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Simulation Technology & Operations Resource Magazine (STORM)

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Letter from the Editorial Board

Lessons Learned When Everything Goes Wrong

I recently found myself in a manikin failure scenario that tested my skills as a simulation operations specialist. I was disheartened by challenges and faced the difficult decision to declare the end of life for our pediatric manikin (nearly ten years past its manufacture date). Unhappy though I am, I see a benefit in sharing the struggles and lessons learned from this experience, providing a troubleshooting resource to the simulation operations community.

My simulation center does not run many pediatric simulation activities, and we don't have many options when it comes to pediatric manikins. In fact, one such manikin was only being used once a year for an anesthesia residency pediatric laryngospasm simulation. Little did I know at the time, but during a refresh walkthrough for this event, I would make one mistake after another. Reflecting on that day, I am reminded of four key lessons that could benefit anyone in the simulation operations community.

Lesson #1: Trust Your Gut

Several times the week prior to the walkthrough, I had a feeling I should test the pediatric manikin in advance. The year before, we had issues with one feature on the manikin, but had found ways to work around it. However, when I felt the urge to test the manikin, I talked myself out of it. I reasoned that we had 2 hours blocked for setup the day of the walkthrough, which would be plenty of time. And, I asked myself, since we hadn't used the manikin for a full year, what could possibly be wrong with it? If I had trusted my gut and tested the manikin a week earlier, I would have saved myself from stress later on. It would have seen that I needed more time to communicate with simulation instructors about the functionality needed to meet the learning objectives and I may have had enough time to locate a backup manikin option.

Lesson #2: Don't Make Assumptions

When we began setup of the manikin, we heard a large internal air leak, which meant it would not function. I assumed, since the air leak came from a short, detached tube, it would be easy to identify where it needed to be reconnected. We tried our best, tracing all kinds of connections and searching the internet for pictures of various manikin pieces, but after two hours, we were no closer to having the manikin working than when we started. We lost that time. I then assumed, since this pediatric manikin was no longer on a warranty plan, we would be unable to get technical support for it. That was not the case either, and that lesson leads us into lesson #3.

Lesson #3: Ask for Help

Due to the assumption that our air leak would be an easy fix, and the assumption that we would not be able to get technical support for an out-of-warranty manikin, I took way too long to ask for help. I'm sure overconfidence in my problem-solving ability also came into play as well. Only when my team and I reached a dead end after two hours on our hunt for the air leak connection, did I decide to call technical support. Even then though, I figured it was pointless.

Fortunately for us, technical support was able to help, and after 1.5 hours on the phone with them, we reconnected the air hose. Unfortunately, once the air hose was reconnected, all our issues were not resolved. In fact, we found additional problems that technical support declared would require sending an on-site technician.

Lesson #4: Test Critical Features First

After more than 5 hours of setup, and only 30 minutes away from the walkthrough start time, we had the manikin working. Sure, we had some hardware and software challenges, but the manikin was breathing, and we had some software control. However, we hadn't yet tested the laryngospasm feature, and with ten minutes to spare, we activated it. Immediately we saw that the vocal cords didn't close as they should for a laryngospasm. Instead, we heard more leaking air. A closer look at the airway revealed that the laryngospasm feature was irreparable. This was the final straw. We finally decided that this pediatric manikin had reached the end of its useful life. While we were still able to use a different manikin for the simulation event, we wasted time and effort by not focusing on the most critical features earlier in our testing.

Ultimately, these lessons were learned over the course of a very long day. I felt discouraged repeatedly as we fixed one problem with the manikin only to find another. This experience serves as a reminder of these key lessons for technology troubleshooting. Although I "know" the things I should have done, it's so much harder to take the correct actions when in the actual situation. I'm thankful for this opportunity to practice and reflect on problem-solving.

When faced with a technology obstacle, I encourage everyone to remember to use the resources we have available, which can include our teams, our time, and our access to support. Take time to test equipment and consider alternative options in advance. Explore the pieces of the problem as unbiasedly as possible, and trust in your experiences and abilities. I'm sure I'll make mistakes in the future, but the next time I approach a technology problem, I will start by taking a step back and leaning on these lessons learned.

Amy Follmer, CHSOS-A
STORM Editorial Board Member

Standardized Technical Communicators: A Novel Simulation Center Staffing Model

Authors

Kathrine C. Branch, PhD, MSN, RN, CHSE[1], Douglas J. Ayers, BSN, RN, CHSE[1], Sharon K. Baker, BSN, RN, CHSE[1].

[1]Grand Valley State University, Grand Rapids, Michigan

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Brief Description / Abstract

Many healthcare and government organizations are concerned about a growing shortage of healthcare workers. In response, educational institutions are under pressure to produce competent and qualified healthcare graduates. However, as academic programs increase the number of learner cohort sizes, institutions face challenges such as staffing shortages and limited clinical placements. To address these challenges, institutions have increased the use of simulation to provide learners with clinical practice experiences. Unfortunately, the increase in demand for simulation in healthcare program curricula also increases the workload of simulation staff. In response to the increased demand, the Standardized Technical Communicator staffing model enables simulation centers to meet the needs of healthcare programs while maintaining high-quality experiences for learners.

Introduction

In today’s economic environment, simulation centers face several challenges when trying to expand services or accommodate increased demand without the significant accumulation of additional resources. One such challenge is establishing adequate staffing. This article provides a focused review of how Standardized Technical Communicators have been defined and incorporated into the standard operating procedures of a large, interprofessional, university-based simulation center for over half a decade. The use of Standardized Technical Communicators has demonstrated to be an innovative, economical, and effective staffing model to address staffing gaps and enhance both faculty and learner experiences.

The concept of asking employees to do more with less often leads to employee burnout, low productivity, low satisfaction, and higher attrition rates (Brunner, et al., 2019; Esteve, et al., 2017; Russell et al., 2020). Over the past decade, Grand Valley State University’s (GVSU) Interprofessional Simulation Center has grown from its original 6,409 square feet footprint in one building to today’s 67,828 square feet footprint spread across three buildings on the University’s Health Campus. During this timeframe, the number of learners and academic programs utilizing the Center has grown exponentially. On average, the Center provides over 1,500 simulation-based events with over 8,000 total learners in attendance every year. Incorporating Standardized Technical Communicators allows the Center to adequately increase services and meet demand without needing to significantly increase the workload for existing staff or the number of full-time, benefits-eligible staff members.

Discussion

Terminology

The title of the Standardized Technical Communicators was informed by terminology in the Society for Simulation Healthcare's (SSIH), Healthcare Simulation Dictionary (Lioce et al., 2020). This innovative role is a blend of a Standardized Patient and Simulation Technology Specialist. Defined by SSIH, a Standardized Patient is, "An individual trained to portray a patient with a specific condition in a realistic, standardized, and repeatable way and where portrayal/presentation varies based only on learner performance" (Lioce et al., 2020, p.49). A Simulation Technology Specialist is defined as "An individual who provides technological expertise, instructional support, and advocacy in healthcare simulation" (Lioce et al., 2020, p.47). The Standardized Technical Communicator is an individual trained to support the facilitation of healthcare simulation by portraying the "voice" of the patient simulator/mannequin and operating the patient simulator software allowing for patient data to be communicated in a realistic, standardized, and repeatable way whereas portrayal and patient data presented varies based only on learner performance.

Employee Classification

Standardized Technical Communicators are classified by the university as temporary, hourly paid, non-benefit eligible employees. Scheduled hours are based on simulation event types, the number of simulations running simultaneously, and Standardized Technical Communicators' availability. The hourly pay rate for Standardized Technical Communicators is the same wage Standardized Patients are paid at the university. Standardized Technical Communicators are community members, who typically do not have a professional healthcare background. In terms of recruitment and hiring for this position, word of mouth or referrals from existing Standardized Technical Communicators is most effective. The position requirements include a high school diploma, completion of a criminal background check, and a signed acknowledgement and agreement to adhere to the policies and procedures outlined in the GVSU Standardized Technical Communicator's Manual. Although it is not required, most of the current Standardized Technical Communicator employees have some form of experience in local theater, voice acting, or broadcasting communications which enhances realism or accuracy in portraying the voice of a patient during a simulation. In addition, it is advantageous if prospective Standardized Technical Communicators have previous experience working as a Standardized Patient, as well as an understanding of simulation-based methodologies and fundamentals. However, no prior experience in simulation is necessary for a Standardized Technical Communicator to be successful. Preferred work experience includes the ability to work independently, coordinate multiple tasks, technologically savvy, good organizational skills, flexibility with job tasks, and the ability to maintain effective working relationships with faculty, supervisors, team members, and students.

Standardized Technical Communicator Onboarding

Currently, the GVSU Interprofessional Simulation Center has a pool of 11 Standardized Technical Communicators, in addition to its pool of over 200 pediatric and adult Standardized Patients. Upon hire, individuals are encouraged to choose a specific role either as a Standardized Technical Communicator or Standardized Patient as scheduling conflicts may arise from individuals signing up for the entire semester and indicating their availability for both roles. It is the responsibility of the Standardized Technical Communicator to ensure they do not double-book themselves for simulation events. Due to the investment of time and resources required to adequately train new employees, it is important that the Standardized Technical Communicator Program maintains a high retention rate of employees. Maintaining a smaller pool of Standardized Technical Communicators allows for Center staff to build rapport with each employee. The professional relationships help the Standardized Technical Communicators feel supported and identify as a member of the team. The Standardized Technical Communicator role may be preferred over Standardized Patient work because the Standardized Technical Communicator is not in direct contact (no physical exam component) when interacting with learners nor has to memorize specific details of a patient scenario. Standardized Technical Communicators are stationed in a separate control room, with video access to learners, while maintaining immediate support from Center staff as well as direct communication with faculty. Additionally, the Standardized Technical Communicators have opportunities to work a wide variety of events and hours because patient demographics are not a limiting factor when scheduling for events.

Adequate onboarding of a Standardized Technical Communicator is an investment. The process is dependent on the experience and technology comfortability of the employee. The average onboarding process includes a one-hour orientation which includes a tour of the facility and time to review the Standardized Technical Communicator manual with a Center staff member. Following the orientation, three shadow shifts are scheduled. During the shadow events, the new Standardized Technical Communicator is paired with a Center staff member or an experienced Standardized Technical Communicator with at least one year of experience. The objective is to provide exposure to simulation events and observe the role of the Standardized Technical Communicator. Experienced Standardized Technical Communicators model how to communicate with faculty, students, and other Center team members. Finally, a “supported” event is scheduled. During this time, the novice Standardized Technical Communicator is shadowed by a Center staff member for evaluation and immediate feedback following each simulation event. On average, the total onboarding process is 13 hours. It is most effective to begin the onboarding process near the start of the semester. This method allows the Standardized Technical Communicator to begin training and follow along with a cohort of first-semester students who are in a course featuring simulations with fundamental cases. Typically, fundamental simulation cases are simplified, low stakes, and have basic technology management compared to final semester simulation events which are more technologically demanding. The fundamental simulation events allow the Standardized Technical Communicator to build confidence and understanding of the job responsibilities and communication skills needed to provide an optimal simulation experience. The duration of the training time/onboarding process may be altered as needed by the professional judgment of Center staff members.

Like the training of Standardized Patients, Standardized Technical Communicators are trained by Center staff members on each simulated case. Training is often provided in person. However, it has been found most effective to produce training videos for each simulation case. The Standardized Technical Communicators can view the videos before or at the beginning of their scheduled work session. This process also ensures the training provided for each case is standardized. The case-based training videos are password protected and accessible to the Standardized Technical Communicators through the Center’s website. After the Standardized Technical Communicators view the training videos, they are provided training by Center staff on the type of patient simulator software they will be utilizing for the simulation case they will be facilitating during their work session. GVSU simulation cases are produced based on an algorithm, which are designed so that the Standardized Technical Communicators are cued on when to move from one programmed state to another state in the software, based on the learners' patient care actions during the simulation. All GVSU simulation cases are also designed to include talking points that Standardized Technical Communicators use as verbal content to serve as the "voice" of the patient.

Daily Responsibilities

The primary responsibilities of the Standardized Technical Communicators include being the "voice" of the patient simulators/mannequins, operating the patient simulator software through pre-programmed states as learners progress through patient simulator-based events, and manipulating patient simulator vitals software used during standardized patient-based simulations. The facilitation and use of technology allow for patient data to be communicated in real-time based on learner actions or the scripted progression of the case. This often eliminates the need for Standardized Patients to use physical exam cue cards during simulations. Additional duties include the resetting of simulation rooms after learner encounters in preparation for the next round of learners. As with all Center staff, it is expected that Standardized Technical Communicators will display professionalism and adhere to the Family Educational Rights and Privacy Act (FERPA).

Before the start of any simulations, the Standardized Technical Communicators have a checklist of items they work through to ensure all technological components intended for use during their assigned simulations are in working order, including microphones, speakers, and vitals monitors. During the facilitation of simulations, the Standardized Technical Communicators work in the Center's control room and utilize the Center's communication system to broadcast the "voice" of the patient through a microphone in the control room, to a speaker at the head of the bed, in a specific patient care room. The GVSU Interprofessional Simulation Center has 14 inpatient care rooms, an operating room, a three-bed ward, and one maternity suite with 12 Standardized Technical Communicator stations in the control room. The Standardized Technical Communicator stations are designed so that any station's hardware and cables may be routed to coordinate with any of the patient care areas previously mentioned in the Center. Faculty observing simulations have remote access from the faculty observation room which is conveniently located adjacent to the Center's control room. This allows faculty to speak with their assigned Standardized Technical Communicator either in person or through commercial instant messaging software. To troubleshoot any technical issues or answer any medical-based questions that the Standardized Technical Communicators may have, a full-time Center staff member, with a health-related professional background remains in the control room while simulations are being conducted. The high capacity of stations in the control room allows for 12 simulation patient care areas to be utilized at one time. If needed, one single Center staff member can manage 12 Standardized Technical Communicators at one time. However, it has been found that a staffing ratio of one Center staff member to four competent Standardized Technical Communicators to be optimal.

After a simulation event is completed, the Center staff will debrief with the Standardized Technical Communicators to address any concerns regarding the event and how it might be improved if the event is repeated. Evaluation procedures are being implemented in the form of quality assurance initiatives. These include designating time to review recordings of simulation events to ensure that the assigned Standardized Technical Communicators appropriately completed all expected job responsibilities. For example, Center staff will monitor that the vital signs were changed at the correct time based on the learners' interventions or that the Standardized Technical Communicator appropriately and accurately expressed the patient's case symptoms, while portraying the "voice" of the patient.

Standardized Technical Communicator Justification

Faculty feedback at GVSU has been positive regarding the use of Standardized Technical Communicators. Although there is no research surrounding the specific role of Standardized Technical Communicators, current evidence regarding the role of Simulation Technologists reflects faculty feedback about the use of Standardized Technical Communicators. Smaller simulation centers typically demand faculty fulfill multiple roles such as directing the flow of the simulations, changing inputs of simulator software, observing the performance of students, and resetting the room after encounters (Sibbald et al., 2019). These duties add workload and stress to faculty and may interfere with student evaluation and learning opportunities. Evidence supports the use of Simulation Technicians and similar roles. Simulation supportive staff allows faculty to focus on observing the actions of learners, adding annotations directly into the learners' simulation video recordings, and taking note of educational opportunities to review during the simulation debrief which occurs immediately after the encounter (Lowther & Armstrong, 2023).

The decision to use Standardized Technical Communicators is made during the planning phase of simulation design. Through tabletop meetings with faculty and Center staff, resource usage is decided based on the type of simulation, level of fidelity, number of students, number of simulations running simultaneously, and timing of the simulation event. It should be noted that faculty prefer to use Center staff to fill the role of the Standardized Technical Communicator when possible. Center staff are more desirable due to their expert knowledge of simulation methodology, technology, and medical knowledge. However, it is not always feasible or cost-effective to use Center staff instead of hiring temporary Standardized Technical Communicators. Over the past fiscal year, Standardized Technical Communicators were utilized an average of 1,733 hours, which cost approximately $26,000. The total cost of using Standardized Technical Communicators is significantly lower than a full-time, benefit-eligible, Center staff.

Considerable challenges in the implementation of the Standardized Technical Communicator staffing model include the time invested and the lack of medical knowledge of the temporary employees. It is difficult to designate Center staff time for one-on-one training sessions when onboarding Standardized Technical Communicators. If multiple simulation events are running simultaneously, often the Center staff are pulled away to address and troubleshoot any technical issues. A favorable solution is to pair the Standardized Technical Communicator trainee with a competent Standardized Technical Communicator who utilizes best practices and is willing to take on the additional responsibility of training. It is the judgment of the Center staff which Standardized Technical Communicators are best suited for training new employees. Without a health-related education, the Standardized Technical Communicator may not be confident in appropriately responding to unanticipated student actions during a simulation. It is the responsibility of the Center staff to be present and available to assist the Standardized Technical Communicators with any medical-related questions. The instant messenger software between the Standardized Technical Communicator and faculty is another means for medical questions to be answered, if needed. Additionally, faculty are capable to utilize an intercom feature, which is included in the Center's video streaming software, to interject into the patient care room during a simulation, if needed. Overall, the utilization of Standardized Technical Communicators to accommodate demand and offset workload in the Center far outweighs the challenges posed by the incorporation of another category of temporary employees in the delivery of simulation-based education at the university.

Conclusion

The utilization of Standardized Technical Communicators at GVSU has produced several advantages besides being able to expand services and accommodate increased demand. The advantages include a successful way of filling staffing gaps, especially when obtaining approval and funding for additional full-time, benefits eligible positions is difficult, they allow for numerous simulation cases to be run simultaneously, and eliminate the need for most physical exam cue cards. Additionally, it permits faculty to observe and critique the simulations in real-time while intentionally focusing on learners' actions and embedding annotations, as to what they have done well or need to work on, into the learners' recorded simulation videos, which can then be used to enhance debriefing or help guide learner reflection activities post simulation. Another advantage of Standardized Technical Communicators is that many of those hired are professional actors who provide an enhanced level of realism as the "voice" of the patient, like a pediatric patient voice, crying or intense pain. Finally, a few of the greatest advantages of utilizing Standardized Technical Communicators are that they promote a very collaborative work environment, lead to overall long-term employee satisfaction, and free up time for Center staff to be continuously innovative in providing simulation experiences.

Healthcare Simulation Technology Specialist (HSTS) Survey

Authors

Lisa A. Paganotti, PhD, PA-C, CHSOS[1], Gregory E. Gilbert, EdD, MSPH, PStat®[2], Scott B. Crawford, MD, CHSOS[3], Ronald J. Shope, PhD1

[1]George Washington University, Translational Health Sciences Program, Washington D.C.

[2]ΣigmaΣtats ConsultingTM, LLC, Charleston, SC

[3]Scott B. Crawford, MD, Associate Professor, Texas Tech University Health Sciences Center El Paso, El Paso, TX

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Corresponding Author

Lisa Paganotti, George Washington University, Department of Health, Human Function and Rehabilitation Science (Email: lisaannbuckley@gwu.edu)

Brief Description / Abstract

In general, little is known about the features of the current healthcare simulation technology specialist (HSTS) workforce. This information is essential to best support and develop a robust workforce to support simulation-based education. The intention of this research is to understand demographic information about HSTS professionals and understand their education and experiences. An online survey was developed and distributed to professional societies that support training and education for HSTS. Researchers analyzed 97 completed, and 23 partially completed surveys, representing a 3% response rate. Investigators evaluated data from the survey to generate a job profile for the HSTS role. This study provides baseline data on the characteristics of the HSTS profession in 2021. Despite the low response rate, these data provide a baseline for characteristics of the HSTS workforce and suggest heterogeneity exists among those working in the HSTS role.

Introduction

Healthcare Simulation Technology Specialist (HSTS) Survey

Simulation in healthcare has been growing over the last twenty years (Motola et al., 2013). As the use of simulation technology has grown, so too has the demand for technical and operations support staff for simulation programs. Job titles and responsibilities for HSTS roles are far from unified due to the varied nature of each simulation center and the evolution of the profession (Bailey et al., 2015; Steer et al., 2019). A review of simulation center operations found “technicians” to be the most common role employed (Tranel et al., 2021). The technical side of simulation operations is essential for a highly functioning simulation center and for the growth of healthcare simulation (Bailey et al., 2015). Qayumi et al. found the need for a dedicated simulation technician was a top barrier to the growth of a simulation program in an international survey (Motola et al., 2013). This article will use the term HSTS to encompass all technical and operational simulation roles (Lioce et al., 2020).

In 2012, Gantt described the need to define the title and role of the person who operates the simulator (Gann, 2012). To grow and professionalize HSTS, Bailey et al helped define the responsibilities and core duties (Bailey et al., 2015). Supporting the findings of the Bailey study, the Society for Simulation in Healthcare (SSH) and the Gathering of Healthcare Simulation Technology Specialists (SimGHOSTS) each conducted a practice analysis of necessary skills and domains of knowledge for this role. Crawford et al., described the overlap of these respective five and eight domains with example work tasks (Crawford et al., 2019). The five-domain outline was used as the basis for the Certified Healthcare Simulation Technology Specialist (CHSOS) certification from SSH. Steer et al. developed a capability framework to further define and differentiate the progression of skills for the foundational, intermediate, and senior-level HSTS using the eight-domain outline from SimGHOSTS (Steer et al., 2019). Collectively, the described work has clarified and codified the role of the HSTS and was used to support the standards and elements for recognition as a CHSOS – Advanced by the SSH.

Methods

Survey Design and Pilot Study Procedures

Survey questions were based on the job profile questionnaires of other professions and from the experiences of the authors in consultation with other HSTS experts. Initial survey feedback was provided by two authors (Ron Shope and Gregory E. Gilbert) with expertise in survey development. The initial draft was circulated to five individuals for feedback on design, clarity, grammar, typographical errors, survey flow, visual display features, and ease of use. Subsequently, the survey was pilot tested with HSTS experts who provided feedback on content. Feedback was received from five experts, two of which had substantial experience with survey creation and data collection. All five HSTS experts agreed the survey questions have face validity. Finally, the survey was reviewed by the Board of Directors of SimGHOSTS. See Appendix A for survey questions. This study was reviewed and determined to be exempt by the Institutional Review Board of George Washington University. The authors conducted the project in accordance with the tenets espoused in the Declaration of Helskinki (World Medical Association, 2012).

Sampling Plan

The target population was HSTS currently working in the field. Over 4,000 individuals with membership to either SimGHOSTS or SSH CHSOS and Simulation Operations and Technology Section Listserv groups received an invitation to complete the survey. The survey link remained open for one month and reminders were sent weekly.

Analysis

Data analysis was completed using R statistical software. Researchers calculated absolute frequencies and percentages for the data. Researchers investigated several questions related to salary using null hypothesis statistical tests that used Fisher's exact test and report Cramer's V as an effect size. In accordance with the 2019 American Statistical Association statement admonishing investigators draw no conclusions with respect to "statistical significance", the authors chose not to dichotomize "statistical significance" in favor of interpreting p values in the vicinity of .05 as evidence of statistical difference (Wasserstein et al., 2019).

Table 1: Demographics

		%(n)
Gender	Male	55(51)
	Female	43(40)
	Non-binary	2(2)
Age Group	18-25	1(1)
	26-30	8(8)
	31-35	14(14)
	36-40	11(11)
	41-45	10(10)
	46-50	12(12)
	51-55	14(14)
	56-60	11(11)
	61 or older	12(12)
	Missing	4(4)
Ethnicity	Hispanic	11(11)
	Non-Hispanic	62(60)
	Middle Eastern/Northern African	3(3)
	Other	15(15)
	Missing	8(8)
Education	Associates or less	24(23)
	Bachelor's	42(41)
	Master's+	29(28)
	Missing	5(5)
Country	Qatar	3(3)
	Singapore	1(1)
	United Kingdom	6(6)
	USA	76(74)
	Canada	4(4)
	Finland	1(1)
	Japan	1(1)
	Australia	2(2)
	Missing	5(5)
Licensure	Licensed	36 (35)
	Not Licensed	52(50)
	Previously Licensed	8(8)
	Missing	4(4)

Results

At the close of the survey link, 97 respondents completed surveys and an additional 23 surveys were partially completed, representing a total of 120 survey respondents (a 3% response rate of the possible 4,000 list serve recipients). The results showed most respondents worked over 51% of their time in a technical role and worked 31 to 40 hours weekly. Roughly half of respondents (Table 1) were not a licensed or registered healthcare professional. The vast majority of HSTSs spend most of their time on manikin-based simulation (79%, n=76) followed by task trainers (15%, n=14), standardized patients (4%, n=4), and lastly virtual reality/augmented reality, or mixed reality simulation (2%, n=2).

In response to experience, respondents were equally distributed between two and fifteen years. Responses showed 25% (n=24) had been employed with their current employer for less than two years, 34% (n=34) two to four years, 14% (n=13) four to six years, 6% (n=6) longer than six to eight years, 6% (n=6) eight to ten years, 8% (n=8) ten to fifteen years, and 5% (n=5) for greater than fifteen years. Employer-paid funding for professional development revealed 18% (n=18) had no funding. The remainder of responses ranged from $1 to more than $2,000 annually.

Table 1 shows the location and demographic characteristics of respondents. Educational background responses varied with the majority having a bachelor's degree (Table 1). In addition, over 50% of respondents have the CHSOS credential. Twenty-seven percent (n=25) plan to take the CHSOS examination, and 20% (n=18) do not have it and are not planning to take it. Twenty-seven percent (n=26) of respondents use the job title Simulation Operations Specialist or HSTS. Respondents identified various job titles which include simulation manager, coordinator, director of simulation education and research, simulation operations technician, simulation engineer, surgical lab manager, lead simulation operations specialist, and senior trainer.

There was a range of informal education opportunities described as on-the-job training (79%), attending conferences (81%), and being mentored or mentoring (50%). Additional text responses included reading articles, posts in a listserv community, performing committee work, attending simulation courses, college courses, participating in vendor training, or attending simulation webinars. Fifty-five percent of respondents spend between 21 and 40 hours annually in informal training; however, additional written responses ranged from 80 to 200 hours.

Table 2 represents the organizational characteristics of respondents. Most respondents (67%, n=62) have no employees reporting to them; 11% (n=10) one direct report, 4% (n=4) have two direct reports, 3% (n=3) have three direct reports, 2% (n =2) have four direct reports, and 13% (n =12) have five or more employees reporting to them. Almost all respondents (98%, n =91) reported employers paid for vacation, sick and/or personal leave. Respondents described their employer as an academic medical center (37% n =36), nursing school (20%, n=19), a medical school (11%, n=11), a health profession school (9%, n=9), a community hospital (7%, n=7), or a government, consultant, military, or vendor position (4%, n=4) (Table 2). Still, an additional 11% (n=11) listed their employer as "other".

Table 2: Percentage (frequency) of organizational characteristics of HSTS employers

		% (*n*)
Type of employer	Corporate/Gov't	13 (12)
	Healthcare School	41 (38)
	Hospital	46 (43)
Number of simulation employees	1	32 (29)
	2	20 (18)
	3	14 (13)
	4	9 (8)
	5	26 (24)
Number of simulation technicians	1	34 (31)
	2	22 (20)
	3	12 (11)
	4	7 (6)
	5	7 (6)
	6	20 (18)
Total Organization Employees	<99	18 (17)
	100-199	4 (4)
	200-299	4 (4)
	300-399	3 (3)
	400-499	3 (3)
	>500	41 (38)
	Unsure	13 (12)
	Other	13 (12)

Respondents reported a wide range of annual salaries. Responses varied from less than $25,000 per year to over $86,000 United States Dollars (USD) per year. The category with the most responses was ≥$86,000 (14%, n=12). The next highest response rate was tied between $36-41,000 and $51-56,000 (both 11% (n=10). Cramer's V was used to evaluate a relationship between salary and role/respondent characteristics. There was a weak (Cramer's V=.32) association between the number of direct reports and salary. There was statistical evidence of an association (p=.060), however weak.

Cramer’s V was used and there was no statistical evidence in this sample of an association between salary (<$55,000, $56,000-$85,999, and ≥$86,000) and region of the world (Asia-Pacific, North America, and Europe) (p=.110). Cramer’s V is .21, meaning the maximum amount of variation in salary explained by region is 21%. However, there was statistical evidence of an association between education (Associate’s or less, Bachelor’s, and Master’s+) and salary (<$55,000, $56,000-$85,999, and ≥$86,000) (p=.021with 26% of the variance in salary being explained by education. Similarly, association in the sample between licensure (licensed, not licensed, and previously licensed) and salary (<$55,000, $56,000-$85,999, and ≥$86,000) also showed statistical evidence of an association (p=.026) with 26% of the variance in salary being explained by licensure category. There was no statistical evidence of an association between certification (CHSOS and no CHSOS) and salary (<$55,000, $56,000-$85,999, and ≥$86,000) (p=1.000). Virtually no variation in salary was explained by certification (2%). Lastly, salary (<$55,000, $56,000-$85,999, and ≥$86,000) and institution were examined (corporate/government, healthcare school, and hospital) salary and institution showed no statistical evidence of association (p=.174). The maximum amount of variation in salary explained by institution was 20%.

Discussion

Prior studies identified the lack of persons in the HSTS profession to be a barrier to simulation education development (Qayumi et al., 2014). A study reported at the SSH conference in 2017 surveyed 108 simulation center directors, and only two respondents found well-qualified HSTS individuals available to hire and 81% of respondents (n=87) found few applicants for the positions (Forinash et al., 2017). The same survey found a similar dichotomy in salary reported with 42% (n=52) of directors surveyed in 2016 reporting a salary for HSTS between $30,000-50,000 and 38% (n=47) in the $50,000-70,000 range (Forinash et al., 2017). Promoting the HSTS role as a healthcare career with science, technology, engineering, and math (STEM) opportunities may be a way to increase the availability of persons in this role and increase the diversity of the workforce.

A comparison was made between this study and the Bailey et al. article. Bailey et al. had slightly more male (64%) respondents than female (36%) compared to this study (55% male and 43% female) (Tranel et al., 2021). One explanation is an increase in HSTS women between 2015 and 2021. Alternatively, it is possible more women were motivated to respond to this survey. Age ranges and degrees were similar in both studies.

An article by Tranel et al. in 2021 surveyed simulation centers about their operations (Tranel et al., 2021). The only data collected by both studies was the distribution of employers associated with a school. Trenel and Qayumi, 57% and 79%, respectively, were associated with a school and in this study, 40% (n=39) were employed by a nursing, medical, or health professions school (Tranel et al., 2021; Qayumi et al., 2014). This contrasts with those employed by a hospital, government, or other employer, which represented 45% of responses in this study. This may represent an expansion in location of simulation centers from academic institutions to academic and community hospitals.

Interestingly, Qayumi et al. noted the most used modality was online simulation modules, followed by task trainers and lastly human patient simulation (Qayumi et al., 2014). This contrasts with this study where respondents reported spending most of their time on manikin-based training, then task training, followed by standardized patients, and lastly virtual/augmented or mixed reality simulations. It could represent a shift in simulation use over time and will be interesting to follow this trend into the future.

This study had a high number of respondents (53%, n=49) who earned their CHSOS. This is likely biased by using the CHSOS distribution list to recruit study participants, and therefore, the percentage of overall HSTS professionals with the credential of CHSOS may be lower than represented by this survey.

The lack of racial and ethnic diversity in responses provides an opportunity for outreach to encourage the inclusion of diverse backgrounds in the HSTS profession. Since 50% of respondents reported being mentored or mentoring another individual, mentorship could increase diversity.

This study demonstrates heterogeneity across the HSTS profession in the characteristics surveyed and provides a baseline on characteristics for HSTS professionals. This heterogeneity may present a barrier to the growth of the profession, the development of training programs, and the recruitment of new HSTS into the field. A similar survey targeting other simulation center staff, to identify areas of role overlap could help identify this possibility. The results are not only interesting for those in the field of healthcare simulation but also for individuals interested in an HSTS career.

Limitations

The main limitation was the small sample size (n=120). The low response rate may be due to inactive or out-of-date email accounts, individuals deleting the survey without opening it, or ignoring the content due to email/survey fatigue. Another explanation is individuals did not participate if they did not primarily identify as an HSTS and thought it did not apply to them. This may have occurred because a common feature described by simulation staff is the concept of a hybrid role, where an educator or administrator may also be asked to perform the duties outlined in HSTS domains.

Conclusions

Prior to this research, summary data has been collected for marketing and tracking purposes by professional societies but, the authors are not aware of any studies that have sought to identify characteristics of the HSTS professionals and jobs. Therefore, these results provide baseline data for the profession in 2021. Due to the low response rate, the authors are hesitant to generalize the data to the HSTS profession. Despite the response rate, it is suggested that much heterogeneity exists among the HSTS workforce. The authors plan to repeat the survey with the hope to increase the response rate and to compare and track changes in the HSTS profession over time. Efforts to increase the response rate will include in-person advertising and promotion of the survey at the annual conferences for SSH's SimOps, International Meeting for Simulation in Healthcare, and SimGHOSTS.

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Enhancing Medical Education: Exploring the Use of Virtual Reality in Practical Sessions

Authors

Vineetha Menon[1], Ahmad El Ouweini[2], Sandhya Arun[3], Aliaksandr Marozou[4], Pavel Makarevich[4], Aliaksandr Lisavets[4]

[1]College of Pharmacy, Department of Clinical Pharmacy, Gulf Medical University, Ajman, United Arab Emirates.

[2]College of Pharmacy, Department of Pharmacy Practice, Gulf Medical University, Ajman, United Arab Emirates.

[3]Center for Advanced Simulation in Healthcare (CASH) Gulf Medical University, Ajman, United Arab Emirates.

[4]Proven solution information technology, Dubai, United Arab Emirates.

The authors (VM, AEO, SA) declare no conflict of interest. AVM, PVM, ASL are employees of the company Proven Solution Information Technology. The study used equipment and software provided by the company Proven Solution Information Technology.

Corresponding Author

Aliaksandr Marozou, MD, Proven Solution Information Technology, Dubai, United Arab Emirates (Email: amorozov@provensolution.com)

Brief Description / Abstract

This article explores the use of virtual reality (VR) technology in medical education, focusing on its potential in training medical professionals to acquire essential skills, such as taking patient histories and ordering investigations. VR simulations provide a safe, risk-free environment for trainees to practice complex medical procedures, making mistakes and learning from them. The article cites several research studies that show the efficacy of VR in improving clinical outcomes and enhancing medical education. The article then evaluates an innovative VR application developed by Proven Solution, which allows pharmacy students to interact with virtual patients and practice various clinical skills. The study involved 34 pharmacy students who were trained using the VR application to collect patient histories and order investigations. The results of the study were analyzed to determine the effectiveness of VR in training pharmacy students to acquire essential skills.

Introduction

Virtual Reality (VR) is currently changing the way healthcare professionals are trained. VR technology has the potential to provide immersive, realistic, and interactive training simulations, allowing medical professionals to practice complex medical procedures without risk to patients. In addition, specialists can train to work with patients, communicate with them, understand how to make a correct diagnosis, starting from the first contact. The use of VR in medical education has been the subject of numerous research studies, highlighting its efficacy in improving clinical outcomes and enhancing medical education.

One area where VR has proven particularly effective is in surgical training. VR surgical simulations allow trainees to practice surgical procedures in a controlled environment, providing a safe and risk-free space to make mistakes and learn from them. A study by Neal E Seymour et al. found that surgical trainees who received virtual reality simulation training outperformed those who did not in actual laparoscopic surgical procedures (Seymour et al., 2002).

Another study shows the benefits of virtual reality for the training of staff in radiology departments. Radiology departments have begun exploring the use of these technologies to help with radiology education and clinical care (Uppot et al., 2019). The study showed that virtual and augmented reality technologies are a novel means to communicate and have potential for supplementing radiology training; communicating with colleagues, referring clinicians, and patients; and aiding in interventional radiology procedures. It is also shown that as opposed to textbooks or online learning modules, immersing the learner in a virtual world is associated with a higher level of active learner participation because of increased social, environmental, and personal presence within the learning activity.

However, virtual reality can probably help and comprehensively train a doctor to work with a patient - from taking an anamnesis and examination to prescribing examinations and making a diagnosis.

One of the fundamental skills that medical professionals must acquire is the ability to take a patient history and order investigations. A patient's medical history provides valuable information about their current health status, medical conditions, and potential risk factors. However, training medical professionals to master these skills can be a challenging task that requires significant effort and dedication.

Several research studies have explored the difficulty in training medical professionals to take a patient history and order investigations. These studies highlight some of the challenges faced by medical students and professionals in acquiring these essential skills.

Several studies have revealed deficiencies in the history-taking skills of medical students. In one study less than 40% of students were found to have acquired the necessary skills for identifying major health issues, symptom analysis, gathering past medical information, and covering social aspects (Ahmed, 2002). These students frequently struggled to generate multiple hypotheses or ask relevant questions. In another study, only 23% of patients were given the opportunity to fully express their concerns, with physicians often interrupting and redirecting the conversation towards a specific issue in 69% of visits (Beckman & Frankel, 1984). At Michigan State University, one-third of third-year medical students failed to introduce themselves to their patients, and inadequate performance was also reported for other skills such as ruling out alternative diagnoses (60%), gathering social (38%) and family history (35%), characterizing problem dimensions (23%), gathering past medical history (17%), and analyzing chief complaints (6%) (Mavis et al., 2013).

Another study found that residents in internal medicine struggled to order appropriate investigations. The study found that residents often ordered unnecessary tests or failed to order appropriate tests, leading to delays in diagnosis and treatment (Sedrak, 2016).

Goal of Scientific Work

The use of virtual reality in medical education has been gaining popularity in recent years, and the Proven Solution company has developed an innovative application that allows medical students to interact with virtual patients and practice various clinical skills. The goal of this scientific work is to evaluate the effectiveness of the virtual reality application in training pharmacy students to collect anamnesis and order investigations.

Materials and Methods

The Proven Reality virtual reality application was integrated into the College of Pharmacy's Professional Skills modules at Gulf Medical University. The course covers various topics, such as the assessment of the cardiovascular and gastrointestinal systems and provides learning outcomes for each topic. Students are expected to develop a comprehensive understanding of the common symptomatology, assessment techniques, and diagnostic tests for each system. The virtual reality application, utilizing the advanced Oculus Quest 2 headset, allows students to practice these skills in an immersive and interactive environment, enhancing their learning experience and promoting better retention of knowledge.

The study involved 34 pharmacy students, divided into two groups of 17 students each. One group was trained for three weeks on cardiac clinical cases, including Myocardial Infarction, Cardiac Arrhythmias, and Heart Failure, while the second group studied for three weeks on gastroenterological clinical cases, including Peptic Ulcer, Irritable Bowel Syndrome, and Liver Cirrhosis. Both groups were trained using the Proven Solution virtual reality application (“Patient examination”).

- VR equipment: Oculus Quest 2 virtual reality headset, featuring a display resolution of 1832x1920 per eye, a refresh rate of 90 Hz, 6 GB of RAM, and built-in cameras for tracking the user's position and movements in a 1000-degree field of view. The headset provides room-scale tracking without external sensors and allows users to be fully immersed in a 360° virtual environment. It also includes two touch controllers, which emulate the user's hands, and built-in positional audio for an enhanced experience.
- Number of cases and time spent: Students used the virtual reality application during two modules in the Health Assessment course, specifically the Assessment of Cardiovascular System and Assessment of Gastrointestinal System. The VR training was incorporated into these modules, with each student spending a total of 30-40 minutes on VR training, distributed over four 3-hour sessions (2 sessions per group).
- Feedback: After completing a case, learners receive immediate, objective feedback on their performance, highlighting areas of improvement and reinforcing correct actions.

- Academic year: The study involved second-year pharmacy students in their 3rd semester in the professional skills session at the College of Pharmacy, Gulf Medical University.
- Prior/concurrent experiences: The students had limited prior experience in obtaining patient histories, performing physical examinations, and ordering labs. However, they had concurrent experiences through their regular course work.
- Training environment: Immersive virtual reality environment simulating a clinical setting.

The training with this application included:

1. Obtaining important relevant history, including patient's data, disease history, general complaints, past medical history, allergies, medication history, family history, and social history.
2. Examining the patient's appearance (Figure 1).

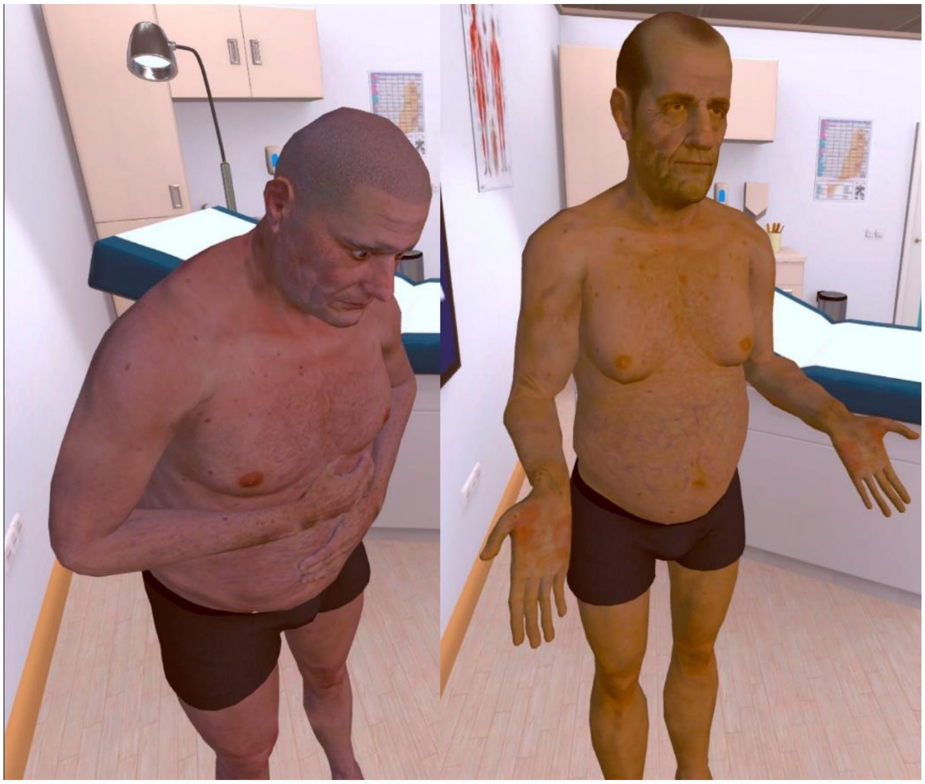


Figure 1: An example of the patient's appearance. On the left, a patient with a stomach ulcer complains of pain in the epigastrium. On the right - a patient with cirrhosis of the liver, a characteristic appearance: jaundice, venous pattern, hepatic palms.

3. Conducting a physical examination, including measuring temperature and body mass index, conducting auscultation of the lungs, heart (Figure 2), and stomach, conducting percussion of the chest and abdomen, measuring blood pressure, inspecting the palms, and examining the throat (Figure 3).

Figure 2: An example of auscultation of the heart of a virtual patient.

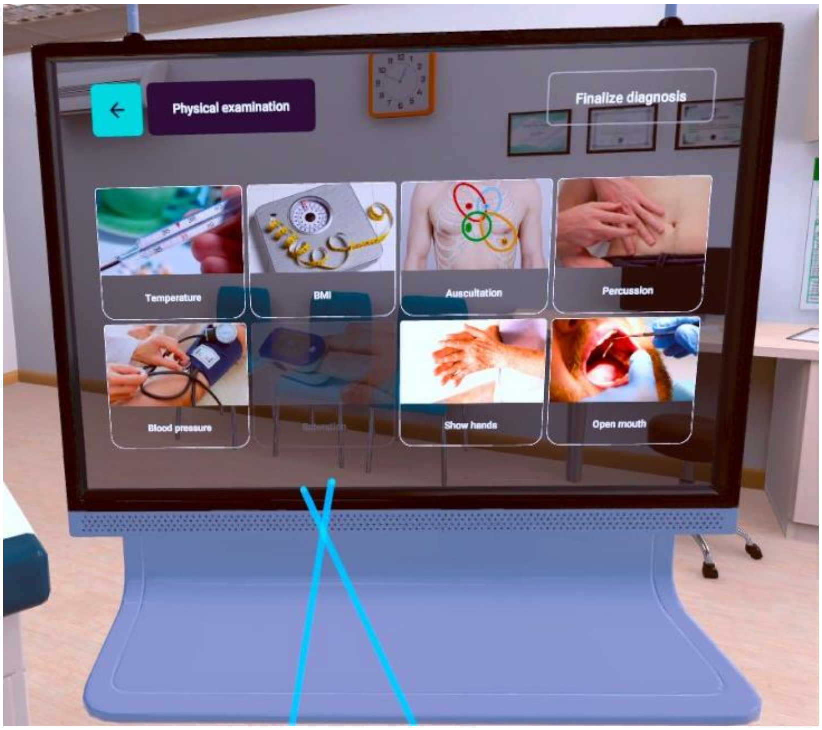
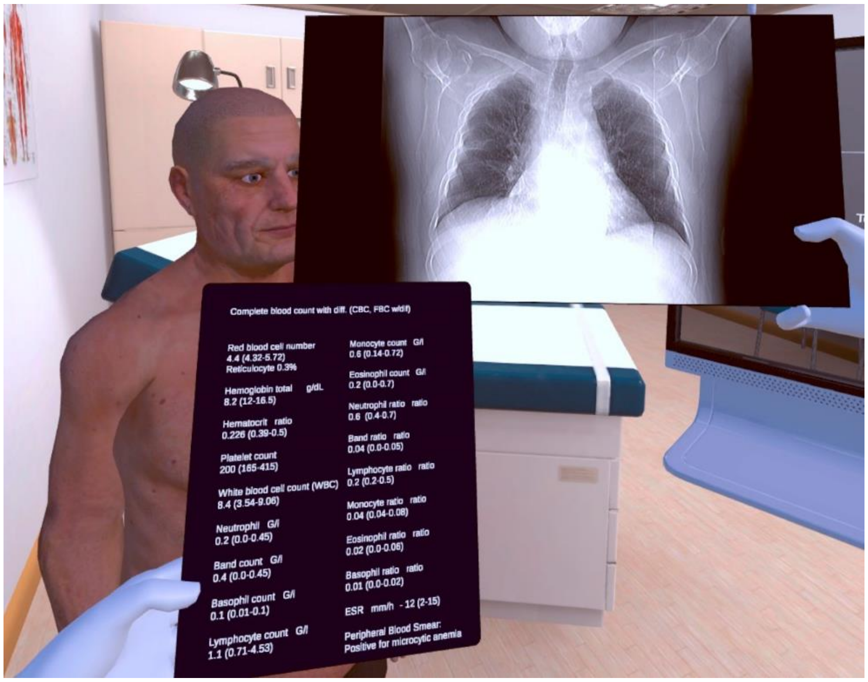


Figure 3: The choice of method of physical examination of the patient.

4. Conducting a laboratory examination of the patient, including complete blood count, blood chemistry, endocrine tests, coagulogram, immunology, tumor markers, serology, analysis of urine, and fecal analysis. (Figure 4)
5. Conducting an instrumental examination of the patient, including ultrasound (reading the conclusion), chest x-ray (viewing the image), computed tomography (viewing the study in two projections), MRI (reading the conclusion), endoscopy (reading the conclusion), spirometry (seeing the study results), and electrocardiogram (seeing the ECG). (Figure 4)



Complete blood count with diff. (CBC, FBC w/diff)

Red blood cell number
4.4 (4.32-5.72)
Reticulocyte 0.3%

Hemoglobin total g/dL
8.2 (12-16.5)

Hematocrit ratio
0.226 (0.39-0.5)

Platelet count
200 (165-415)

White blood cell count (WBC)
8.4 (3.54-9.06)

Neutrophil G/l
0.2 (0.0-0.45)

Band count G/l
0.4 (0.0-0.45)

Basophil count G/l
0.1 (0.01-0.1)

Lymphocyte count G/l
1.1 (0.71-4.53)

Monocyte count G/l
0.6 (0.14-0.72)

Eosinophil count G/l
0.2 (0.0-0.7)

Neutrophil ratio ratio
0.6 (0.4-0.7)

Band ratio ratio
0.04 (0.0-0.05)

Lymphocyte ratio ratio
0.2 (0.2-0.5)

Monocyte ratio ratio
0.04 (0.04-0.08)

Eosinophil ratio ratio
0.02 (0.0-0.06)

Basophil ratio ratio
0.01 (0.0-0.02)

ESR mm/h - 12 (2-15)

Peripheral Blood Smear:
Positive for microcytic anemia

Figure 4: The study of data from instrumental and laboratory studies. Above is an x-ray of the chest, below are the results of a complete blood count.

6. Choosing the correct diagnosis.

The development of the Proven Solution virtual reality application was carried out using Unity software (game engine). The team involved in the creation of the application consisted of one product manager, one programmer, one 3D artist, two UI designers, and a medical expert.

The 3D artist created the design of the medical room and its interior and patient models using the universal character system Reallusion. The user interface was developed by a team of two UI designers, who ensured that the application was user-friendly and easy to navigate.

The scenarios of clinical cases were drafted by a medical expert based on notes from teachers at Gulf University, ensuring that the virtual reality application was medically accurate and relevant to the training needs of the pharmacy students.v

The application was specifically designed for the Oculus Quest 2 system. However, it can be adapted for any headset that works with virtual reality, making it versatile and accessible for various educational institutions and training facilities.

In terms of design cost and equipment, the Proven Solution virtual reality application was developed with affordability in mind, making it a cost-effective solution for medical education institutions. The equipment required for the application includes just a compatible virtual reality headset, such as the Oculus Quest 2.

To evaluate the effectiveness of the virtual reality training, the researchers conducted a survey of the participating students. The survey aimed to assess their level of engagement with the educational process and their ability to assimilate the material. The results of the survey were analyzed to determine the impact of the virtual reality training on the students' learning outcomes.

In addition to the 34 pharmacy students (Figure 5), the study also involved 4 teachers who participated in the study and filled out the questionnaire. The questionnaire posed inquiries to educators about their satisfaction with the learning possibilities provided VR technology, as well as the learning outcomes achieved through its usage. It also addressed the ease with which the teachers were able to adopt VR. Furthermore, the questionnaire solicited the views of educators on the benefits they perceive VR technology offers for educational purposes and what modifications they would propose for the current approach to VR utilization. The questionnaire also asked if they would consider incorporating VR into their regular practical exercises. The teachers' feedback and evaluations of the students' performance were also considered in the analysis of the study's results.

Figure 5: A student of a medical university conducts an examination of a patient in a virtual reality application.

Results

The results of the study indicate that the pharmacy students (n=34) found the use of virtual reality (VR) in patient examinations to be a generally positive experience. On a 10-point scale, the average score for the experience was 8.6 out of 10 (SD=1.12), with a range of scores from 6 to 10 (on the 10-point scale used in the study, 1 represents a bad experience, 5 is neutral, and 10 indicates a positive experience).

The advantages identified by the students in using VR for patient examinations were its effectiveness in learning, motivation, and its ability to provide a realistic experience. Students found it helpful in understanding complex concepts and felt that it boosted engagement during practical learning. They appreciated the ability to hear real sounds during procedures and found it helpful in dealing with real patients.

On the other hand, some disadvantages of VR in patient examinations were reported, including time consumption and lack of real communication. Eyestrain and discomfort due to the inability to move freely were also reported.

In terms of changes, students suggested the addition of more variety in cases and the integration of VR and education. Additionally, some students suggested the need for backup VR headsets and better physical examination tools.

The teacher questionnaires provided valuable insights into their perceptions and experiences of using virtual reality in practical sessions. The teachers assessed the students' experience with VR on topics such as Learning Capabilities, Learning Outcomes, Ease of use of conducting VR session, Advantages in VR Tech, Change in Approach of VR, and Use of VR for Teaching. Overall, the teachers were highly satisfied with both the learning capabilities and outcomes using VR technology, with an average satisfaction score of 8.5 (SD=0.87) for both questions. In terms of the ease of getting started with VR, the average score was 8.25 (SD=0.89), indicating that it was not too difficult to begin using the technology.

The teachers also identified several advantages of using VR technology, including the ability to examine patients from different angles, multiple variations of cases, easy mastery, and excellent visualization of pathology in patients. Additionally, they appreciated the experience of interaction with the patient and the ability to listen to the sounds of the heart, lungs, and abdomen.

The teachers suggested some changes to improve the approach to using virtual reality, such as introducing an easier case selection system, adding more virtual patient interactions, patient positions (for example, on a bed), and an explanation of pathological mechanisms (e.g., increased blood pressure). The teachers expressed a desire to use VR on a permanent basis for practical sessions, indicating that they saw value in incorporating this technology into their teaching practices.

Discussion

The results of this study suggest that virtual reality technology can be an effective tool for training medical students in the collection of anamnesis and ordering of investigations. The use of the Proven Solution virtual reality application resulted in a significant improvement in the students' ability to collect patient histories and order investigations, as reported by the survey results.

The virtual reality training allowed students to practice these skills in a safe and controlled environment, without putting real patients at risk. The application also provided a high level of interactivity, allowing students to engage in realistic simulations of patient interactions and clinical procedures. This immersive and engaging learning experience may have contributed to the improvement in learning outcomes observed in this study.

The study also highlights some of the challenges faced by pharmacy students in acquiring these essential skills. Previous research has shown deficiencies in medical students' ability to collect patient histories and order investigations, which can lead to delays in diagnosis and treatment. The use of virtual reality technology may help to address these challenges by providing a safe and effective training environment.

The responses from the teacher questionnaires suggest that the use of virtual reality technology in practical medical education was well received. The teachers expressed satisfaction with the learning capabilities and outcomes with virtual reality technology. They also found it easy to get started with VR during the first session. Moreover, the teachers recognized the advantages of using virtual reality in medical education, such as the ability to examine patients from different angles, experience interaction with the patient, and visualization of pathology. The teachers also provided some suggestions for improving the approach, such as introducing an easier case selection system and adding more virtual patient interactions. Overall, the positive feedback from the teachers supports the potential benefits of using virtual reality technology in medical education.

However, it is important to note that this study had some limitations. The sample size was relatively small, and the study was conducted in a single institution. Further research is needed to confirm these findings in larger and more diverse populations.

There are other applications that allow students to work with virtual patients (eg: iHuman Patients). Features of such applications are life-like patient interactions, where the virtual patient breathes, blinks, answers questions, and responds to interventions. Furthermore, many of such applications can be accessed 24/7 on laptops and tablets wherever an internet connection is available.

In contrast, the Proven Solution virtual reality application has several innovations that set it apart from existing virtual patient applications. Firstly, it does not require a permanent internet connection, which can be advantageous for institutions with limited connectivity or for users who want to practice in various settings. This flexibility allows medical students to engage with the application at their convenience, ensuring that the learning process is not hindered by connectivity issues.

Another innovative aspect of the Proven Solution application is its immersive virtual reality environment. Unlike iHuman, which primarily relies on laptops and tablets for display, the Proven Solution application is designed for virtual reality headsets, creating a more realistic and engaging experience for users. This increased level of immersion can lead to better knowledge retention and improved clinical decision-making skills.

Moreover, the Proven Solution application can be easily adapted for various virtual reality headsets, making it more versatile and accessible than some other virtual patient applications on the market. Its development using Unity software and collaboration with medical experts ensures that the application is not only technologically advanced but also medically accurate and relevant.

Conclusion

In conclusion, this study suggests that virtual reality technology can be an effective tool for training medical students in the collection of anamnesis and ordering of investigations.

The immersive and engaging learning experience provided by virtual reality training may help to address some of the challenges faced by medical students in acquiring these essential skills. However, further research is needed to confirm these findings in larger and more diverse populations.

The positive feedback from the participating teachers supports the effectiveness and potential of virtual reality technology in medical education. The suggestions and feedback provided by the teachers can help improve the VR program for better outcomes and a more user-friendly experience.

Overall, the results of this study support the use of virtual reality technology in medical education, particularly in the training of pharmacy students in the collection of anamnesis and ordering of investigations. As virtual reality technology continues to advance, it has the potential to revolutionize medical education and improve the quality of healthcare worldwide.

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Real-time Chest Compression Fraction Measurement

Authors

Guy C. Gilbert, MS, CHSOS-A, CHSE[1], Daniel J. Backlund PhD, CHSOS, CHSE[2], Matthew Pierce MS, NREMT, CHSOS[2]

[1]Texas Tech University Health Sciences Center, Amarillo, TX
[2]Texas Tech University Health Sciences Center, Lubbock, TX

These authors have no conflicts of interest or disclosures.

Corresponding Author

Guy Gilbert, MSM, MSOL, CHSOS-A, CHSE, Texas Tech University, School of Veterinary Amarillo, TX (Email: guy.gilbert@ttu.edu)

Brief Description / Abstract

The American Heart Association (AHA) recommends maintaining a Chest Compression Fraction (CCF) of 60% to 80% during Cardiopulmonary Resuscitation (CPR). Achieving an 80% CCF has been shown to increase survival by up to 300%1. The calculation of CCF is customarily done by the use of two stopwatches. One stopwatch is for the duration of the mock code and the other is for the timing of high-quality CPR. The two stopwatches are operated by the CPR coach or recorder and the calculation of CCF primarily occurs at the conclusion of the training exercise. The inability of a CPR coach or mock code team members to know if their CCF is sufficient does not allow any opportunity for the team to make real time adjustments.

Introduction

AHA introduced the CCF parameter and recommended threshold in the 2015 CPR guidelines for ACLS, BLS, and PALS. The American Heart Association has stated that a CCF between 60% and 80% increases survival outcomes2. Within the team dynamics activity, CCF is calculated manually using a two stopwatch method. The two stopwatch method does not provide a calculation of real time CCF. Currently, there is no capability to calculate and present CCF through the use of patient simulators or their associated vital sign displays. As far as the authors are aware, many of the systems that we have investigated do not show the participant either the dynamic or cumulative CCF and the exercise relies on the two-stopwatch method.

Real time CCF calculation provides code teams the opportunity to make performance adjustments during mock codes. In conjunction with feedback devices, the use of a computer-based tool provides the team with real time performance data. An example of such a tool would be a progressive web application with functionality to calculate real time CCF. Our application provides a low-resource, low-overhead supplement to any existing CPR system for providing both dynamic and cumulative CCF calculations.

Traditional CCF Calculation

American Heart Association states Healthcare providers can calculate CCF mechanically by using a feedback device or manually by using 2 stopwatches1. One stopwatch measures the total code time for code start until code stop or the return of spontaneous circulation, and a second stopwatch is meant to capture the total time of chest compressions. To measure chest compression time, the second timer is started each time compressions begin or resume and is stopped during each pause in compressions. The chest compression time is then divided by the total code time2.

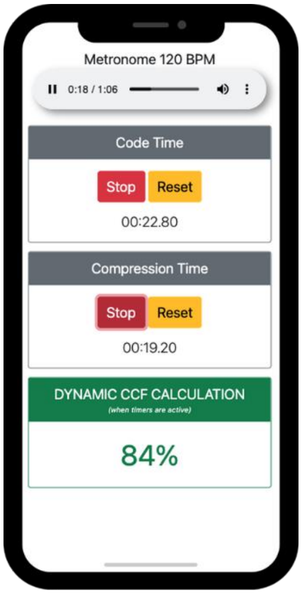
$$\text{CCF} = \frac{Total\ time\ of\ high\ quality\ chest\ compressions}{Total\ code\ time}$$

With the existing method of calculating CCF manually using timers, stopwatches or AHA’s Full Code Pro application, feedback for CCF is only provided retrospectively. The method of manually calculating CCF retrospectively, does not provide real time feedback. Further applications, such as AHA’s Full Code Pro4 do not have the functionality to real time CCF. AHA Full Code Pro (FCP) 4 is a free, mobile application that allows a CPR coach to measure the time of different events and interventions during a mock code. FCP has the ability to start multiple, digital stopwatches during a mock code and document timestamps of events. The FCP user interface does not automatically calculate either the cumulative or the dynamic CCF for the users; cumulative CCF must be calculated at the conclusion of the mock code. Though FCP allows the elimination of monitoring two physical stopwatches by including both running times on one display, the calculation of the CCF still must be done manually.

Our applications eliminate the need for manual CCF calculations, whether they be dynamic or cumulative. One challenge introduced by the two-stopwatch method is small errors in the cumulative CCF value being calculated. This error is a result of the user stopping the cumulative-time stopwatch at the correct time. For a mock code lasting a duration of 10 minutes (600 seconds), a 10 second runover of the stopwatch would result in an error of approximately 1.67%. Though small, a more automated solution such as those methods implemented in applications such as FCP and our applications reduce this error by expediting the process of stopping all stopwatches. Monitoring dynamic CCF allows both the participants and the CPR coach in a mock code to assess the overall impact of external factors such as code interruptions, AED shock applications, advanced interventions, etc. Coaches can demonstrate to participants in debrief how these external factors affect CCF using the dynamic CCF calculation as a guide.

Development of a Web Application

To take advantage of readily available resources, a Progressive Web Application (PWA) was developed with the collective efforts of 3 simulation operationists who respectfully brought experience from web design, AHA guidelines and JavaScript. We consulted Jonathan Craddock, a colleague within the university who specializes in mobile application development. Development of the PWA was done using a collection of Bootstrap, HTML5, CSS, JSON and JQuery. PWAs are websites that work as a traditional website but are also progressively enhanced with offline capabilities and cross-platform interoperability to operate like a native app when installed on a mobile device. The CCF PWA was designed for a CPR coach to be able to easily control 2 timers during a code in order to reduce errors, accurately calculate CCF and allow the CPR coach to stay focused on the rate, placement and depth of compressions. A dynamic calculation of CCF is displayed while the two timers are active, and a final CCF is displayed if either one of the timers has been paused. An optional, audible metronome is also available to the CPR coach to hear while the chest compression timer is active. Code duration is displayed to help the CPR coach to keep track of time for transitions, and pulse checks.



https://sim.ttuhsc.edu/ccf/

Figure 6: Screenshot of the Progressive Web Application. Both of the timers for the Code Time and the Compression Time are marked for easy access. The metronome is at the top and can be toggled on and off for convenience. When the timers are active, the real-time CCF calculation will be displayed at the bottom of the app. QR code included.

Using and Trialing the Application

The PWA for monitoring CCF allows for CPR coaches during the team dynamics activity to provide real time CCF during mock codes for ACLS, BLS, and PALS. The application being supported by ubiquitous devices and the ease of use allows for participants to easily install or use the application. The ease of use decreased the amount of instructions and confusion with the two-timer method. Further, the real time feedback provided to the team helps to ensure that interruptions are limited to 10 seconds. The application was tested and used during team dynamics and CPR training during Basic Life Support, Advanced Cardiac Life Support and Pediatric Advanced Life Support Courses taught in our facilities over the last 3 years.

To improve the Application and gather user feedback, a web-based form was developed. This feedback form is accessible through the PWA and asks users about utilization, data accuracy, general impressions as well as gathering demographics of the end user. Users are invited to complete the feedback form at any time. Feedback form submissions are automatically sent to developers via email.

There are limitations to the use of real time CCF as a data point. For example, mathematically the CCF starts at zero and increases after the first few cycles of CPR. Providing feedback of CCF within the first few cycles of CPR might falsely portray the timeliness of CPR. During advanced courses, additional interruptions to CPR pose a threat to the current CCF. However, it has been observed that these interventions do not decrease the CCF below 60% when quality CPR was performed prior to.

An internal, companion application was also developed by the authors to record the historical CCF calculation throughout the code. This historical code consists of 0.1-second interval timestamps along with the real-time calculation of the CCF at that point in time. This historical data can be plotted to observe the evolution of the CCF throughout the entire duration of the code. Figure 2 shows the historical CCF calculation during one complete mock code. In the figure, the times at which various events occurred, such as when compressions are started, compressions are stopped or paused, and when the AED assessed and advised a shocked, are denoted with different colors. During the mock code that was depicted in the figure, the CCF was steadily maintained within the recommended range of 60-80% after about one minute. As expected, the CCF increased while compressions were being performed and it decreased during the times when breaths were given or when the AED assessed and/or advised administering a shock.

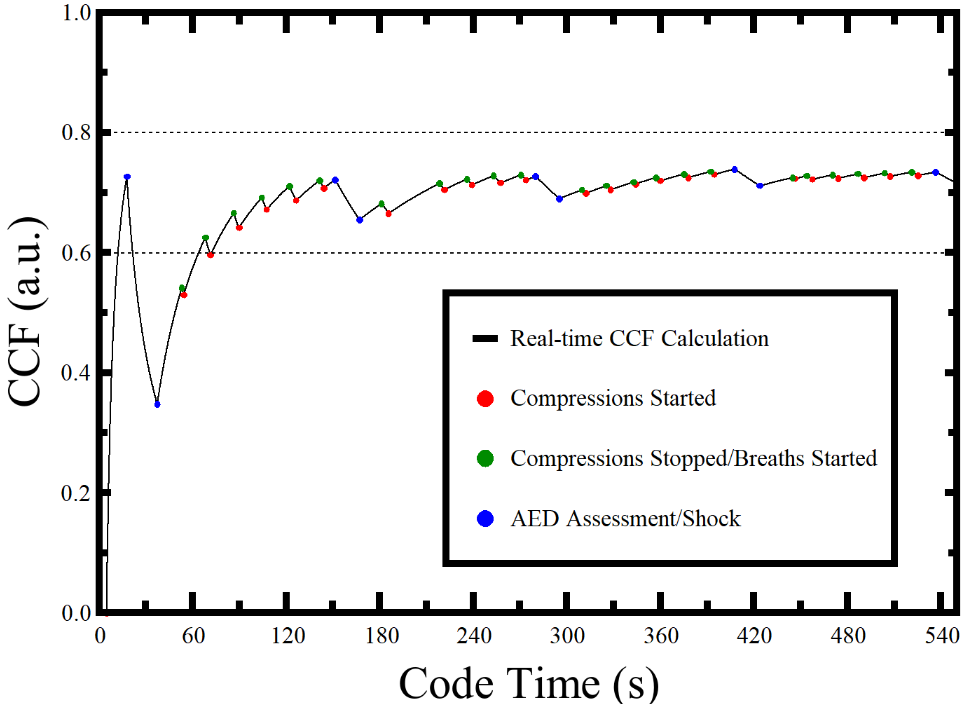


Figure 7: Historical evolution of CCF calculations throughout the full duration of a mock code. Red dots indicate when compressions were started. Green dots indicate when compressions were stopped or paused, and breaths were started. Blue dots indicate when the AED assessed the rhythm and/or advised administering a shock. Dotted, horizontal lines denote AHA's recommended CCF range of 60% to 80%.

Conclusion

Computer-based tools have been developed to replace the use of stopwatches in mock codes. One such tool is a Progressive Web Application (PWA) that calculates CCF using built-in timers in one easy to access interface. The PWA can be used as a guided resuscitation tool to enhance CPR training and teamwork to minimize interruptions and improve the effectiveness of CPR. The tool also provides the functionality of an adjustable metronome. Historical data from the mock code was captured with a companion application. This data was plotted and analyzed for trends.

It is shown that the CCF varies greatly between the first few rounds of CPR, but begins to stabilize afterwards. Over the longer duration of the code, the stabilization will result in the real-time CCF converging to the overall, mean CCF. Thus, we can conclude that the initial calculations of CCF during the first cycle of CPR are not a good indicator of overall participant performance during a mock code.

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Management of Obstetrical Hemorrhage: Low-cost Uterine Task Trainers Provide Simulation for Residents

Authors

Johanna N Voutyras, MD[1], Lynn ET Shaffer, PhD[2], Alissa D MacAdam, BS[1], Dawn M Prall, MD[3]

[1]Mount Carmel Health System Graduate Medical Education, Grove City, Ohio
[2]Mount Carmel Research Institute, Grove City, Ohio
[3]Mount Carmel Health System Center for Innovative Learning, Columbus, Ohio

These authors have no conflicts of interest or disclosures.

Corresponding Author

Johanna N Voutyras, MD, Mount Carmel Health System Graduate Medical Education, Grove City, Ohio (Email: johanna.voutyras@gmail.com)

Brief Description / Abstract

Introduction

Simulation training may improve patient safety and decrease trainer and trainee anxiety. The ability to manage the emergency of obstetrical hemorrhage is a requirement for Obstetrics & Gynecology (OBGYN) physicians. Two operative procedures used to manage obstetrical hemorrhage include uterine artery ligation and uterine compression. Without simulation, resident physicians will initially encounter these procedures during a hemorrhage.

Methods

Didactic sessions on Obstetrical Hemorrhage were held for OBGYN resident physicians including new low-cost, reproducible simulations for uterine artery ligation and uterine compression. The residents were surveyed pre-simulation and post-simulation regarding their confidence in managing obstetrical hemorrhage, including their comfort with these specific surgical skills before and after participating in the simulation sessions.

Results

Twenty-one resident learners completed the paired pre-simulation and post-simulation questionnaires. Upon statistical analysis, the comfort with each procedure significantly improved as did the confidence to independently manage obstetrical hemorrhage (mean confidence level 2.5 + 0.9 vs 3.0 + 1.2, $p = .002$). The easily constructed low-cost uterine models, one to practice uterine artery ligation and one to practice uterine artery compression, were readily accepted as didactic tools.

Discussion

Obstetrical hemorrhage is a rare and serious complication requiring a timely and effective response, with few opportunities for training on live patients. Our didactic training with simulation using low-cost models improved physician comfort with the techniques of uterine artery ligation and uterine compression, better preparing them for high stakes operating room procedures utilized to treat obstetrical hemorrhage.

Introduction

Life-threatening emergencies that are low-frequency are ideal for simulation during residency training (Deering & Rowland, 2013). Simulations are now commonly incorporated into graduate medical education didactic curriculums and may improve patient safety in addition to reducing both trainer and trainee anxiety (Gavin & Satin, 2017).

Obstetrical hemorrhage is a life-threatening emergency and can be a preventable cause of maternal mortality (Lu, 2013). High-fidelity obstetric models for simulating obstetric emergencies, including multidisciplinary simulation of obstetric hemorrhage, have been described and determined beneficial for learners (Kerbage et al., 2016). Most high-fidelity postpartum hemorrhage models and simulations focus on teamwork, initial management, and medications for postpartum hemorrhage (American College of Obstetricians and Gynecologists, 2021). One of the published high-fidelity models allows for the specific surgical skills mentioned to be practiced (Pereira & Delvadia, 2013). Planning the logistics to utilize high fidelity trainers can be complex, time consuming and require specific spaces often coordinated by a multidisciplinary team.

Low fidelity, portable task trainers, however, can be regularly incorporated into practice on the Labor and Delivery units. Advantages of low-fidelity task trainers to practice specific obstetrical hemorrhage surgical skills include the ability to hone dexterity by repetition outside of the operating room, simplicity of set up and low cost. Several models for task training these skills exist but most are not yet well studied in regards to effectiveness with confidence (Ramseyer & Lutgendorf, 2019). Additional low fidelity task trainers have been studied that simulate other components of obstetrical hemorrhage management. These include Bakri balloon insertion, uterine packing, pelvic packing and temporary abdominal closure, all of which also showed significantly improved perceived competency (Ramseyer & Lutgendorf, 2019). The combination of standardized patients and task trainers was also evaluated for management of other obstetrical emergencies such as Shoulder Dystocia and Cord Prolapse (Le Lous et al., 2020). In competency-based medical education, simulation training has the potential for standardized evaluation for graduate medical education in addition to increasing perceived competence (Weiss & Rentea, 2021; Hamstra & Philibert, 2012).

We developed two low-cost low-fidelity uterine models to function as task trainers. The task trainers were designed for learners to practice specific operative procedures used to manage obstetrical hemorrhage including uterine artery ligation and uterine compression sutures. These obstetrical surgical skills are typically utilized emergently in the operating room for an obstetrical hemorrhage that has been unresponsive to initial management including medications and manual uterine massage. High-fidelity simulation for these surgical maneuvers is available but at greater cost, including equipment and set up time (Pereira & Delvadia, 2013). Additional low-fidelity task trainers are available but also require a greater production time (Ramseyer & Lutgendorf, 2019).

The objective of this focused, small group didactic and skills session was to become more efficient and confident with two specific surgical skills required to manage obstetrical hemorrhage in a low-pressure environment. Residents practiced their skills on the task trainer uterine models during didactic sessions on obstetrical hemorrhage. Pre- and post-simulation questionnaires were analyzed to determine a) if comfort with each procedure improved after practicing on the models and b) if confidence regarding independent management of obstetrical hemorrhage improved after practicing the procedures on both models. We report the change in comfort for physicians using low-cost models to simulate the techniques of uterine artery ligation and uterine compression.

Methods

Development

The Mount Carmel Center for Innovative Learning (CIL) is a systemwide education center that includes experiential and simulation-based learning for colleagues and learners within our community-based healthcare system. The CIL develops custom task-training models in addition to developing and supporting simulation-based education throughout the healthcare system. This obstetrical hemorrhage simulation was incorporated into the longitudinal Obstetrics and Gynecology residency simulation curriculum.

Two uterine model task trainers were created (with the acknowledgement of similar albeit different task trainer models (Pereira & Delvadia, 2013; Ramseyer & Lutgendorf, 2019; Chuang et al., 2021) to help residents practice two specific procedures that are utilized in vivo in an immediate, life-saving operative intervention. The didactic sessions included a brief discussion reviewing prevention, etiology, and management of obstetrical hemorrhage directly followed by a practical skills session using these uterine model task trainers. These training sessions were held in a training space dedicated for resident education.

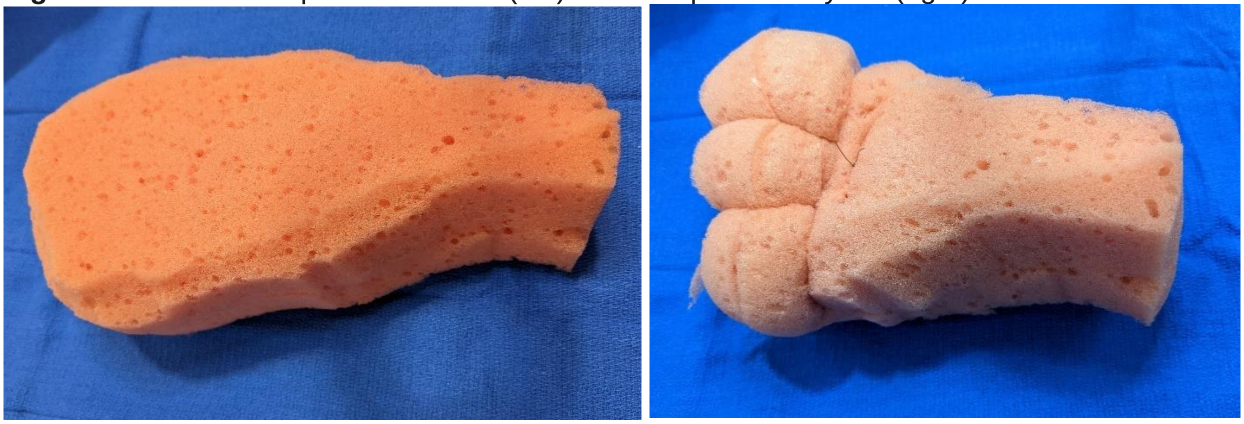
The questionnaire inquired how comfortable the learners were in the two procedures practiced and how confident they were managing obstetrical hemorrhage independently. The comfort and confidence levels were measured on a 4-point Likert scale (1 = least comfortable/confident and 4 = most comfortable/confident). The questionnaire also included knowledge-based questions to assess the retention of the material provided in the brief discussion on the management of obstetrical hemorrhage. The Wilcoxon signed rank test compared pre- vs. post-simulation comfort and confidence levels with aspects of managing obstetric hemorrhage, and whether the residents improved their total number of correct responses to knowledge questions. Test results were considered statistically significant at $p<0.05$, without adjustment for multiple comparisons. SAS version 9.4 (Cary, NC) was used for statistical analysis.

Equipment

Task Trainer #1 - Uterine Compression Model (Figure 1)

The uterine compression model was created with car wash sponges, glue and scissors, stabilized with a clipboard at the "cervix" during the procedure. Two infinity-shaped car wash sponges were glued together. Adding the second sponge recreates a postpartum uterus with a similar size. After the glue dried, scissors were used to carve the sponge into a uterine shape within minutes. The density of the sponge creates a similar pliability as an atonic uterus. During our simulation session, the B-lynch uterine compression suture was practiced. However, the models were also sufficient to practice other uterine compression sutures, including Hayman compressions and Cho box sutures. The cost of the uterine compression model was approximately $3.40 per model. Reusable surgical instruments and one-time use #1 Chromic suture were utilized during the simulations, which were additional costs. These models are reusable and withstood several simulations. Both sides could be utilized. Some of the models started to tear after four sessions though others lasted up to eight sessions. This sponge model is more three dimensional compared to the described felt model (Chuang et al., 2021).

Figure 1: Uterine Compression Model (left) with completed B-Lynch (right)



Instructions for building uterine compression model:

1. Adhere two elliptical shaped car wash sponges using multi-purpose glue.
2. Allow to dry overnight.
3. Carve sponge model into uterine shape with sharp scissors and/or scalpel.

See video: Supplemental Digital Content 1: Uterine Compression Model.mp4

Task Trainer #2 - Uterine Artery Ligation Model (Figure 2)

The uterine artery ligation models were created with tennis balls, large tube socks, water balloons and a Foley catheter simulating a leiomyomatous uterus. This model was also stabilized with a clipboard at the "cervix" during the procedure. The Foley catheter was utilized to represent the uterine artery. The rubber of the catheter provides tactile resilience and moves within the model similarly to a large artery. The water balloons represented the venous plexus within the broad ligament, engorged during pregnancy. The tennis balls were left whole or cut in half to create various shapes and types of leiomyomas. The tennis balls were firm compared to the sock portion of the model creating a density differential similar to a leiomyoma within a uterus. The size of the complete model is a similar size to a postpartum uterus. The cost of the uterine artery ligation model was approximately $8.80 per model. Reusable surgical instruments and one-time use #0 Chromic suture were utilized for the O'Leary ligations during the simulations, which were additional costs. These models withstood multiple sessions well. These models required replacement of new water balloons with each session. These models were required to be semi-disassembled and dried between sessions if the water balloons were punctured during the exercise. This sock model is more three dimensional compared to the described felt model (Chuang et al., 2021).

Figure 2: Uterine artery ligation model:
Inside layer cut open to view core contents, pinned for display

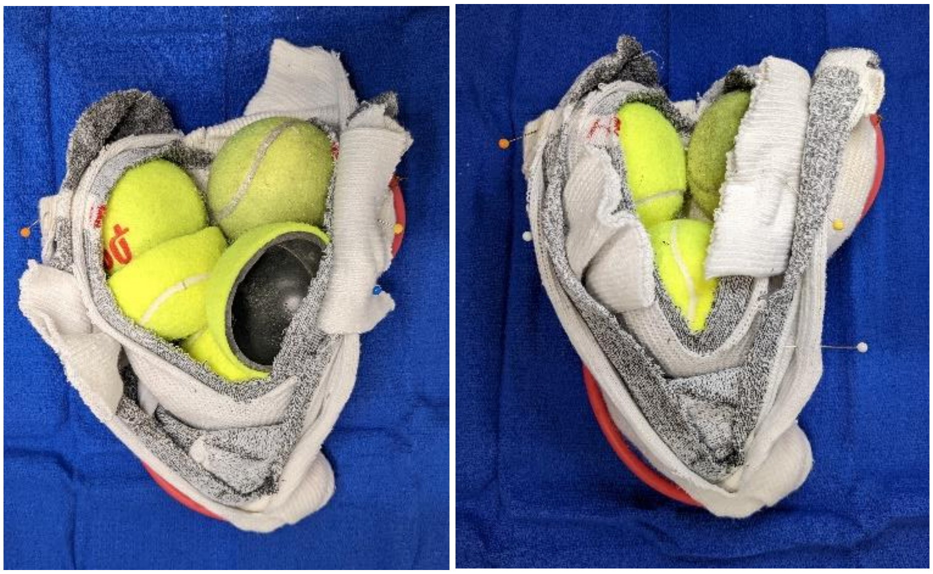


Figure 3: Inside layer with uterine arteries (red rubber catheters) attached bilaterally, coronal view (left). Outer layer opened to see uterine artery (red rubber catheter), sagittal view (right).

Instructions for building uterine artery ligation model:

1. Cut some tennis balls in half using scalpel.
2. Fill large sock with combination of whole and halved tennis balls into uterine shape.
3. Twist sock, invert and re-cover uterine model creating cervix.
4. Cut red rubber foley catheter in half to create uterine arteries.
5. Attach each half of red rubber catheter along uterus bilaterally with interrupted sutures in 3 locations.
6. Place model into second large sock creating broad ligament.
7. Add semi-filled water balloons along uterine arteries to create venous plexus.
8. Twist sock, invert and re-cover uterine model to again create cervix.

See Supplemental Digital Content 2: Uterine Artery Ligation Model.mp4

Personnel

The Ohio State University Obstetrics and Gynecology (OBGYN) residency program has a total of 44 residents. Mount Carmel Health System is the academic-community partner where this education was conducted. Since there is a small group of residents rotating at this community site at any given time, multiple small group sessions were held with different groups of rotating residents. Two or three Mount Carmel Health System OBGYN faculty members facilitated the activity.

Implementation

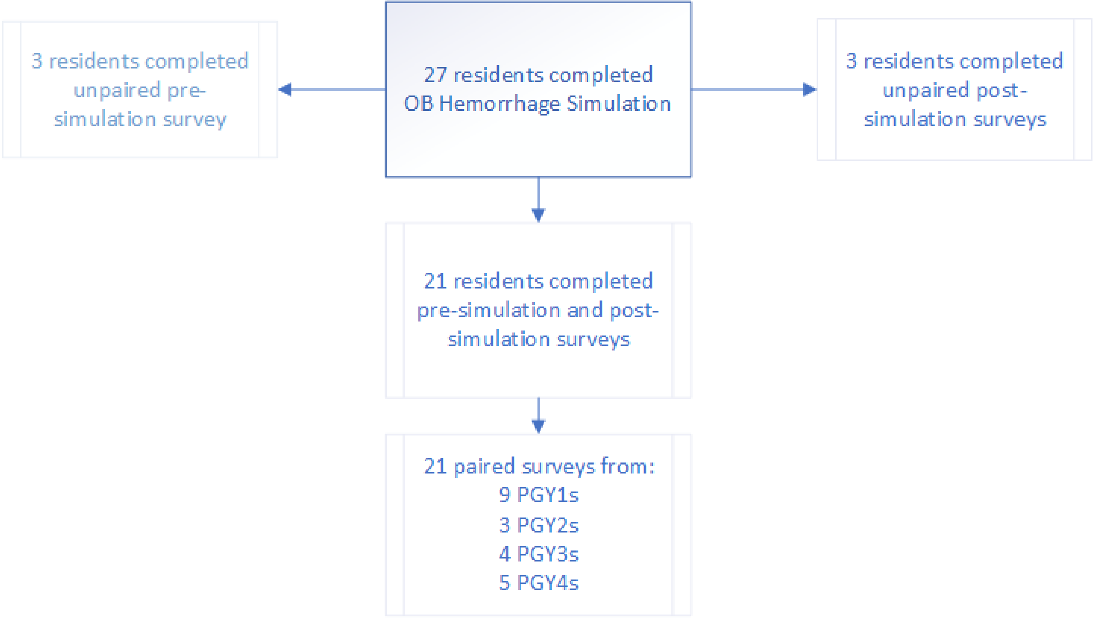
Pre-simulation questionnaires were distributed upon arrival to the small group didactic session and immediately completed without identifiers. After a short discussion regarding management of obstetrical hemorrhage, the residents were split into three or four groups, typically pairing a junior and senior resident. The task trainer models were utilized in successive rotation. Every resident practiced each surgical intervention at least twice, each functioning in the surgeon and assistant surgeon roles. A faculty member provided guidance and instruction for each group throughout the activity. The facilitators observed the paired surgeon and assistant surgeon during their practicing of the surgical procedures and provided contemporary instruction and feedback regarding techniques.

After the second task trainer exercise was complete, the post-simulation questionnaire was distributed and completed again without identifiers. Upon completion of the post-simulation questionnaires, both questionnaires were paired by each resident prior to collection and collected in an anonymous fashion. An informal debriefing was held with the facilitators and learner participants after the questionnaires were collected. The Mount Carmel Institutional Review Board granted exemption for this analysis as simulation activities for obstetrical hemorrhage are an accepted educational practice and no identifiers were collected on the anonymous data.

Results

Twenty-seven learners participated in the simulations between July 2019 to September 2020. Of those twenty-seven, twenty-one learners participated in the brief didactic session, both task trainer simulations, and completed both the pre-simulation and post-simulation questionnaires. Three pre-simulation and three post-simulation questionnaires each were unpaired and therefore excluded. These excluded learners participated in only a portion of the activity either arriving late or leaving early likely due to patient care needs. Therefore, the unpaired residents' change in knowledge and comfort could not be assessed. With respect to postgraduate year level among the paired surveys, 9 were first-year residents, 3 were second-year residents, 4 were third-year residents and 5 were fourth-year residents (Figure 3). The questionnaire was developed by the lead author as there was no suitable validated instrument at the time the sessions were performed (Supplemental Digital Content 3: Questionnaires.doc).

Figure 4: Flowchart of Included and Excluded Participants



The change in comfort with each task trainer and the change in confidence with overall management of obstetrical hemorrhage were significantly improved after the exercises (Table 1). Subdividing the results among each post-graduate level revealed improvement in comfort with both uterine compression and uterine artery ligation at all four skill levels (Figure 3). For the first-year, second-year and third-year residents, comfort managing an obstetrical hemorrhage independently improved after the didactic session and simulation (Figure 4). The fourth-year residents' comfort managing an obstetrical hemorrhage independently did not change because all five fourth-year residents reported maximum comfort on both their pre-simulation questionnaires and maximum on their post-simulation questionnaires. While the mean comfort levels increased significantly for the entire cohort (Table 1), the increase amongst each class of resident was not significant, likely due to the small sample size once subdivided by year of residency.

Table 1: Mean Difference in Scores Among Paired Participants (N=21)

Topic	Mean Baseline Score[a]	Mean Postsimulation Score[a]	Mean Difference (95% Confidence Interval)	*p*
Perceived Comfort with Uterine Compression	2.3	2.9	0.6 (0.34 to 0.95)	0.0009
Perceived Comfort with Uterine Artery Ligation	2.3	2.8	0.5 (0.2 to 0.85)	0.0054
Overall Confidence Managing Obstetrical Hemorrhage	2.5	3.0	0.5 (0.24 to 0.71)	0.002

[a]Rated on a 4-point scale (1 = least comfort, 4 = most comfort)

Figure 5: Graphs display resident comfort as rated on Likert scale (1-4) before and after using task trainers for uterine compression (left) and uterine artery ligation (right) by year of resident training.

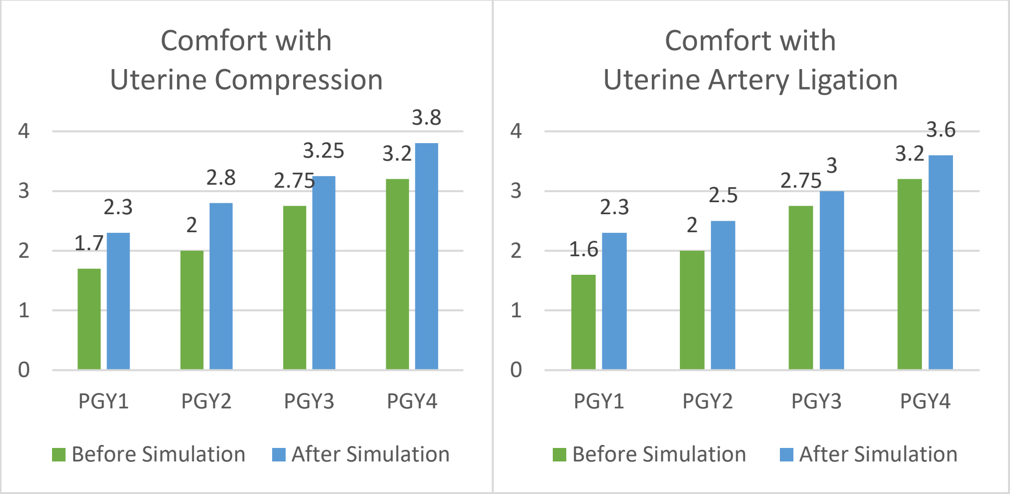
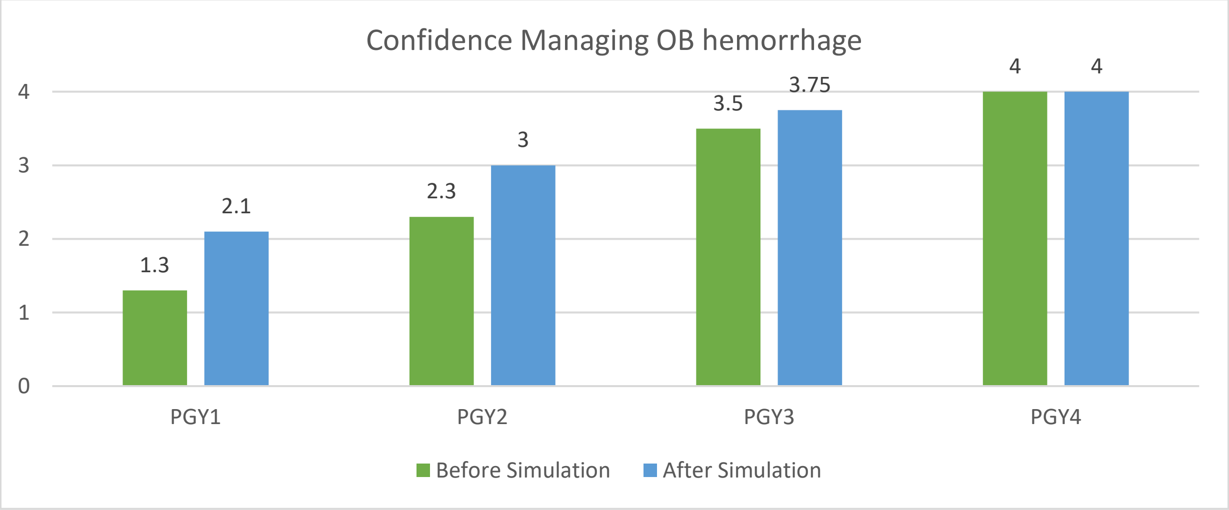


Figure 6: Graph displays resident confidence as rated on Likert scale (1-4) before and after using hemorrhage simulation by year of resident training.



The questionnaires also included knowledge-based questions to assess the retention of the material provided in the brief discussion on the management of obstetrical hemorrhage. As anticipated the percentage of correct answers to the knowledge-based questions significantly improved after the didactic session (number of correctly answered questions 2.5 + 1.2 vs. 4.7 + 1.0, $p<0.0001$).

Discussion

The overall confidence in managing life-threatening obstetrical hemorrhage improved through the task trainer simulation. Simulating these surgical maneuvers has the potential to improve the efficiency of the residents in the operating room, though this was not evaluated in this study. The uterine model task trainers described are easily constructed, inexpensive and reusable. Low-fidelity task trainers focusing on specific obstetrical surgical skills are ideally utilized in workshop settings with multiple stations where the residents can practice the skill with repetition, allowing for improved comfort and confidence. Repetition of the specific surgical skill has the potential to improve dexterity and efficiency although those aspects were not studied at this time.

Although simulation has become an accepted component of OBGYN residency didactics, little is known regarding how these training exercises correlate with patient outcomes (Satin, 2012). While this study does not correlate directly to patient outcomes, it is a good foundation for future studies evaluating a direct link from simulation to patient outcomes. As of July 1, 2020 the Joint Commission has required annual multidisciplinary drills on obstetric units in effort to reduce the incidence of postpartum hemorrhage (The Joint Commission, 2019; Gavigan et al., 2019). Multidisciplinary drills on Labor and Delivery units with nursing and provider staff will ideally prevent postpartum hemorrhage and/or improve timeliness and effectiveness of treatment. Determining correlation between simulation exercises for obstetrical hemorrhage and patient outcomes is worthy of future investigation.

Our study has limitations including the small sample size from one residency program. External validity needs to be established. The increased confidence in overall independent management of hemorrhage may be attributed to the brief didactic discussion and not solely practicing with task trainers. A follow up study could involve the lecture with a knowledge-based pre-test and post-test questionnaire followed by the skill session with a separate pre-test and post-test questionnaire isolating comfort and confidence to the practical activities. Further investigation of emergent obstetrical skills training effectiveness and impact on patient care is warranted. Additionally, this simulation focuses on specific aspects of managing obstetric hemorrhage and is merely one component of a comprehensive approach to improve and review management of obstetric hemorrhage.

Task trainer activities to manage obstetrical hemorrhage have been incorporated into our simulation curriculum with annual participation. This study found that practicing these obstetrical surgical maneuvers on simple task trainers improves OBGYN resident comfort with each maneuver and their overall confidence managing obstetrical hemorrhage. PGY-1 and 2 residents appear to show the largest increase in these outcomes; however, this would need to be confirmed with additional research. Additional research could also evaluate the value to senior residents to practice teaching these surgical maneuvers in a non-emergent situation. Given their low cost and ease of construction, the task trainers developed for this curriculum can be adopted by most OBGYN training programs across the country.

Supplemental Digital Content (SDC) Legend

SDC 1: mp4. Uterine Compression Model

SDC 2: mp4. Uterine Artery Ligation Model

SDC 3: doc. Questionnaires

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Effective Use of Existing Mobile Technologies to Augment Simulation-Based Experiences

Authors

Guy C. Gilbert, MS, CHSOS-A, CHSE[1], Kelsey Launer, MPH, CHSE[2], Daniel Backlund, PhD, CHSOS, CHSE[2]

[1]Texas Tech University Health Sciences Center, Amarillo, TX
[2]Texas Tech University Health Sciences Center, Lubbock, TX

These authors have no conflicts of interest or disclosures.

Corresponding Author

Guy Gilbert, MSM, MSOL, CHSOS-A, CHSE, Texas Tech University, School of Veterinary Amarillo, TX (Email: guy.gilbert@ttu.edu)

Brief Description / Abstract

Smartphones and other mobile devices have been among the most disruptive innovations to date due to the cumulation of their capabilities and what they have replaced in the marketplace (i.e., computers, cameras, camcorders, audio recorders, wired telephones, Global Positioning System navigation, barcode scanners, etc.). Mobile device use is becoming more common and necessary to function in routine aspects of modern life. Traditional post-secondary learners that are starting their education have had access to a mobile device since the beginning of their formal/primary education, and their reliance on mobile devices has become a large part of their lives. In a 2021 survey of Americans, 96% of adults between 18-29 years old own a smartphone (Pew Research Center, 2021). Given that mobile devices are ubiquitous among post-secondary learners, potential exists to augment simulation-based experiences with technologies such as quick-response (QR) codes and the near-field communication (NFC) protocol. The Simulation Program at Texas Tech University Health Sciences Center collaborated with the Texas Tech University School of Veterinary Medicine to investigate the implementation of both QR codes and the NFC protocol in immersive simulation-based experiences.

Introduction

Technologies such as QR codes and NFC tags have been utilized since 1994 (S. -H. Hung, 2020) and 1983 (Walton, 1983) respectfully. While NFC is a communication protocol, and a QR code is a machine-readable optical label, both are efficient and effective means of transmitting information to a mobile device through a scanning method. Either method allows a data payload to be sent to a mobile device for interpretation. The mobile device can be configured to process that data and perform an action such as connecting the user to more information like a webpage containing text, pictures, videos, etc. Given the ease of use, both methods described are an efficient way to transmit information to a learner in a manageable and timely manner via a capable device.

Since QR codes are optical, the use of the device's camera is necessary to translate what is encoded. An unobscured, high-contrast (e.g., Black on white background), 2-dimensional depiction of the QR code is ideal for proper scanning by a camera that is optimally held parallel to the face of the QR code. Nearly all mobile devices on the market currently possess the capability to translate a QR code with the onboard camera application. With the aid of a dedicated QR reading application, a computer can also be used to decode a string from a QR code into a string of text or a web address. The use of a dedicated application can provide a means of simplifying the experience of the end user, as well as providing in-application browsers and caching of files.

NFC is most commonly found in the marketplace, with credit and debit cards, to tap the reading device to make the transaction occur; or hotel keys that only require holding a card near the device to unlock the door; and authentication devices for computers containing sensitive data. NFC is a communication protocol based on radio frequency identification (RFID) technology, but has lower transmission range of 4 centimeters or less. Both RFID and NFC operate on the principle of inductive coupling for short-range implementations. This requires a reader device to generate a magnetic field which allows an electrical current to pass through a coil and return with data to the reader. When an NFC tag (containing its own coil) is within 4 cm to the reader (i.e., when the tag enters the magnetic field), a current is induced in the tag's metal coil. The NFC protocols and standards dictate that when the handshake between the coil and the reader is complete, the stored data on the tag is wirelessly transmitted to the reader (Subtil, 2014). Many mobile devices currently on the market have NFC reading and writing capabilities made possible by a secure element chip. The major operating systems available on most mobile devices have native support for the NFC protocol. Windows introduced support for NFC in their Windows 8 release in 2012 (Warren, 2012). Apple added NFC implementation into their iOS platform in 2014 (Apple, 2021). Android, Inc. implemented native support for NFC in their Android 4.4 release in 2013(Android Developers, 2023).

Applicable Uses of QR Codes and NFC Tags in Simulation-Based Experiences

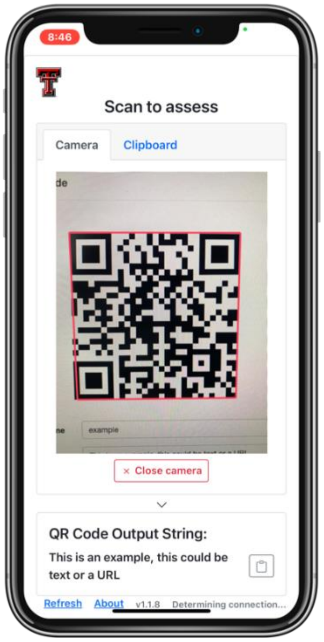
With the capabilities that these wireless protocols provide, it is possible to standardize assessment points such as a string of text, audio, still images and video. From a simulation operations standpoint, the capabilities of these protocols provide a potential means to save time on set-up, negate the need for moulage, or introduce capabilities to the simulation that had not previously been possible. From a simulation educator standpoint, a QR code or NFC tag can provide reliable, consistent, standardized information to be replicated and easily distributed throughout all modalities of simulation. These protocols can also allow learners the ability to discover codes/tags during the patient's physical assessment, interpret findings, and diagnose based on what information they have been provided. Some example applications of QR codes and NFC tags in simulation are listed below.

- Provide a standardized verbal report / handoff / SBAR / intake note / door sheet
- Allow visible assessment points to be discovered upon examination (i.e.- rash on the torso)
- Auscultation sounds at different points (introduce a uniform sound for a systolic murmur)
- Intended result for blood pressure, SpO¬¬¬2, blood sugar, etc.
- Present visuals of patient monitors or user interfaces for medical equipment (i.e. – IV pump settings, or ventilator settings)

- Represent hazards or safety concerns, without it actually being a safety concern
- Invasive exams (HEENT, rectal, vaginal)
- Difficult or Acute presentations (burns, complex disfiguring injuries or active bleeding)
- Add diversity with images or video to represent the intended patient or family members
- Chaperoned or sensitive examinations of genitals
- Ambulatory exam / reflexes (visualize the lameness in the gait of a horse or a particular balancing failure during a concussion evaluation)
- Timely diagnostic reports / results
- Timely diagnostic imaging X-ray / ultrasound
- Cues such as bruising, needle tracks, or tattoos on the patient or family members
- Present a trigger film to learners

Development of a Progressive Web Application for Scanning QR Codes

A progressive web application (PWA) was developed to aid in the use of QR codes in simulations and testing environments. Development of the PWA was done using a collection of Bootstrap, HTML5, CSS, JSON and jQuery. PWAs are websites that work as a traditional website but are also progressively enhanced with offline capabilities and cross-platform interoperability to operate like a native app when installed on a mobile device (MSEdgeTeam, 2022). The aim of the PWA development was to create an installable application that was easy for learners to use, could translate QR codes, have a non-caching in-app browser, and could be locked (using guided access on iOS, or screen pinning on Android) to prevent learners from visiting other applications. The ability to lock the PWA allows exam proctors the ability to guide and control mobile devices during summative events.



QR Code Output String:

This is an example, this could be text or a URL

https://sim.ttuhsc.edu/qrscanner/

Figure 8: Screenshot of the Progressive Web Application in the mobile device’s default browser.

Using and Trialing the Application with QR Codes

The PWA has been used in numerous simulations in healthcare and veterinary settings since 2020. Scenarios have included human trafficking simulations where QR codes were placed to represent bruising, evidence of abuse, sexually transmitted diseases (STDs) and tattoos on standardized patients. QR codes have also been extensively used in head, ear, eye, nose, and throat exams in OSCEs in our medical school. They have also been applied in veterinary simulations for auscultation sounds, visual assessment, depiction of the animal’s environment as well as cues that are present in the animal’s environment. The option to lock and limit functionality to the PWA on a mobile device (using guided access on iOS, or screen pinning on Android) has potential value for testing experiences.

Students and faculty expressed that the utilization of the QR codes has made the simulations flow better, eliminated the distraction and awkwardness of scripted responses, and errors related to documents and finding cards being exchanged during OSCEs. The faculty also appreciate how the use of QR codes has allowed learners to interpret findings rather than being given deciphered descriptions.

Trauma scenarios have also utilized QR codes to represent injuries and trauma that has allowed standardization across duplicated scenarios, as well as saving time by eliminating the need for moulage and clean up. Codes were beneficial in providing X-ray and sonography imaging in a quick and efficient method. Instructors and students have appreciated the use of QR codes in these scenarios and felt that it provided a better depiction of the severity of the cases.

Using and Trialing NFC Tags in Simulations

NFC tags are inexpensive and readily available at consumer outlets in a variety of styles, ranging from small adhesive stickers to credit card-sized plastic tags. The tags we utilized can either be disposable or reusable, flexible or rigid, and can typically be written and rewritten with up to 504 bytes of data by NFC authoring apps that can be installed on any smartphone. The versatile design of the tags makes it easy to place them practically anywhere on standardized patients, animals, equipment, simulators and task trainers. Tags are still functional when placed beneath clothing or a simulator’s skin. Larger NFC tags can be given to learners as finding cards at appropriate times or when prompted in response to their examination or particular intervention. The use of coin-sized plastic NFC tags has worked the best for most of our applications. The coin sized tags are comfortable for SPs to wear, easy to label and can be held in place with Tegaderm dressing or medical adhesive.

NFC tags were utilized on SPs and simulators in simulation based education to supplement and augment the simulation as points of physical assessment. 6 NFC tags were placed at respective assessment points to deliver auscultation sounds and visual cues in the same human trafficking simulation in which the QR codes were used. 35 learners were able to easily access the web resource that the NFC tag was programmed to deliver by momentarily holding their unlocked smartphone within 4 cm of the tag, without the need for a dedicated application. The scanning of the NFC tags allowed a quick and seamless assessment for the learner as they discovered things such as bruising, evidence of abuse, STDs, and tattoos on the standardized patients at points where dime-sized NFC tags were placed. NFC tags were labeled identifying which case they were associated with and the location on the patient where they should be placed for set-up and later reuse. When a student successfully scanned an NFC tag, a banner-style notification appeared on the screen of the mobile device. Upon clicking the notification, the learner was directed to the web resource by the mobile device's default browser. In order to scan another NFC tag, the learner simply repeated the process and was directed to a new web resource with a single tap. The NFC tags utilized were rewritable (with an option of being password protected) and were programmed utilizing an application titled NFC tools (available on Google Play and the App Store). Specifications of the NFC tags were that they were 2.5 cm in diameter, contained the NFC 215 chip, had a polyvinyl chloride (PVC) waterproof exterior, could hold 504 bytes of data, and cost $0.30 each. The only challenge presented through the use of NFC tags was labeling tags for the ability to apply and place them properly to the SP, and for later reuse.

Comparing QR Codes to NFC Tags

Through the trialing of these two technologies there were benefits and shortcomings to both. The NFC tags in simulation-based experiences have the potential to be easier and faster to utilize, since a smartphone can read and prompt navigation to a webpage in one click without the need for an application or camera. Since no application is needed to scan the NFC tag, the web resource encoded into the NFC tag is opened in the default browser and caches the data supplied. In our simulation, the ability to reuse the NFC tags was a benefit over the need to reprint QR codes for subsequent repetitions of the simulation. NFC tags are a fast and efficient method of getting information to a learner, but the use of the default browser on the smartphone does make it more difficult to prevent data from getting cached on a device. This could affect the integrity of testing materials in summative evaluations. The reproduction of QR codes is a quick process when a QR code encoder is available, while the process of programming NFC tags can be more time consuming and has additional steps compared to printing QR Codes. Through the use of QR codes in conjunction with our QR reading PWA, it is easier to control the dissemination of information provided by the QR code. The PWA is beneficial in maintaining the integrity and security of summative evaluations, since no data or URLs are stored or cached.

	Application or PWA required to decode	Use on tablets	Ability to resolve to URL path	Ability to resolve to text string	Number of touches required to resolve on mobile device	Camera required
QR Codes	Yes	Yes	Yes	Yes	3-4	Yes
NFC Tags	No	Limited	Yes	No	1	No

Table 1: Comparison of QR Code and NFC Usage

Feedback from End Users

Feedback on QR codes has primarily come through a contact form available in the PWA, and from what has been shared in dialogue between students and faculty following the simulations in which the codes were utilized. Feedback shared regarding the use of QR codes without the use of the PWA that it is cumbersome, slow and requires 2 or more apps to decipher the QR code. Students who did use the PWA were complimentary of its functionality and delivery of assessment findings. The constructive criticism received has been in regard to issues with loss of internet connection and connection speeds, which limit or impair the function of the PWA, but are not directly associated with the function of the PWA itself or the QR codes.

Feedback regarding NFC tags was captured through shared dialogue between learners and faculty and was very complimentary of its speed and ease of use. Criticism of NFC Tags included the current inability for use in summative testing and that many tablets are not capable of reading NFC tags.

Conclusion

While there is still so much to explore in the use of QR codes and NFC tags to augment simulations, both technologies provide innovative means of expanding and standardizing simulations in ways that were otherwise difficult to do. Learners and educators expressed that both technologies were easy to use, applicable to simulation, and their experiences were satisfactory. Both of these technologies allow for more immersive, standardized, and accurate simulation-based experiences and assessments. We are continuing to explore potential solutions for both QR codes and NFC tags in simulation.

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