Literature Review: Donning and Doffing and Virtual Reality

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Submission: September 18, 2020; **Published:** October 19, 2020

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Abstract

The current global crisis has highlighted the need for strict infection control in health care facilities. The need for teaching and training large numbers of health care providers to in a timely manner has come under the microscope. The need for safe effective donning and doffing of personal protection equipment (PPE) is an important part of protection for the health care provider. Appropriate use of PPE helps to reduce the potential for transition of infectious disease to their patients, their families, and the public. This literature review considers current training modalities, issues found with current donning and doffing procedures, problems noted with the current procedures and it reviews the potential for use of Virtual Reality, specifically avatars, to support the knowledge, skills and attitudes to don and doff PPE without self-contamination or contamination others.

Keywords: COVID-19; World health organization; Personal protection equipment (PPE); Donning and doffing, Mask, Gloves, Gown, Goggles, Face shield, Health care, Respiratory syndrome-coronavirus, Gamification

Introduction

The current global crisis of the transmission of COVID-19 has highlighted the need for improved infection control practices [1]. In March 2020, 1700 cases of COVID 19 reported in Italy were health care providers. In the United States of America, as of April 2020, approximately 9,282 health care providers were identified as COVID positive [2,3]. Even this high number of cases was thought to be an underestimation due lack of reporting of cases that were either mild or asymptomatic. An August 4, 2020 article by The Conversation stated that in Victoria, Australia some 1,100 health care providers had been infected with COVID-19 [4]. Effective use of PPE by health care providers is integral to safe effective care in all settings and becomes more imperative in the COVID setting. World Health Organization (WHO) recommendations underline the importance of PPE in terms of when they are worn and how they are donned (put on) and doffed (taken off) [1]. With the advent of COVID19 as a global disaster, hospitals everywhere are struggling to upskill health care providers in infection control procedure using simulation, webinars, and online courses to support PPE donning and doffing practices.

The recommendation by the CDC and the WHO is to have an observer watch both the donning and doffing processes to ensure that procedures are correctly adhered to and protocols are not breached [5]. However, this takes time, a central location and, of course, training of observers, and the staff numbers to continue to support patient care while the training process is ongoing. Simulation and virtual reality have been introduced to health care education because they allow the care provider to practice in a safe environment that imitates reality (Keskitalo & Ruokamo,2011). Virtual reality (VR) and augmented reality (AR) are recognised as technologies that will have a transformative impact on how we live, work, communicate and learn. The project is to consider the development of a VR program using avatars to improve the safety and welfare of health care providers who care for patients with infectious diseases by making education available that has the potential to overcome the problems of location, time, costs, and the need for frequent updating of skills.

This literature review is the first step in the project. It is important to consider what is the current practice, problems with the current practice and current use of VR to support teaching of this and other skills. Hence, the aim of this literature review is then threefold. The first aim is to review the current methods of teaching health care procedures for doffing and donning. Secondly, the literature will be reviewed to determine if there are knowledge gaps in the donning and doffing procedure and where these occur in the procedure. Thirdly, the literature will

be reviewed to consider the current research on the use of digital technology for teaching of health care providers. This information will then help to determine if there would be value in engaging digital opportunities, specifically avatars, to support the teaching of students and health care providers in this specific infection control issue.

Background

While the Centers for Disease Control and Prevention state that there may be more than one donning or doffing method for PPE [6], The World Health Organization [7], AUSMED [8] and The National Health System United Kingdom [9] all have similar recommended sequence for donning and doffing of PPE. The initial step for donning PPE is hand washing. After hand hygiene the PPE are placed in the following order: gown, mask or particulate respirator (P2/N95 mask), protective eyewear or face shield and finally gloves. For doffing The CDC (2020), WHO (2020), and AUSMED (2020) [2,7,8] the procedure advises removal of gloves and gown and then hand wash. The NHS (2020) recommends hand hygiene after each step. In general, the process is gloves, gown, goggles, or face shield and finally removal of mask or particulate respirator (N95/P2 mask).

The significant difference between the authorities in infection control in the doffing process is the number of times that hand hygiene is carried out. Authorities agree that doffing is specifically critical in control of the spread of pathogens. Incorrect choice of PPE and incorrect removal of PPE by health care providers leads to an increased risk of contamination for the user, other patients, and the greater public. This literature recognises the important of education on PPE and is focusing on the education methods currently in place to support our health care providers to promote safe effective care.
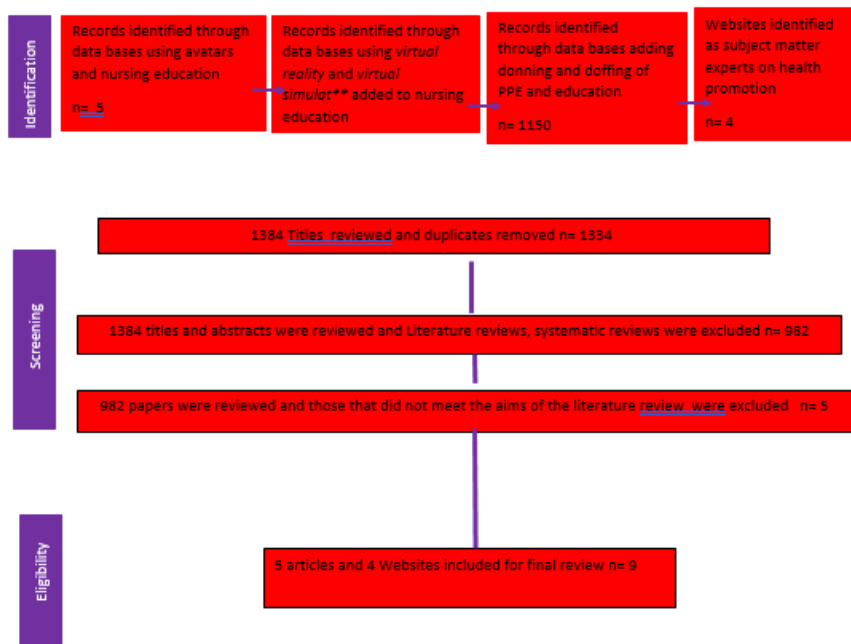
Method

A literature search was conducted using CINAHL complete, Google Scholar. MEDLINE complete, and Clinical Key. The papers that were considered eligible for inclusion English language journal articles, conference proceedings or thesis published between 2015 and 2020. The initial search using the terms *avatar* and *nursing education* from 2015 onwards only found five articles. A further search adding the terms *virtual reality* and *virtual simulat*** yielded an additional 234 articles for review. Finally, the terms Donning, and Doffing were added to education resulting in a further 1,150 papers.

The PRISMA flowchart in Appendix A demonstrates the search strategy employed for this literature review. The inclusion criteria were articles in English language with full text availability and published between 2015 and 2020. The titles and abstracts of all papers were reviewed. Given the limited time and word length requirement for this paper, the decision on which papers to include was stringent and only those that answered the specific questions asked were included. Those questions were as follows. What are the current modalities used for teaching donning and doffing of PPE to health care providers? What safety issues occur with donning and doffing of PPE by Health care providers? The studies included were conducted in Saudi Arabia, India, Australia, and the United States of America. Finally, only five journal articles and four internationally or nationally renowned for provision of evidence-based information to the health care provider websites were selected for inclusion (Appendix B)

Appendix a

Appendix B – Articles reviewed

Author	Title	Year	Methodology	Reason for Inclusion	Outcome
Al Tawfiq, Rothwell, McGregor, & Khouri	A multi-faceted approach of a nursing led education in response to MERS-CoV infection	2018	Qualitative	Current education on use of PPE	Need for ongoing education in donning and doffing
Baloh J, Reisinger HS, Dukes K, da Silva JP, Salehi HP, Ward M, Herwaldt L	Healthcare Workers' Strategies for Doffing Personal Protective Equipment	2019	Qualitative		Noted need for redesign of PPE along with updated policies and procedures and training strategies
Eubanks JC, Somareddy V, McMahan RP, Lopez AA	Full-Body Portable Virtual Reality for Personal Protective Equipment Training	2016	Qualitative	Described the development of VR interventions that could help overcome some of the recognised challenges of PPE training including costs, availability of learners, and trained facilitators.	Need to evaluate and improve upon the prototype using feedback from subject-matter experts in the field
Phan LT, Maita D, Mortiz D C, Weber R, Fritzen Pedicini C, Bleasdale SC, Jones RM	Personal protective equipment doffing practices of healthcare workers.	2019	Quantitative with a check list	Review of training procedures for donning and doffing	Noted need to change the training procedures used for PPE use in health care settings
Singh A, Naik B, Soni S, Puri G	Real-Time Remote Surveillance of Doffing during COVID-19 Pandemic: Enhancing Safety of Health Care Workers.	2020	Discussion paper	Discussed the importance of real time observation of donning and doffing of PPE	A two-way audio-visual communication in the doffing areas had advantages for cost effectiveness of maintaining safety of health care providers
Tiffany JM, & Hoglund B A	Using Virtual Simulation to Teach Inclusivity	2016	Qualitative Case Study	investigated use of VP with active student participation in nursing education regarding students' learning experiences of clinical reasoning.	Experiential learning theory supports learning experiences using virtual patient cases and appears to promote active learner participation.

Literature Review

Current Practice

Current information readily available for health care providers on such sites as the World Health Organization [7], Centers for Disease Control [2], AUSMED [8], Australian Commission on Safety and Quality in Health Care [11] all made use of posters or short videos to train health care providers in use of PPE. None of these sites offered a virtual reality experience to the user.

The 2012 outbreak of Middle East respiratory syndrome-coronavirus (MERS-CoV) resulted in several health care related outbreaks and highlighted the need for an improved approach to donning and doffing of PPE [10]. The health care facility implemented a formal education program to support a standardised approach to the use of PPE that included donning and doffing of the PPE. This study was conducted at Johns Hopkins Aramco Healthcare in Dhahran, Saudi Arabia. The program included on-line video, simulated demonstration, practice on a mannequin and debriefing over a four-day period. The program has been instituted as an annual competency for health care providers in the organisation. This program was highly successful however it was also very labour and resource intensive and time consuming.

Identified issues in donning and doffing of PPE

A study undertaken by Phan et. al. [10] in an acute care facility that took place from March 2017 to April 2018 used a trained observer to oversee the donning and doffing procedures with a focus on doffing procedures. The observer used a check list developed from the Center for Disease Control and Prevention (CDC) guidelines. The doffing procedures were observed 162 times for health care providers caring for 52 patients who were diagnosed with diseases related to respiratory viral pathogens. The study found that 90% of the cases studied were incorrect related to application of appropriate PPE and the doffing related to doffing sequence or doffing technique. The study noted that there was a clear need to change the training procedures used for PPE use in health care settings.

In a research project [5] that looked specifically at doffing strategies health care providers were recruited and assigned to one of three different doffing scenarios. The participants were asked to doff the PPE as per their routine practice. Performances were videoed and reviewed with the participants. The study looked at PPE removal safety, expedience, and barriers to safe doffing. The qualitative study indicated that health care providers routinely self-contaminated during the doffing procedure. In this study by Baloh et. al [5]

found that the rates of self-contamination rates ranged from 46%–90% across PPE types and scenarios. While the study did implicate that the PPE design need to be considered, along with revising policies and procedures, there was also a need to revise

doffing training in healthcare organizations.

Use of Avatars in Nursing Education

A paper by Eubanks et. al. [11] stated that virtual reality (VR) supports the development of distinctive interventions that could help overcome some of the recognised challenges of PPE training including costs, availability of learners, and trained facilitators. VR can provide consistent lessons that do not vary in quality or content. It also supports the ability to provide this consistent education to large numbers of learners and overcome issues of time and location. According to Eubanks and his team, VR allows the user the opportunity to practice gross psychomotor skills needed in donning and doffing of Personal Protection Equipment (PPE) and improves memory recall. The paper discusses the development of a VR program that is designed to teach health care providers the skills required for safe effective doffing and donning of PPE and allows them to repeat the procedure until they are comfortable with it. The program will not permit the user to skip steps.

The hardware used included a head-mounted display and an IMU-based tracking system to determine motion, orientation, and direction. The program also included handheld controllers and a high-performance laptop. The software package provided the user with an introduction and a practice module that supported rehearsing and learning from errors. Noted problems in the study were the inability of the user to practice fine-motor skills and the lengthy set up time involve. Both problems were thought to be overcome with improved software. The team planned to evaluate and improve upon the prototype using feedback from subject-matter experts in the field.'

A 2020 study by Suppan et al. [12] considered the use of "gamification" in education of health care providers regarding both selection and use of appropriate PPE. The team designed a gamified e-learning module that was focused on promoting knowledge and understanding of PPE use among prehospital health care providers. The researchers used a literature review and pre-testing to determine the appropriateness of gamification of the skills that they wanted the learner to acquire. Recommendations from the study were that the impact of the learning module now needs to be assessed through a randomized controlled trial.

Findings

The ongoing pandemic and the numbers of health care providers infected with COVID-19 has demonstrated the need for improved infection control teaching. The papers reviewed demonstrated the need for the development of an online interactive program to teach health care providers and in particular health care students to don and doff PPE in accordance with recognised guidelines may be timely for meeting the changing needs of education along with supporting for Health Care providers delivering safe effective care in the clinical environment.

Conclusion

Research has shown that the doffing of PPE is a high-risk period for the transfer of pathogens from the PPE to the wearer of the PPE [10]. Given the current situation and the ongoing risks to health care providers, there is a clear need to improve the teaching donning and doffing of PPE among health care providers. The world of avatars offers pedagogically sound opportunities for learning [13]. Avatars provides opportunities for educators to develop simulation activities that facilitate learning using a constructivist approach. Yet current programs for teaching doffing and donning, updated for COVID 19, focus on the use of paper posters, and videos that do not allow interaction from the viewer. And despite the noted need for an updated approach to the teaching of infection control, and especially in these recent circumstances of a global pandemic, there is a dearth of recent articles on the use of Avatars in teaching hands on health skills such as donning and doffing of PPE.

According to the Interim Provost, Professor Zlatko Skrbis, Australian Catholic University (ACU) [14] as higher education seeks to meet the challenges of COVID-19 "there is a noted need to harness digital opportunities to meet the changing education needs of a global market has been a long time coming Skirbis [14] went on to say that the focus needs to be on quality learning and provide the anywhere and anytime approach to learning [15,16].

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