Infection Prevention in Practice 5 (2023) 100308

Available online at www.sciencedirect.com

Infection Prevention in Practice

journal homepage: www.elsevier.com/locate/ipip

The PATH to PPE Mastery - Programme for Assessment and Training in HCID (High Consequence Infectious Diseases) PPE (Personal Protective Equipment), Mastery

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A R T I C L E I N F O

Article history:
Received 9 January 2023
Accepted 10 July 2023
Available online 12 September 2023

Keywords:
PPE
HCID
VHF
Simulation based mastery learning (SBML)
Simulation based education (SBE)

S U M M A R Y

Background: High Consequence Infectious Diseases (HCIDs), have the potential to cause pandemics and require particular focus for preparedness due to their high mortality rates. The application of Personal Protective Equipment (PPE) for HCIDs is complex and carries significant risk of Health Care Worker (HCW) contamination if done incorrectly. Previous reviews have reported a lack of information on the nature of training provided and the ideal timing of repeat training to best retain skills. Simulation Based Mastery Learning (SBML) is a methodology for skill acquisition which encompasses deliberate practice and repeated assessment until the learner achieves a pre-set Mastery standard. SBML has been demonstrated to improve competence, skill retention and patient outcomes in other clinical procedures. SBML has not been previously studied or utilised in HCID PPE training.
Aim: We aimed to increase the likelihood of safe clinical practice by evidencing that Lothian modified SBML for PPE effectively prepares our priority learners.
Methods: A quasi-experimental within group post-test design was used. Learners undertook a modified SBML programme which included two-hour asynchronous and two-hour synchronous components.
Findings: 11 learners (10 infectious diseases registrars and 1 infectious diseases consultant) were enrolled in the programme with 8 completing all stages, all of whom achieved the Mastery passing standard. The resources were highly rated by learners with the exemplar videos of skills highlighted as particularly useful. Self-assessed preparedness for each skill increased following pre-learning and synchronous sessions.
Conclusion: Modified SBML can be used as an effective methodology for the training and assessment of HCWs in the donning and doffing of HCID PPE.

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https://doi.org/10.1016/j.infpip.2023.100308

Introduction

Pandemic preparedness is a key priority for healthcare services and governments following the COVID-19 pandemic. High Consequence Infectious Diseases (HCIDs), including Viral Haemorrhagic Fevers (VHF), have the potential to cause pandemics and require particular focus for preparedness due to their high mortality rates.

Personal Protective Equipment (PPE) for HCIDs is more complex and thus more challenging to use safely than standard PPE; is associated with Health Care Worker (HCW) anxiety [1]; and carries significant risk of HCW contamination if done incorrectly [2,3].

HCIDs include viruses such as Ebola, which remains an ongoing risk as evidenced by the current outbreak in Uganda [4]. The PPE used for HCIDs is particularly complex and it has been shown that the majority of errors in its use are due to HCWs deviating from the donning (putting on) and doffing (taking off) steps [2,3,5,6]. In addition to proposed changes to PPE equipment [7] and patient care systems [5] it is key that HCWs are adequately trained in donning and doffing, and retain these skills post training. A Cochrane review of HCID PPE [8] found that there was a lack of reporting on both the nature of training provided and the ideal timing of repeat training to best retain skills remains unknown. A later systemic review [9] identified that there remain issues with implementing training, and the evaluation of training programmes often relies on learner satisfaction rather than measures of competence in the simulated setting. Other measurements such as learner self-perceived proficiency in doffing have been found to have no correlation with competence [10].

Simulation Based Mastery Learning (SBML) is an established methodology for skills training [11]. Mastery Learning is, as defined by McGaghie as [11], 'a form of competency-based education in which all learners acquire essential skill and knowledge measured rigorously in relation to high and fixed achievement standards without restricting learning time to a uniform interval to reach the outcome.'

The Lothian modified SBML approach is a methodology for the acquisition of skills Mastery by novice learners which encompasses deliberate practice an asynchronous pre-learning package, peer assisted deliberate practice and repeated assessment until the learner achieves a pre-set Mastery standard [12]. This differs from usual simulation-based education for HCID PPE which may lack opportunity for deliberate practice, may lack an assessment component, and if an assessment is present there may not be standard setting applied. It has been shown that SBML is more effective than standard simulation scenarios in the retention of selected clinical skills, such as neonatal resuscitation skills [13] and core clinical procedures such as venous catheter insertion [14]. SBML has an evidence based link in other settings between simulation competence and improved patient outcomes in clinical procedures when reviewing translation outcomes such as patient care practices, patient outcomes and collateral effects [15]. Additionally SBML has been shown to be an effective method of training HCWs in the use of PPE in other contexts such as COVID-19 [16,17]. Provision of pre-learning materials has been shown to maximise the efficiency of SBML synchronous learning time [12]. SBML has not previously been reported in the training of HCID PPE donning and doffing.

Developing an efficient and effective method to both train and assess HCWs in the skills of donning and doffing HCID PPE is an important facet of preparedness. We aim to increase the likelihood of safe clinical practice by evidencing that Lothian modified SBML for PPE effectively prepares our priority learners. The aims of the training sessions were to ensure the safety of staff and patients by reducing the risk of HCID transmission through errors in PPE use; and improve healthcare worker self-assessed preparedness and thus anxiety around this skill.

Methods

In this pilot study a quasi-experimental within group post-test design was used. Learners undertook a modified SBML programme (Figure 1) which included asynchronous and synchronous components. The asynchronous competent involved completing approximately two-hours of interactive pre-learning packages including: background information on HCIDs; the main risks of HCID transmission; relevant local and national guidelines; and exemplar videos of donning and doffing. For the synchronous component, learners attended a two-hour training session held in a specialised training room which simulates the clinical environment. The pre-briefing included: discussion around the pre-learning materials; highlighting any areas of uncertainty following the pre-learning; establishing a fiction contract; outlining the logistics of the session; and clearly explaining the intended learning objects of the session, as per Rudolph *et al.*'s findings on which factors led to psychological safety in simulation [18].

Following pre-briefing the learners first undertook deliberate practice which focused on areas of the protocols which remained unclear to the learners following the pre-learning components. There was also facilitator directed instruction on particularly high-risk parts of the doffing protocol, if these had not been raised as a priority by the participants, such as: outer gloves and apron removal; overshoe removal; and boot removal.

The protocols were available to learners as posters on the wall during the synchronous session, as they would be in clinical practice. The assessment focused on the learners' ability to safely interact with their PPE, each other and the environment. Learners were then assessed against a checklist for each skill (donning, specimen collection, doffing) along with global assessment by both the learner and the facilitator. Critical safety steps within the protocols were determined by the Mastery Ang off standard setting process [19]with a threshold of 0.9 set for each point. This high difficulty reflects the high-risk nature of the procedure and that the protocol is well written with only necessary important steps included. During this iterative process the checklist was updated to change any wording which was unclear. In the doffing protocol every step was considered a critical safety step and so the pass mark was set at 100%. Assessment was repeated with terminal feedback until all learners had reached the required standard.

Questionnaires were completed by learners at 4 stages (Figure 1) to assess their self-assessed preparedness (Likert 7 point scale 1= least prepared, 7 = most prepared) for clinical practice along with gathering information on the learners prior experience and training in this skill.

The NHS Research Ethics Committee assessment tool was utilised which stated that this research did not require NHS ethical approval.

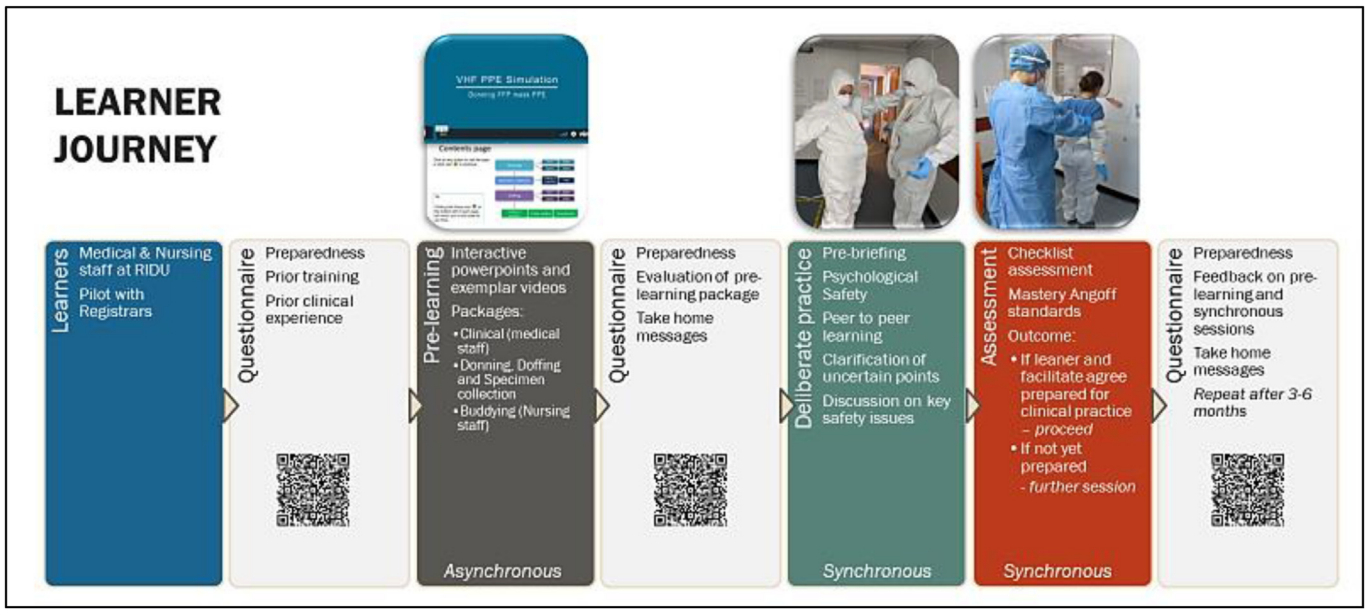

Figure 1. Learner journey through training programme.

Results

A total of 11 HCW participated in the study, with eight learners completing all stages and a further three completing the pre-learning package only (learners 5, 6 and 11). All participants were infectious diseases medical staff with a minimum of 4 years post graduate experience, nine (81%) of participants were women.

Of the 11 learners, nine (82%) had previously received training in HCID PPE and seven (64%) had previous clinical experience of assessing a patient with a possible HCID. Free text responses on the previous training suggested that previous experiences were viewed as useful but not adequate preparation. Given the lack of a terminal assessment in previous training it was not possible to determine prior competence. Skill retention post training was highlighted as a concern amongst learners in qualitative feedback.

All eight learners who attended the synchronous SBML session achieved the Mastery passing standard for donning, specimen collection and doffing. The resources were highly rated by learners (Figure 2), with the exemplar videos of skills highlighted as particularly useful. Self-assessed preparedness for each skill increased following pre-learning and synchronous sessions (Figure 3).

Feedback from learners on the training programme highlighted the need to minimise the amount of distracting information within the training environment, an important consideration given the known high cognitive load of this skill [20], and the potential for increased extraneous cognitive load that distractors in the environment can entail which is relevant both in the simulated and clinical environment. Take home messages from learners involved the importance of having a buddy to assist with doffing and a focus on familiarity with the PPE and protocol without memorising the protocol, along with

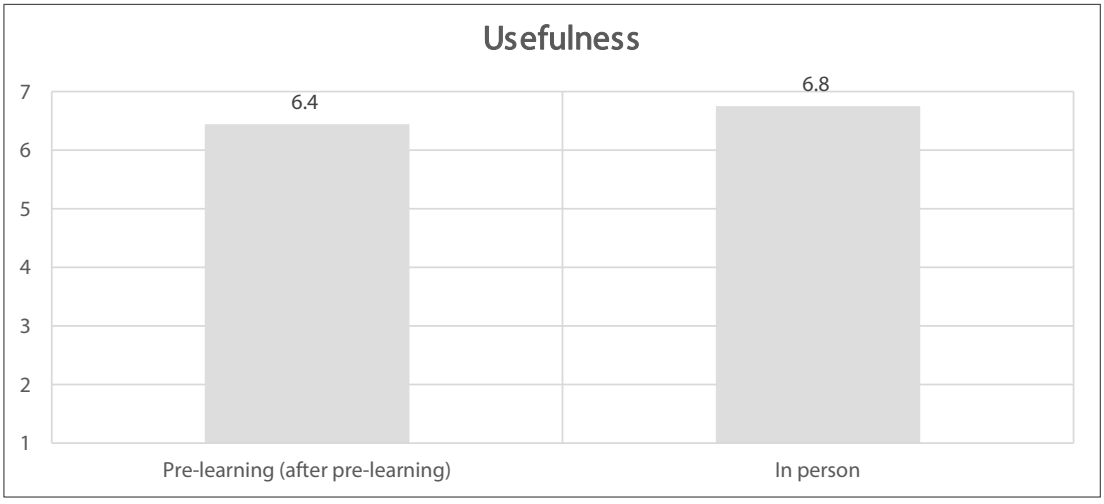

Figure 2. Mean usefulness by skill (likert 1–7, 1= least useful, 7 =most useful).

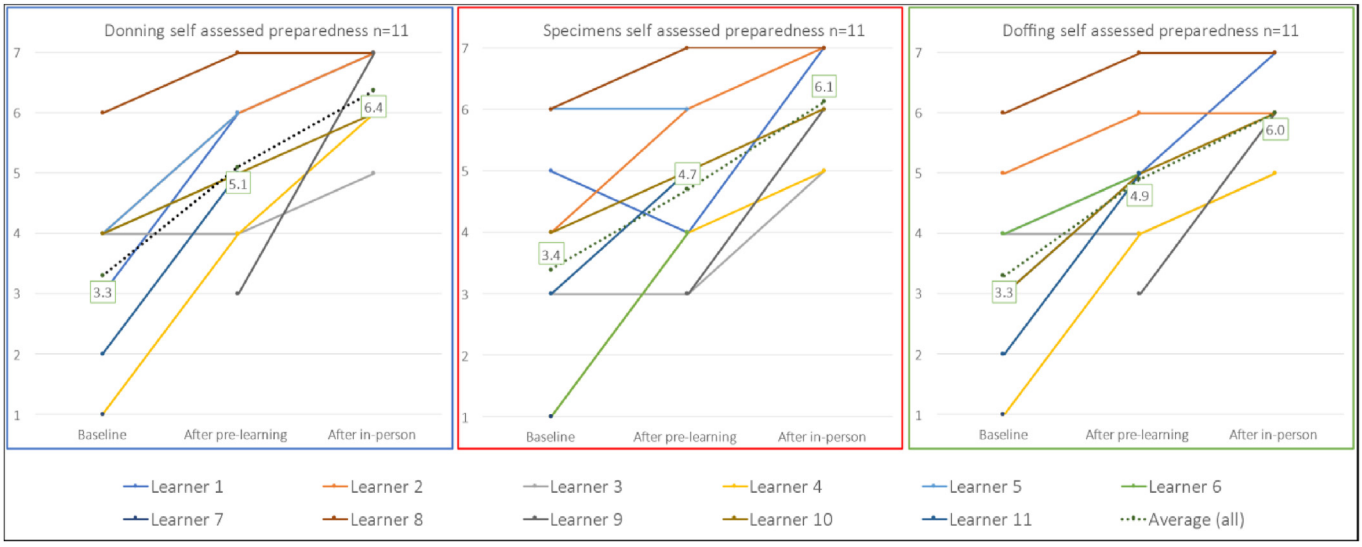

Figure 3. Self assessed preparedness by learner (likert 1—7, 1= least prepared, 7 =most prepared.

awareness of errors and how to correct them (Figure 4). Additionally, it was highlighted by several learners that the pre-learning resources were considered very high quality and that they planned to utilise these as a refresher if they encountered any clinical cases of suspected HCID in the future.

Discussion

HCID PPE donning and doffing is a complex process fraught with risk for both HCW and patients. Ensuring that PPE is used in the correct manner is a key part of HCW preparedness along with ensuring the PPE being used is evidence based [7] and the clinical environment is suitable [5]. Utilising SBML for teaching and assessment of this skill has the potential to address the issues involved in other methods of training and assessment such as an absence of assessment, or lack of standardisation of assessment.

In our setting a large proportion of the learners had undertaken previous training, however the qualitative feedback showed that learners felt the previous training had not been adequate, and during the peer assisted deliberate practice component, although there was no formal assessment component there were consistently mistakes made by learners in the most complex steps of the protocol: doffing in the patient room; boot cover removal; and boot removal. Considering our methodology for this pilot in more detail, the post-test design was chosen as it balanced the practicalities of data collection with a quantitative approach. A pre-test post-test design was

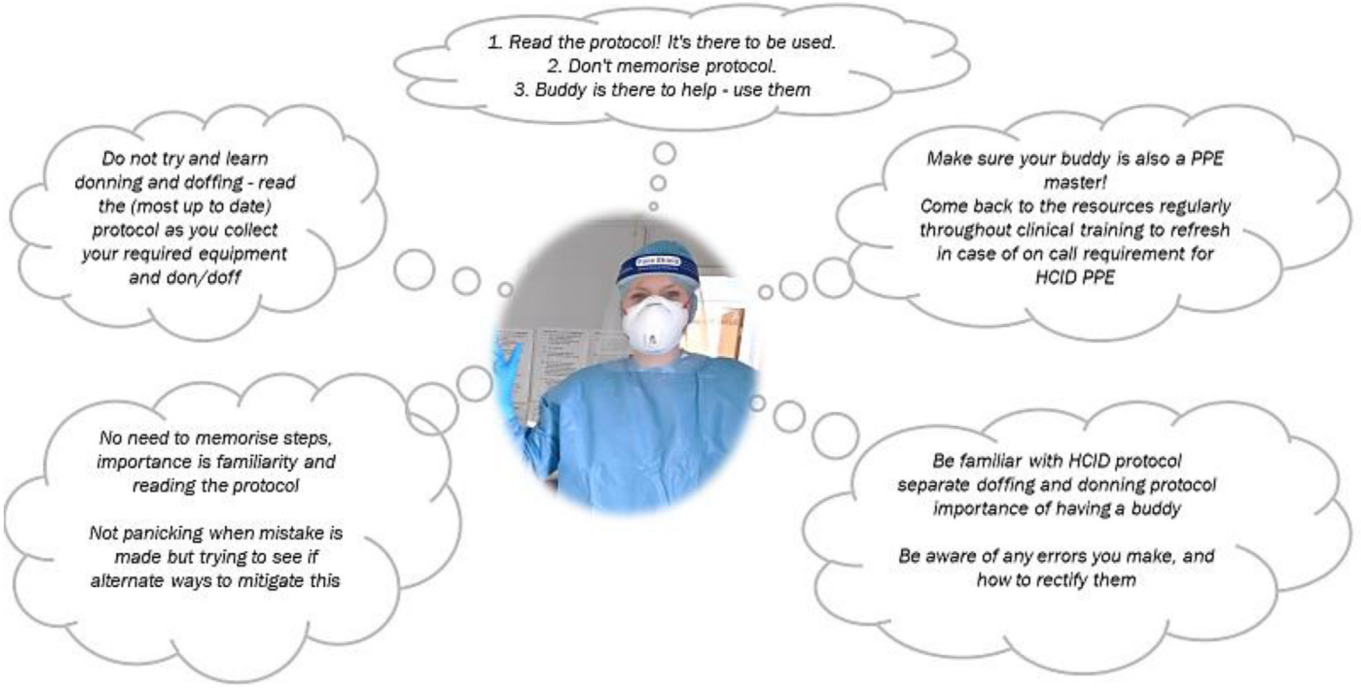

Figure 4. Learners' take home messages.

considered but given that SBML results in all learners achieving the same standard and performing a pre-test would be time intensive without clear benefit to the learners this was decided against. The errors witnessed during deliberate practice suggests that if a pre-test had been performed most learners would have failed. All learners who had undertaken previous training either in our centre (seven) or other centres (two) had experienced unstructured simulation training without assessment of competence. Few of the participants had clinical experience with a suspected VHF case, but most had experience with airborne HCID PPE from the initial COVID-19 response, when this had been classified as an HCID. Of note, in our setting, the PPE for airborne HCIDs such as COVID-19, and the PPE for VHFs differs significantly. A control group with a non-SBML approach was considered however the literature has already demonstrated the superiority of SBML in inducing skill retention and translation outcomes over standard simulation in other skills. As such a control group was considered unethical, as exposing learners to an inferior technique could potentially lead to harm. A qualitative approach could be taken to the study of SBML use in this setting, however it has been shown that there is poor correlation between learners perception of their own competence in PPE and their performance [10] and so qualitative data may be misleading.

Considering the standard setting process, whilst a pass mark of 100% may appear to describe an unrealistically difficult assessment, it is important to note that the assessment is reflective of clinical practice. Doffing is carried out only in the presence of a skilled 'buddy' who supervises the process to watch for mistakes, which has been shown to reduce the cognitive load of these skills [20]. Additionally, the protocol is available during assessment and clinical practice as a large poster on the wall.

Implementing SBML into HCID PPE training in our setting led to all learners meeting the Mastery passing standard. Additionally, learners found the training sessions useful and it improved their self-efficacy, as measured by their perceived preparedness. In terms of Kirkpatrick's model of evaluation [21] we can demonstrate impacts on learner satisfaction and learning however it is challenging to demonstrate impacts such as a change in performance in a real life clinical setting as it would not be safe to assess this. Due to the low incidence of suspected HCID patients in the UK, and the potentially catastrophic nature of a transmission episode it is challenging to study return on investment parameters. This causes an issue in terms of determining the effectiveness of training programmes for this skill as it has been argued that simulation competency does not always equate to clinical performance, as there are many other factors that influence performance such as individual and system factors as outlined by Rethans *et al.* [22]. Nevertheless, some manner of assessment is a necessity in this setting to ensure HCWs are as well prepared as possible. Overall we know that SBML translates into real life outcomes in other clinical settings [15], and we know that our local learners value the additional components which we have added to provide modified SBML [12] and therefore, demonstration of simulation competency is currently the best measure of real life competency available.

A major challenge to pandemic preparedness interventions is the huge pressures facing healthcare services within the UK. Preparing for potential future problems needs to be balanced against the impact this may have on more immediate issues. Barriers exist to the acceptability of this assessment, mainly related to the time and resource required which could be utilised in other areas. In our setting there was a large initial outlay in terms of staff time to produce the pre-learning materials. Whilst the exact time and resource costs have not been calculated for this study, the time taken was around 40 hours to produce the pre-learning packages, record videos and transcripts and prepare the training environment. This initial large outlay has resulted in a training programme that can be delivered with minimal faculty and the resource implications of each session is very low, with two hours of faculty time required for two learners. The use of PPE is another consideration, in our setting we used equipment had expired and reused equipment where it was safe and practical to do so. Besides the increased efficiency of faculty time, having the protocols and exemplar videos in advance of the synchronous session provides a scaffold for the learner to construct their learning upon, as discussed in more detail by Scahill *et al.* [12].

We have demonstrated that modified SBML can be used as an effective methodology for the training and assessment of HCWs in the donning and doffing of HCID PPE. We have produced a structured and evidence-based programme that could be rolled out in other centres, as well as being used for "just in time" refresher training at the point of a patient presenting with an HCID. Future work will examine the duration of skill retention in this setting to guide the frequency of refresher training sessions and what format these should take to best balance optimal preparedness and time resource pressures.

Credit author statement

Callum Mutch: Conceptualisation, Methodology, Investigation, Writing — Original Draft, visualisation. James Tiernan: Methodology, Data curation, Writing- review & editing. Oliver Koch: Supervision, Writing- review & editing, Investigation. Bozena Poller: Supervision, Methodology, Writing- review & editing

Conflict of interest statement

The authors have no conflicts of interest to declare.

Funding statement

There was no specific funding for this study.

Acknowledgements

Dr Harriet Runcie, Dr Vicky Tallentire, all participants in the programme, and the Masters in Clinical Education at the University of Edinburgh team. All photos original and used with permission.

References

[1] Fryk JJ, Tong S, Marshall C, Rajkhowa A, Buising K, MacIsaac C, et al. Knowledge, attitudes and practices of healthcare workers within an Australian tertiary hospital to managing high-consequence infectious diseases. Infect Dis Heal 2021 May 1;26(2):95.

[2] Mumma JM, Durso FT, Casanova LM, Erukunuakpor K, Kraft CS, Ray SM, et al. Common Behaviors and Faults When Doffing

Personal Protective Equipment for Patients With Serious Communicable Diseases. Clin Infect Dis 2019;69(Suppl 3):S214—20.
[3] Hall S, Poller B, Bailey C, Gregory S, Clark R, Roberts P, et al. Use of ultraviolet-fluorescence-based simulation in evaluation of personal protective equipment worn for first assessment and care of a patient with suspected high-consequence infectious disease. J Hosp Infect 2018 Jun 1;99(2):218—28.
[4] WHO. Ebola Disease caused by Sudan virus - Uganda. 2022.
[5] DuBose JR, Matic Z, Sala MFW, Mumma JM, Kraft CS, Casanova LM, et al. Design strategies to improve healthcare worker safety in biocontainment units: learning from ebola preparedness. Infect Control Hosp Epidemiol 2018;39(8):961—7.
[6] Wangsgard CR, Baalmann DV, Keaveny VR, Tosh PK, Goyal DG, Callies BI, et al. Simulation and lessons learned from the Ebola epidemic. Educ Health 2016;29(2):156—7.
[7] Poller B, Tunbridge A, Hall S, Beadsworth M, Jacobs M, Peters E, et al. A unified personal protective equipment ensemble for clinical response to possible high consequence infectious diseases: A consensus document on behalf of the HCID programme. J Infect 2018;77(6):496—502.
[8] Verbeek JH, Rajamaki B, Ijaz S, Sauni R, Toomey E, Blackwood B, et al. Personal protective equipment for preventing highly infectious diseases due to exposure to contaminated body fluids in healthcare staff. Cochrane Database Syst Rev 2020 Apr 15;(4):2020.
[9] Nayahangan LJ, Konge L, Russell L, Andersen S. Training and education of healthcare workers during viral epidemics: a systematic review. BMJ Open 2021 May 28;11(5).
[10] Fogel I, David O, Balik CH, Eisenkraft A, Poles L, Shental O, et al. The association between self-perceived proficiency of personal protective equipment and objective performance: An observational study during a bioterrorism simulation drill. Am J Infect Control 2017 Nov 1;45(11):1238—42.
[11] McGaghie WC, Harris IB. Learning Theory Foundations of Simulation-Based Mastery Learning. Simul Healthc 2018;13(3S Suppl 1):S15—20.
[12] Scahill EL, Oliver NG, Tallentire VR, Edgar S, Tiernan JF. An enhanced approach to simulation-based mastery learning: optimising the educational impact of a novel, National Postgraduate Medical Boot Camp. Adv Simul 2021;6(1):1—10.
[13] Matterson HH, Szyld D, Green BR, Howell HB, Pusic MV, Mally PV, et al. Neonatal resuscitation experience curves: simulation based mastery learning booster sessions and skill decay patterns among pediatric residents. J Perinat Med 2018 Oct 25;46(8):934—41.
[14] Reed T, Pirotte M, McHugh M, Oh L, Lovett S, Hoyt AE, et al. Simulation-Based Mastery Learning Improves Medical Student Performance and Retention of Core Clinical Skills. Simul Healthc 2016;11(3).
[15] Mcgaghie WC, Issenberg SB, Barsuk JH, Wayne DB. A critical review of simulation-based mastery learning with translational outcomes. Med Educ 2014 Apr;48(4):375—85.
[16] Pokrajac N, Schertzer K, Poffenberger CM, Alvarez A, Marin-Nevarez P, Winstead-Derlega C, et al. Mastery learning ensures correct personal protective equipment use in simulated clinical encounters of COVID-19. West J Emerg Med 2020;21(5):1089—94.
[17] Miller D, Pokrajac N, Ngo J, Gallegos M, Dixon W, Roszczynialski K, et al. Simulation-Based Mastery Learning Improves the Performance of Donning and Doffing of Personal Protective Equipment by Medical Students. West J Emerg Med 2022 May 2;23(3):318—23.
[18] Rudolph JW, Raemer DB, Simon R. Establishing a safe container for learning in simulation: the role of the presimulation briefing. Simul Healthc 2014 Dec;9(6):339—49.
[19] Barsuk JH, Cohen ER, Wayne DB, McGaghie WC, Yudkowsky R. A comparison of approaches for mastery learning standard setting. Acad Med 2018;93(7):1079—84.
[20] Diaz-Guio DA, Ricardo-Zapata A, Ospina-Velez J, Gomez-Candamil G, Mora-Martinez S, Rodriguez-Morales AJ. Cognitive load and performance of health care professionals in donning and doffing PPE before and after a simulation-based educational intervention and its implications during the COVID-19 pandemic for biosafety. Le Infez Med 2020;28(suppl 1):111—7.
[21] Kirkpatrick DL. Evaluating training programs: the four levels. Design. San Francisco, CA: Berrett-Koehler; 1998. p. 00—1.
[22] Rethans JJ, Norcini JJ, Barón-Maldonado M, Blackmore D, Jolly BC, LaDuca T, et al. The relationship between competence and performance: Implications for assessing practice performance. In: Medical education; 2002. p. 901—9.