
Facing shower when PAPR belt/filter unit removed and placed on chair?	Y N
Hood roll performed with assistance from suit support team?	Y N
Suit Support rolled protective suit to expose clean inner liner?	Y N
Stepped out of suit and remained standing in coveralls?	Y N
PAPR hood removed and placed on chair?	Y N
Inner gloves removed?	Y N
Stepped backwards guided by Suit Support team out of shower/tent?	Y N
Vital signs taken and medical examination performed post decontamination?	Y N

General Comments/ or anything you would like to express?

Salway © 2020 Prehospital and Disaster Medicine

Figure 2. Doffing Evaluation Tool.
Abbreviations: PAPR, Powered Air Purifying Respirator; PPE, personal protective equipment.

to happen in sequence and were specifically included in both the video and the in-person trainings.

Evaluators of Group 1 and Group 2 (video trained) identified a total of nine protocol task violations out of 55 evaluated possibilities (Table 1). These violations included tasks that were either performed incorrectly or omitted entirely. This led to an error rate of 16.0% (95% CI, 11.2% to 32.0%). The most frequently failed tasks involved not checking the PAPR for flaws and functionality, and not performing a final safety check by the donning assistant (a buddy check) prior to entering the decontamination showers.

Evaluators of Group 3 and Group 4 (in-person trained) identified a total of 11 protocol task violations out of 56 evaluated possibilities (Table 1). This led to an error rate of 19.6% (95% CI, 8.6% to 28.5%). Their most frequently failed tasks also involved PAPR inspection and forgotten buddy check, but there were additional omissions such as failing to check vital signs or providing hydration during the process.

https://doi.org/10.1017/S1049023X20000564 Published online by Cambridge University Press



Participant Number: _____ Date: _____

SELF EVALUATION
Chemical Decontamination Evaluation Tool

WHICH TRAINING DID YOU RECEIVE: VIDEO IN-PERSON

Please rate the extent to which you agree or disagree with each of the following statements:

1. I felt confident in **donning** (putting on the equipment) **prior to** receiving this training.

Strongly Agree Agree Neutral Disagree Strongly Disagree

2. I felt confident in **doffing** (removing the equipment) **prior to** receiving this training.

Strongly Agree Agree Neutral Disagree Strongly Disagree

3. The training that I received explained the steps of **donning** (putting on the equipment) adequately for me.

Strongly Agree Agree Neutral Disagree Strongly Disagree

4. I felt **more confident** in donning **after** receiving this training.

Strongly Agree Agree Neutral Disagree Strongly Disagree

5. Is there anything that could have made you feel more confident in **donning? Please explain:**

Yes No Explain:

6. The training that I received explained the steps to **doffing** (removing the equipment) adequately for me.

Strongly Agree Agree Neutral Disagree Strongly Disagree

7. I felt **more confident** in doffing **after** receiving this training.

Strongly Agree Agree Neutral Disagree Strongly Disagree

8. Is there anything that could have made you feel more confident in **doffing? Please explain:**

Yes No Explain:

9. This training captured my attention.

Strongly Agree Agree Neutral Disagree Strongly Disagree

10. This training was easy to follow.

Strongly Agree Agree Neutral Disagree Strongly Disagree

11. Were there any steps that you knew you needed to complete but were uncertain of how to perform? **Please explain:**

Yes No Explain:

General Comments/ or anything you would like to express?

1

SELF Evaluation Tool-v4

Salway © 2020 Prehospital and Disaster Medicine

Figure 3. Self-Evaluation Tool.

Using a Fisher's exact test to compare the number of protocol task violations between the two sets of groups demonstrated a two-tailed P value of .81, demonstrating no statistically significant difference between donning errors in the two sets of groups.

Doffing

During the doffing process, each of the four groups were evaluated on 11 critical protocol tasks (Figure 2). These tasks were constructed to appear in sequence and were specifically included in both the video and the in-person trainings.

Evaluators of Group 1 and Group 2 (video trained) identified a total of 15 protocol task violations out of 44 evaluated possibilities (Table 2). This led to an error rate of 34.1% (95% CI, 21.8% to 48.9%). The task violations were largely evenly distributed.

Evaluators of Group 3 and Group 4 (in-person trained) found a total of 12 failures out of 44 evaluated possibilities (Table 2). This led

https://doi.org/10.1017/S1049023X20000564 Published online by Cambridge University Press

Donning Tasks Completed	GROUP 1&2			GROUP 3&4		
Question #	YES	NO	Total Responses	YES	NO	Total Responses
1	2	1	3	4	0	4
2	4	0	4	1	3	4
3	3	1	4	2	2	4
4	4	0	4	4	0	4
5	4	0	4	4	0	4
6	4	0	4	4	0	4
7	4	0	4	4	0	4
8	3	1	4	3	1	4
9	2	2	4	1	3	4
10	2	2	4	4	0	4
11	4	0	4	4	0	4
12	4	0	4	4	0	4
13	4	0	4	4	0	4
14	2	2	4	2	2	4
Total YES	46			45		
Total NO		9			11	
Total Responses			55			56

Salway © 2020 Prehospital and Disaster Medicine

Table 1. Donning Tasks Completed versus Violated

Doffing Tasks Completed	GROUP 1&2			GROUP 3&4		
Question #	YES	NO	Total Responses	YES	NO	Total Responses
1	3	1	4	4	0	4
2	2	2	4	4	0	4
3	4	0	4	4	0	4
4	2	2	4	2	2	4
5	4	0	4	4	0	4
6	2	2	4	3	1	4
7	2	2	4	3	1	4
8	2	2	4	1	3	4
9	4	0	4	4	0	4
10	2	2	4	3	1	4
11	2	2	4	0	4	4
Total YES	29			32		
Total NO		15			12	
Total Responses			44			44

Salway © 2020 Prehospital and Disaster Medicine

Table 2. Doffing Tasks Completed versus Violated

to an error rate of 27.3% (95% CI, 16.2% to 42.0%). Their most frequent task violations involved the removal of the PAPR hood and the rechecking of vital signs after decontamination was complete.

Using a Fisher's exact test to compare the number of failed tasks between the two sets of groups demonstrated a two-tailed P value of .64, demonstrating no statistically significant difference in doffing errors between the two sets of groups.

Self-Evaluation

The drill participants each completed a self-evaluation Likert-scale survey (with a 100% response rate) assessing their confidence in donning/doffing before and after the different trainings, the ease of the training, and the captivity of the training (Figure 3). Unsurprisingly, both the video and the in-person trainings showed a statistically significant difference between the before and after confidence levels of the participants in the donning and doffing procedures (Table 3). In addition, a two-tailed T test revealed a significant difference between the two groups for the explanation of donning, but not for doffing (see Question 3 in Figure 3/Table 3). A comparison of the two sets of groups regarding the ease of the different trainings or how captivating they were detected no significant differences.

https://doi.org/10.1017/S1049023X20000564 Published online by Cambridge University Press

Discussion

The analysis demonstrated no statistically significant differences in the number of protocol task violations in both donning and doffing between the two training modalities. This would seem to show the two methods are equally effective, at least based on the criteria the investigators chose for evaluation. Therefore, it is not possible to reject the null hypothesis at this time. However, it is conceivable that different criteria may have elicited a difference (eg, time to completion). The investigators focused on the quality of the donning/doffing rather than the time needed to accomplish the actions. It is possible that a group trained by a certain modality would complete the procedures more quickly, which would be advantageous if the error rates were similar between the groups.

While the two training modalities appear equally effective, they also appear equally ineffective. The error rates for donning ranged from 16% to 20% for each modality, with even higher doffing rates. This is especially concerning given that the risk of contamination has been shown to be highest in doffing.[4,23] There are multiple possible explanations for these high rates, but examination of the evaluator data shows that the majority of the failed tasks involved PAPR inspection, use, and removal. This might indicate that more emphasis should be placed upon this portion of the training in both the video and in-person modalities.

The self-evaluation identified a statistically significant difference with respect to the donning training between the two modalities. Eighty-two percent of the participants in the in-person demonstration group "strongly agreed" that the training explained the steps of donning adequately, compared to only 22% of the video group participants. Several explanations can be posited for this difference, including the inability to ask questions of a presenter. However, this difference was not borne out in the doffing group and the remaining 78% of the video group participants "agreed" with the statement, so the difference may not represent a fundamental flaw with the video training.

There was some initial concern that the participants in the video training would be less likely to pay close attention. However, the self-evaluation survey data demonstrated high levels of interest that was not significantly different from the in-person training. While survey data are susceptible to biases, it is also possible that the use of dramatic music and visual effects in the video kept the participants interested.

Importantly, this study was designed as a pilot study, examining whether these methods of training and evaluating the participants were feasible and could then be applied to a larger sample size. Based on the quality of the data collected and participant feedback elicited from this study, a larger scale version appears feasible, with enough equipment, participants, and time. This study also garnered suggestions for additional investigation in a larger setting, such as measuring time to completion by each arm.

Limitations

The primary limitation of this study is the sample size. A power analysis shows it would require 1,771 subjects in each group to show differences in donning technique and 721 subjects in each group to achieve statistical significance in doffing. The sample was limited by the number of PAPRs available (four) and the number of EM residents in conference that week. While the experiment could have been expanded beyond the emergency department and repeated to obtain greater numbers, that might have introduced a selection bias, as these additional non-frontline individuals are less likely to be faced with a HAZMAT situation.

Conclusion

In this pilot study, there were no significant differences found in the error rates of the donning and doffing of Level C PPE by EM residents following video versus in-person training. Both types of trainings increased the confidence of the participants in the procedures and were perceived as equally interesting and easy, though the in-person training may have been more useful to teach donning. Furthermore, it was demonstrated that this method of collecting comparison data is feasible and can be replicated in a larger scale. Overall, this study indicates that video training on donning and doffing may provide a useful alternative to in-person demonstration training in certain situations, though further study with an appropriately powered sample is warranted to further explore this equivalence.

Acknowledgements

This publication is the result of a thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Disaster Medicine (European Master in Disaster Medicine). It was supported by a grant from the US Department of Health and Human Services (HHS) Hospital Preparedness Program (HPP) and Public Health Emergency Preparedness (PHEP) aligned Cooperative Agreements (the HPP Grant and the PHEP Grant, respectively) for the purpose of building and sustaining New York City's public health and health care preparedness capabilities.

References

1. Olivieri C, Ingrassia PL, Corte FD, et al. Hospital preparedness and response in CBRN emergencies. *Eur J Emerg Med.* 2017;24(5):366–370.
2. Williams M, Sizemore DC. "Biologic, Chemical, and Radiation Terrorism Review." In: *StatPearls* [Internet]. Treasure Island, Florida USA: StatPearls Publishing; 2018.
3. Levitin HW. "Personal Protective Equipment." In: Koenig K, & Schultz C, (eds). *Koenig and Schultz's Disaster Medicine: Comprehensive Principles and Practices*. 2nd ed. Cambridge, UK: Cambridge University Press; 2016:219–231.
4. Fischer WA, Weber DJ, Wohl DA. Personal protective equipment: protecting health care providers in an Ebola outbreak. *Clin Ther.* 2015;37(11):2402–2410.
5. Keim M, Pesik N, Twum-Danso N. Lack of hospital preparedness for chemical terrorism in a major US city: 1996–2000. *Prehosp Disaster Med.* 2003;18(3):193–199.
6. Gowing J, Walker K, Elmer S, Cummings E. Disaster preparedness among health professional and support staff: what is effective? An integrative literature review. *Prehosp Disaster Med.* 2017;32(3):321–328.
7. Mangum BP, Dacanay PO, Mangum TL. Preparedness of hospitals for response to chemical terrorist incidents: review and recommendations. *SSRN Electronic Journal*. 2017. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3042071. Accessed May 2, 2019
8. Wetter DC, Daniell WE, Treser CD. Hospital preparedness for victims of chemical or biological terrorism. *Am J Public Health.* 2001;91(5):710–716.
9. National Institute for Occupational Safety and Health (NIOSH). Hierarchy of Control. https://www.cdc.gov/niosh/topics/hierarchy/. Accessed May 5, 2019.
10. Hazardous Substances Emergency Event Surveillance (HSEES), Agency for Toxic Substances and Disease Registry. Annual Report 2009. https://www.atsdr.cdc.gov/HS/HSEES/annual2009.html/. Accessed May 2, 2019.
11. Kang J, Kim EJ, Choi JH, et al. Difficulties in using personal protective equipment: training experiences with the 2015 outbreak of Middle East respiratory syndrome in Korea. *Am J Infect Control.* 2018;46(2):235–237.
12. Centers for Disease Control and Prevention (CDC). Guidance for the Selection and Use of Personal Protective Equipment (PPE) in Healthcare Settings. https://www.cdc.gov/HAI/pdfs/ppe/PPEslides6-29-04.pdf. Accessed May 2, 2019.
13. Occupational Safety and Health Administration. OSHA Best Practices for Hospital-Based First Receivers of Victims from Mass Casualty Incidents Involving the Release of Hazardous Substances. US Department of Labor, OSHA 3249–08N; 2005. https://www.osha.gov/Publications/osha3249.pdf. Accessed May 2, 2019.

https://doi.org/10.1017/S1049023X20000564 Published online by Cambridge University Press

14. Occupational Safety and Health Administration. Occupational Safety and Health Standards, Personal Protective Equipment. General Requirements. 1910.132. https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.132. Accessed May 2, 2019.
15. Personal protective equipment guidelines for health care facility staff. *Ann Emerg Med.* 2016;68(3):406–407.
16. Infectious Disease Dashboard. Special Pathogens Program. New York Health and Hospitals. https://www.nychealthandhospitals.org/special-pathogens-program/. Accessed May 3, 2019.
17. Kang J, O'Donnell JM, Colaianne B, et al. Use of personal protective equipment among health care personnel: results of clinical observations and simulations. *Am J Infec Control.* 2017;45(1):17–23.
18. Hung PP, Choi KS, Chiang VC. Using interactive computer simulation for teaching the proper use of personal protective equipment. *Comput Inform Nurs.* 2015;33(2):49–57.
19. Thorne C, Oliver M, Al-Ibrahim M, et al. Terrorism-preparedness training for non-clinical hospital workers: tailoring content and presentation to meet workers' needs. *J Occup Environ Med.* 2004;46(7):668–676.
20. Cook DA, Hamstra SJ, Brydges R, et al. Comparative effectiveness of instructional design features in simulation-based education: systematic review and meta-analysis. *Med Teach.* 2013;35:e867–898.
21. Cook DA. How much evidence does it take? A cumulative meta-analysis of outcomes of simulation-based education. *Med Educ.* 2014;48:750–760.
22. Doll M, Feldman M, Hartigan S, et al. Acceptability and necessity of training for optimal personal protective equipment use. *Infect Control Hosp Epidemiol.* 2017;38(2):226–229.
23. Suen LK, Guo YP, Tong DW, et al. Self-contamination during doffing of personal protective equipment by healthcare workers to prevent Ebola transmission. *Antimicrob Resist Infect Control.* 2018;7:157.

https://doi.org/10.1017/S1049023X20000564 Published online by Cambridge University Press

	Q1 Video	Q4 Video	Q2 Video	Q7 Video	Q1 Person	Q4 Person	Q2 Person	Q7 Person
Person 1	4	5	4	5	4	5	4	5
Person 2	4	5	4	5	4	5	4	5
Person 3	4	5	4	5	3	5	3	5
Person 4	2	4	2	5	3	5	3	5
Person 5	2	4	2	4	3	5	3	5
Person 6	2	4	2	4	3	5	3	5
Person 7	2	4	2	4	3	5	3	4
Person 8	2	4	2	4	2	4	2	4
Person 9	1	4	1	4	2	4	2	4
Person 10					1	4	1	4
Person 11					1	4	1	4
Sum	23	39	23	40	29	51	29	50
Average	2.5555556	4.33333	2.55555556	4.44444	2.63636364	4.636364	2.6363636	4.545455
Analysis		**0.000022**		**0.000044**		**0.000001**		**0.000002**
		Paired T-test 1 tailed		Paired T-test 1 tailed		Paired T-test 1 tailed		Paired T-test 1 tailed

	Q3 Video	Q3 Person	Q6 Video	Q6 Person	Q9 Video	Q9 Person	Q10 Video	Q10 Person	Q4 Video	Q4 Person	Q7 Video	Q7 Person
Person 1	5	5	5	5	5	5	5	5	5	5	5	5
Person 2	5	5	5	5	5	5	5	5	5	5	5	5
Person 3	4	5	5	5	4	5	4	5	5	5	5	5
Person 4	4	5	4	5	4	5	4	5	4	5	5	5
Person 5	4	5	4	5	4	5	4	5	4	5	4	5
Person 6	4	5	4	5	4	5	4	5	4	5	4	5
Person 7	4	5	4	5	4	4	4	4	4	5	4	4
Person 8	4	5	4	5	3	4	4	4	4	4	4	4
Person 9	4	5	4	4	3	4	4	4	4	4	4	4
Person 10		4		4		4		4		4		4
Person 11		4		4		3		4		4		4
Sum	38	53	39	52	36	49	38	50	39	51	40	50
Average	4.222222	4.81818	4.3333333	4.7273	4	4.454545	4.222222	4.54545	4.3333333	4.6363636	4.444444	4.545455
Analysis		**0.00555**		0.0857		0.163609		0.15767		0.1963945		0.67332
		T-test two tailed		T-test two tailed		T-test two tailed		T-test two tailed		T-test two tailed		T-test two tailed

Salway © 2020 Prehospital and Disaster Medicine

https://doi.org/10.1017/S1049023X20000564 Published online by Cambridge University Press