SSH Society for Simulation in Healthcare STORM

Simulation Technology & Operations Resource Magazine (STORM)

STORM highlights exemplar work contributing to the advancement of healthcare simulation operations. All submissions are peer reviewed before publication in the STORM special edition of the SSH Simulation Spotlight. With articles covering training, policy & procedure, emerging technologies, and professional development, STORM has everything needed to stay current and well-rounded in the pursuit of simulation operations excellence.

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Letter from the STORM Editorial Board

Simulation Operations Specialist Training: Need of the Hour

The use of technology in healthcare simulation has been rapidly evolving. Manikins and task trainers are becoming increasingly sophisticated both in physical characteristics and software. The advent of augmented and virtual reality has introduced an additional level of sophistication. Learning management systems are now routinely used to maintain data in simulation centers with specific requirements for storing and using audiovisual data. Not only do Simulation Operations Specialists (SOS) need to adapt to manage this exponential increase in responsibility, but they are also now given additional responsibilities as educators in many centers.

There are clear-cut education streams for simulation faculty and educators to enhance their knowledge and skills through short courses, certification programs, master's programs and even doctorates. Unfortunately, the same cannot be said for SimOps specialists. A quick Google search for "healthcare simulation operations" returned only a handful of results, most associated with Certified Healthcare Simulation Operations Specialist certification through the Society for Simulation in Healthcare. In addition, the available courses are short, only lasting a few days.

The limited opportunities for SOSs force simulation institutions to provide their technical support teams with training not only to do their jobs well, but also to offer avenues for career progression. This need would be fulfilled by formal training programs that provide a recognized qualification. An offline postgraduate simulation operations technology course leading to a diploma has been developed in India under the aegis of JeevaRaksha, a nongovernmental organization (NGO) devoted to healthcare education, particularly for emergency management skills. To develop the course, senior healthcare educators nationally were invited to be part of the curriculum committee. Initially, the course structure was discussed at an in-person 2-day meeting, followed by virtual meetings to refine it in accordance with local regulations. The course is open to undergraduate students from science backgrounds. The course is 40 credits and lasts one year, with nine months of formal training and three months of internship.

JeevaRaksha is empowered to enter into Memoranda of Understanding with national teaching institutions that have active simulation centers, allowing these centers to offer the course. This ensures the presence of the program across the entire country, offering applicants a broad selection of centers to choose from. It is hoped that this will result in a group of well-trained SOSs with the skills needed to be a part of an expert simulation team.

The simulation world needs to recognize and support the needs of our technical support teams and to step up in providing solutions. This model could guide other countries and institutions to develop similar programs, addressing the significant gap in simulation education. A potential way forward could be to propose a summit or dedicated committee focused on developing and standardizing training criteria for simulation operations competencies. International simulation societies need to take the lead addressing this issue.

The CHSOS blueprint is a good starting point for developing the simulation operation curriculum but needs to be adapted to local needs. This would upskill informally trained technicians, thereby improving the quality of simulation education.

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Sim-Portant Conversations Podcast: An Approach to Professional Development

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Conflict of Interest Statement

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Brief Description

Professional development (PD) had a renewed focus following its inclusion as a new standard with the Healthcare Simulation Standards of Best Practice™ in 2021. Following this change, healthcare simulation centers were tasked with supporting professional development in an innovative way for simulationists in all roles. We created a podcast by and for our simulationists as a cost-effective means of providing professional development to simulationists across four separate locations with diverse roles and backgrounds.

Introduction

Professional Development was established as a new standard with the Healthcare Simulation Standards of Best Practice™ released in 2021 (INACSL Standards Committee, 2021). This change required healthcare simulation centers (HCSCs) to think creatively about how to evaluate and support professional development for simulationists in all roles. Our HCSC is part of a Midwest land grant university in a rural state and exists at four different physical locations across the state. The HCSC was preparing to apply for full Society for Simulation in Healthcare (SSH) accreditation in Teaching/Education when the new Healthcare Simulation Standards of Best Practice™ were issued. We needed to be innovative in meeting the new standard of professional development.

Our project was designed to create high quality professional development that was accessible and palatable for simulationists at all four locations. Prior to the implementation of this project, professional development within our HCSC consisted of webinars shared with the team via email. There were a couple of team members who attended conferences and provided informal presentations regarding key takeaways. Our solution involved utilizing traditional professional development modalities such as journals, brown bag presentations, Nursing Continuing Professional Development (NCPD), and webinars in addition to the innovative approach of creating our own podcast. This paper will discuss the professional development podcast created by our simulation team, for our simulation team, to ensure the learning content was optimally tailored to our specific needs. The podcast was originally intended to share information about the new Healthcare Simulation Standards of Best Practice™, but it has since evolved into a platform where simulationists can create and engage with content aligned with their interests and the needs of our program.

Background

The professional development team, made up of the simulation director and two other simulationists, was tasked with creating a plan which met the professional development standard. An individual needs assessment had been completed in the spring of 2021, and the data was used to inform this project. The needs assessment identified three high priority topics: the role of the healthcare simulation technology specialist, debriefing, and simulation certification. A comprehensive professional development plan was created that would involve NCPD presentations for topics requiring interaction and demonstration. However, the professional development team identified the Healthcare Simulation Standards of Best Practice™ to be a high priority item for the team in order to highlight the changes made in advance of our accreditation visit. After reviewing the literature for ideas and brainstorming solutions, the professional development team decided a podcast would be a novel solution for orienting the HCSC team to the new standards.

Podcasts are used to disseminate information to a wide audience, overcoming barriers of distance. Podcasts have been found to be valuable for helping learners access supplemental information and prepare for exams (Khechine et al., 2013). Utilization of podcasts for professional development draws upon Adult Learning Theory, recognizing that our simulationists are established in their careers. As adult learners, simulationists are assumed to be self-motivated, able to self-identify their learning needs, and seek out information connected to their roles and responsibilities. Podcasts support this self-driven learning by allowing content to be accessed at a convenient time for the learner and replayed as needed (Berk et al., 2020; Gorra & Finlay, 2009; Roy & Roy, 2007).

Several studies examine the use of podcasts for professional development, though few specifically address professional development in healthcare simulation. With medical educators, podcasts were found to be an effective tool for delivering professional development content, resulting in many participants adjusting or altering their education practices (Bernstein et al., 2018). The ability to provide on-demand content and succinct key educational messages contributes to the success of podcasting in professional development among educators (Dowhos et al., 2021).

At the time, most simulation organizations did not have their own podcast, but a literature review revealed they were being utilized in the medical community (Berk et al., 2020). Podcasting was chosen because it allowed the team to overcome barriers associated with synchronous professional development, such as time constraints and distance between sites. Simulationists face additional teaching and service obligations outside of simulation, creating further barriers to attending and staying motivated to engage in simulation-focused professional development material.

Podcast Content

As previously mentioned, a needs assessment identified three high priority topics which informed this project: the role of the healthcare simulation technology specialist, debriefing, and simulation certification. Our own simulationists were enlisted to create the podcast for our HCSC team, further increasing our professional development. Podcast creation leverages constructivist learning theory to support the learning and professional development of the content creators (Berk et al., 2020; Gorra & Finlay, 2009). To construct a meaningful podcast episode, the healthcare simulationists pursued topic experts to record the content.

In addition, the creators grew in their skills and abilities related to planning and creating the content. The podcast creation team needed to plan content that aligned with the needs of the audience while avoiding common podcasting dissatisfiers. Effective podcast content should: 1) avoid topics that require visual demonstration, 2) align with the audience's interests, and 3) not depend on discussion between the learner and presenter (Gorra & Finlay, 2009; Roy & Roy, 2007; Van Patten et al., 2022).

Methods

The podcast was created using software and technologies already accessible and approved by the university. No additional equipment was needed, and thus no cost incurred. The content for each episode was planned using a shared document. The professional development team recorded the content for each episode with videoconferencing technology. Some additional editing software, licensed by the university, was utilized to compile episodes. Podcasts were shared with College of Nursing (CON) faculty and staff, and interprofessional (IP) partners via the university's learning management system (LMS). This ensured closed captioning and enhanced accessibility options were available.

Audience and Dissemination

The podcast was designed for a broad audience of simulationists, spanning diverse roles and varying levels of knowledge and experience. To ensure the content remained accessible to a wider audience, a non-simulation faculty member was recruited as a host. For podcasting to be a suitable professional development tool, the team needed to consider the method used for dissemination to learners. The platform should be easy to use and accessible for individuals with hearing impairment.

Originally, the professional development podcast was created by our simulation team, for our simulation team. The first podcast episode was made available on the university LMS in November of 2021. Following a two-episode series reviewing the Healthcare Simulation Standards of Best Practice™, the professional development team produced additional episodes in early 2022, focusing on the role of the simulation technology specialist and certification. The podcast was received favorably by the HCSC team and continued past the original project date. Since then, episodes have covered other pertinent simulation topics based on the interests of the healthcare simulation team.

Dissemination via the internal LMS provided a better mechanism for tracking professional development involvement within our CON HCSC team. We used records for individual learners and/or our program needs, matching these to our needs assessment each year. In November 2022, our HCSC team achieved Full SSH accreditation in Teaching/Education. LMS tracking was key in demonstrating how our team met the Healthcare Simulation Standards of Best Practice™ Professional Development.

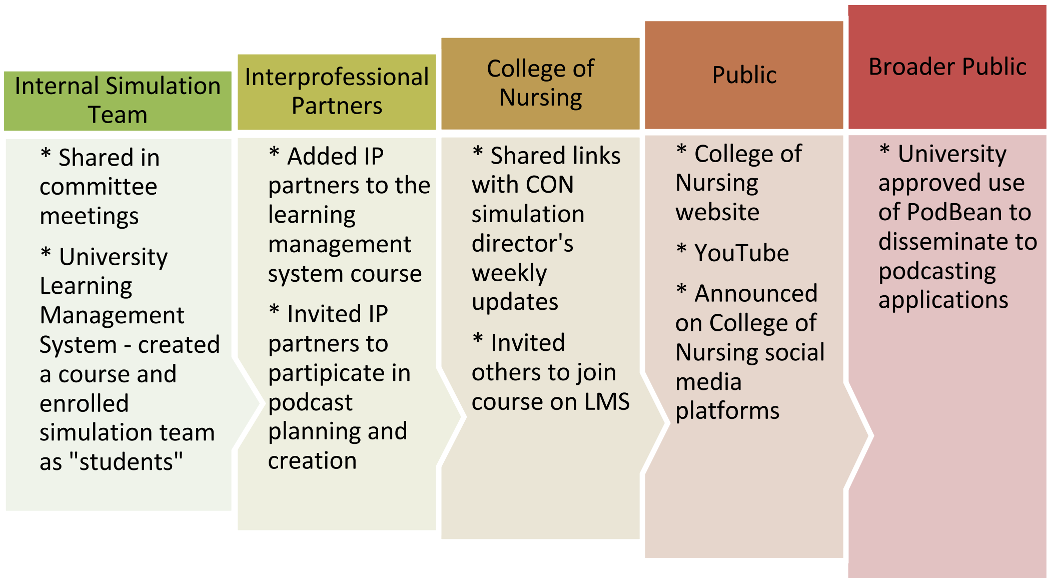
Evolution of the Podcast

As the professional development activity expanded, it shifted to a community focus within the university to include interprofessional groups and community members. In July 2022, after obtaining permission from the university media group, the podcasts were shared with the public on YouTube and the CON website. In the fall of 2022, additional simulationists expressed interest in being a part of the professional development team and assisted in content creation. The team grew to ten members, with several other members of our HCSC making guest appearances on the podcast.

In the summer of 2024, the university media group approved the use of PodBean for podcast dissemination, further expanding the content's reach to major podcast-listening applications. The first episode was shared to podcasting applications via PodBean in July 2024. Dissemination of the podcast on public websites has required new professional development tracking mechanisms; however, the LMS continues to be a valuable tool for alerting simulationists to available opportunities. Figure 1 outlines the evolution of the podcast's dissemination process and audience targets.

Figure 1

Flowchart of Audience and Dissemination Process



Note. *LMS: learning management system; IP: interprofessional; CON: College of Nursing.*

The expanded reach of the podcast created opportunities for a variety of HCSC team members to share expertise and invite guests related to their expertise. The team created an email for the podcast to solicit ideas for future podcasts, reaching out past our CON. A few episodes created through this feedback format were Episode 5 - Partners in Simulation and Episode 9 - Nursing Student Anxiety in Simulation (Schomberg, 2022; Schomberg, 2023).

The team collaborated with the school of design for a class project where the students created the HCSC podcast logo. This logo is a fun, creative demonstration of the professional development team's creativity and willingness to try something new through collaboration (Figure 2).

Figure 2

Podcast Logo Created by SDSU School of Design Team

Sim-portant Conversations

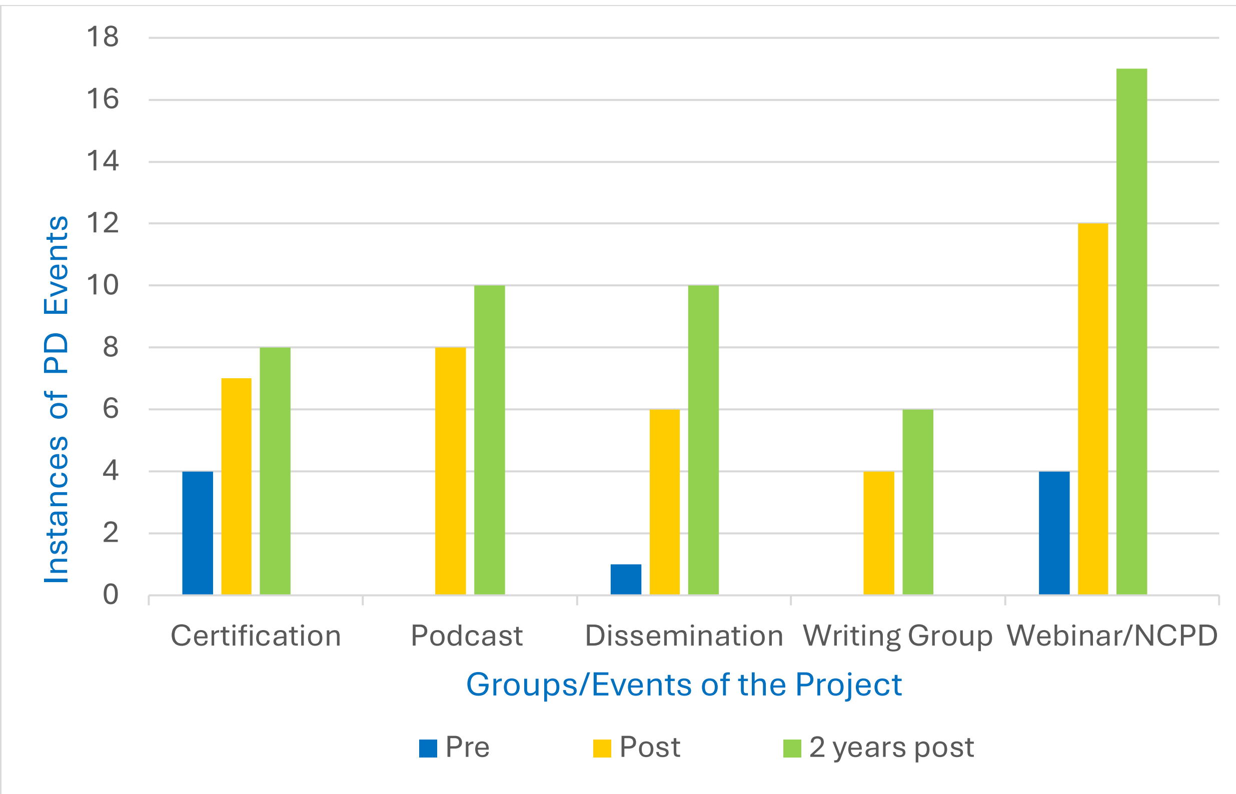
Results

Out of forty-four simulationists participating in professional development from November 2021 through November 2023, 73% (n= 32) were undergraduate nursing faculty, 11% (n=5) were graduate nursing faculty, 5% (n=2) interprofessional healthcare faculty, and 11% (n=5) were simulation staff or operation specialists. Ninety-three percent (n=41) of participants self-identified as females and 7% (n=3) as males. Eighteen percent (n=8) of participants hold certifications as a Certified Healthcare Simulation Educator (CHSE) or Certified Healthcare Simulation Operations Specialists (CHSOS).

Figure 3 shows data related to growth in professional development events from November 2021 through November 2023. The figure demonstrates the tremendous growth in podcast development, strategic simulation professional development opportunities, and the overall increase in certified faculty and staff within the CON HCSC.

Figure 3

Professional development growth from November 2021 through November 2023



Note. Professional development events from November 2021 through November 2023. This data was collected before project implementation (Pre), 1 year post project implementation (Post), and 2 years post project implementation (2 years post). *PD: professional development; NCPD: Nursing Continuing Professional Development.*

Implementation

For programs considering this approach, the authors have outlined some benefits and key considerations identified throughout the planning and implementation phases. Our team noted podcasts as being cost-effective, available on demand, and adaptable to the wants and needs of the team utilizing it. Podcast creation benefits the hosts as well as the listeners. For example, time committed to podcast development elements may count as time towards professional development, service, scholarship of teaching and learning, and meeting standards for certification and/or re-certification.

For a smaller team, further discussion may be needed to define necessary roles such as creation, editing, and dissemination of podcast content. Depending on available resources, programs may consider keeping the content internal rather than disseminating to the public. An additional consideration is the amount of time and effort that goes into podcast creation. A rough estimate of various elements and time of podcast development can be found in Table 1.

Table 1

Podcast Development Breakdown

Elements	**Time**
Commitment of guests/speakers	2 hours/episode
Podcast “directing” (planning, scripting, coordinating, etc.)	2-4 hours/episode
Editing	1-2 hours/episode
Development of online platform (PodBean)	2-3 hours (one time)
Dissemination/website maintenance (posting of content)	15 minutes/episode

Podcast development can be successfully executed by small or larger teams with various disciplines and/or stakeholders involved. For programs that do not currently have access to software or an LMS system through their institution, the authors would recommend utilizing platforms such as GoogleDrive, OneDrive, Microsoft Stream, Google Classroom, and Moodle. Our HCSC podcast speakers have been internal to the University by either direct involvement or a connection to the College of Nursing. Programs with a different team composition may be able to recruit a broader range of speakers. Examples of former speakers include College of Nursing faculty, interprofessional faculty/staff, students, and simulationists. As of now, these speakers have received no monetary compensation.

Discussion

The simulation professional development team used current university resources, making this innovative project a cost-effective and creative response to program needs. We did have restrictions at the university level related to publishing our podcasts; therefore, we were limited to YouTube publications originally. The professional development team found within our university and in the current literature there were limited guidelines for development of podcasting for professional development. The ability to measure impact of this project was limited to the metrics collected via the internal LMS and the scholarly activity by simulationists such as presentations and certifications. The available measures demonstrated the podcast, as part of our professional development initiative, has been acceptable to the simulationists and resulted in an increase of scholarly activity. In the spring of 2024, university-level approval was received for use of PodBean for dissemination and the podcast expanded to ten available episodes with several more in production (South Dakota State College of Nursing, 2023-present). This growth will allow the podcast to reach a wider listening audience. The expansion beyond the LMS created new challenges for data collection regarding professional development but also presented an opportunity to develop a system for more detailed data. The professional development team created a tracking form for HCSC team members to log engagement in professional development activities as well as the knowledge gained from those activities.

The team used creative and engaging ideas to adapt to the needs assessment and current Healthcare Simulation Standards of Best Practice™: Professional Development. As the team evolved, we included other colleges within the interprofessional healthcare realm such as the school of pharmacy and allied health partners, engineering collaborative projects, and the school of graphic design. The interprofessional initiatives and development of a more structured tracking system for professional development activities has led to a creative, engaging, accessible, and high-quality professional development plan for simulationists and healthcare partners at all four campus locations.

Limitations

Limitations of this project include the lack of learning outcome measurements to quantify knowledge gained through the podcast and other professional development endeavors. Although the podcast has moved beyond dissemination using the internal LMS, we are still limited to LMS metrics for measuring the effectiveness of this project in meeting learning needs. Although the newly implemented professional development form allows team members to submit requested professional development activities, this data does not represent the expanded audience of the podcast, such as the demographic data from listeners or listener impressions. Adherence to university policies and procedures limited where we could publish the podcast. Initially, the ability to produce episodes was limited by the small size of the professional development team, which restricted time and personnel available to learn the topics and create the episodes. Interest in the podcast allowed the production team to grow and produce more diverse episodes more efficiently.

Conclusion

In conclusion, podcast creation proved to be an engaging, cost-effective method to meet the HCSC's professional development needs. The podcast project gave our team new opportunities for innovation and creativity. It also provided a more accessible professional development format for faculty and staff within the simulation center and CON. As the podcast evolved, there were opportunities to engage interprofessional and clinical partners as well as develop new partnerships. The project resulted in increased professional development opportunities as well as a more structured professional development tracking system for our HCSC. The small professional development taskforce grew to an interprofessional team. The team continues to create innovative ways to provide professional development content and support healthcare simulation within our HCSC as well as the larger healthcare simulation community.

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References

Berk, J., Trivedi, S. P., Watto, M., Williams, P., & Centor, R. (2020). Medical education podcasts: Where we are and questions unanswered. *JGIM: Journal of General Internal Medicine*, *35*(7), 2176-2178. https://doi.org/doi:10.1007/s11606-019-05606-2

Bernstein, J., Mazotti, L., Ziv, T., Drowos, J., Whitlock, S., Wood, S., Galvin, S., & Latessa, R. (2018). Texting brief podcasts to deliver faculty development to community-based preceptors in longitudinal integrated clerkships. *MedEdPORTAL : The Journal of Teaching and Learning Resources*, *14*, 10755. https://doi.org/doi:10.15766/mep_2374-8265.10755

Dowhos, K., Sherbino, J., Chan, T., & Nagji, A. (2021). Infographics, podcasts, and blogs: a multi-channel, asynchronous, digital faculty experience to improve clinical teaching (MAX FacDev). *Canadian Journal of Emergency Medicine*, *23*(3), 390-393. https://doi.org/doi:10.1007/s43678-020-00069-5

Gorra, A., & Finlay, J. (2009). Podcasting to support students using a business simulation. *Electronic Journal of e-Learning*, *7*(3), 257-264.

INACSL Standards Committee, Hallmark, B., Brown, M., Peterson, D. T., Fey, M., & Morse, C. (2021). Healthcare Simulation Standards of Best Practice™ Professional Development. *Clinical Simulation in Nursing, 58*, 5-8. https://doi.org/10.1016/j.ecns.2021.08.007

Khechine, H., Lakhal, S., & Pascot, D. (2013). University students' perception of the pedagogical use of podcasts: A case study of an online information system course. *Journal of Education and Training Studies*, *1*(2), 136-151. https://doi.org/10.11114/jets.v1i2.139

Roy, A. K., & Roy, P. A. (2007). Intersection of training and podcasting in adult education. *Australian Journal of Adult Learning*, *47*(3), 479-491.

Schomberg, T. (Host). (2022, November 3). Partners in Simulation (No. 5) [Audio podcast episode]. In *Sim-portant Conversations*. https://www.youtube.com/watch?v=tksFZ6190L4&list=PLN3WJUtjQwDtF7RT3pnAVc9w-vVaO21kF&index=7

Schomberg, T. (Host). (2023, May 5). Nursing Student Anxiety in Simulation (No. 9) [Audio podcast episode]. In *Sim-portant Conversations*. https://www.youtube.com/watch?v=-%20He9xpiPaE&list=PLN3WJUtjQwDtF7RT3pnAVc9w-vVaO21kF&index=10

South Dakota State College of Nursing (2023-present). *Sim-Portant conversations at SDSate podcast.* [Audio Podcast]. PodBean. https://sdstatehealthcaresimulation.podbean.com/

Van Patten, R., Bellone, J., Schmitt, T., Gaynor, L., & Block, C. (2022). Digital methods of delivering education and training in neuropsychology. *Archives of Clinical Neuropsychology: The Official Journal of the National Academy of Neuropsychologists*, *37*(6), 1103-1117. https://doi.org/doi:10.1093/arclin/acac033

Designing a Control Room to Support Manikin-Based, Standardized Patient, and Mixed Methods Simulations

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Brief Description

Designing a control room to ensure standardized healthcare simulation events involves a great deal of preparation. Every detail must be reviewed with engineers, construction managers, and internal and external stakeholders involved in the design of an effective control room.

Literature on healthcare simulation design, evaluation, and effectiveness is readily available, identifying best practices and successful approaches for different simulation centers. While there is literature about technology in healthcare simulation and information about control room setup, continued research is needed on effective control room design to support mixed method manikin-based simulation and standardized patient simulations in a central location.

Introduction

Simulation centers rely on a wide array of technologies to operate both behind the scenes as well as in the simulation room. When designing a simulation center, many considerations must be addressed to meet the educational goals for each discipline that will utilize the facility. Additionally, it's important to keep in mind that new disciplines may use the simulation center in the future. An adaptable and flexible simulation center control room will help support changing technology and curriculum needs (Crofut et al., 2020). Before designing or revamping a control room, it is beneficial to visit nearby simulation centers and participate in healthcare simulation conferences. Interacting with personnel from other simulation centers at these events can provide valuable ideas and insights to determine the most effective approach.

An important aspect of the design process includes working with the institution's Information Technology (IT) department to identify computer and network topology requirements, data and storage support, and equipment needs (Huang, 2020). By discussing the audiovisual (AV) components and computer needs, IT can direct all power and data outlet placement requirements with the engineering and building facilities team (Dleikan et al., 2020).

Control rooms can be designed in a variety of ways to meet the layout, functional, and budgetary needs of the simulation center. The authors of this article will explain how a central control room was planned, established, and operated to meet the needs of a variety of simulation scenario setups. By establishing uniformity in the control room configuration, there are dedicated locations for patient simulator laptops, tablets, and monitors. This eliminates the need to move equipment, reducing the risk of equipment damage and staff injury.

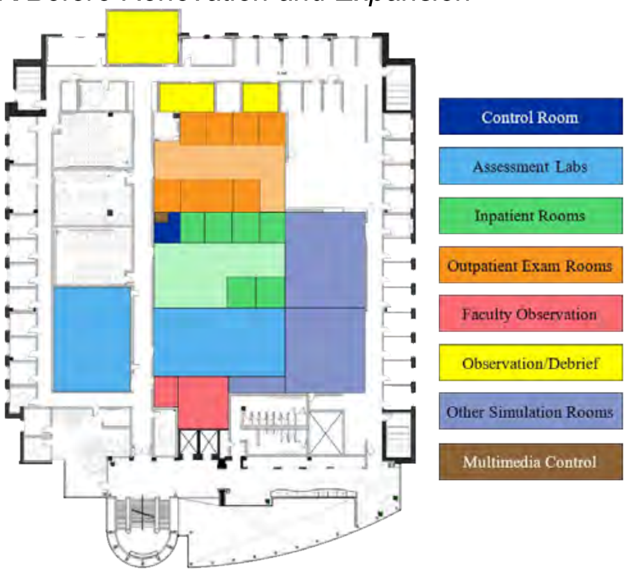
Simulation Center Renovation and Expansion

Over the past decade, Grand Valley State University's (GVSU) Interprofessional Simulation Center has grown from its original 6,409-square-foot space in one building (Figure 1A) to a 67,828-square-foot area spread across three buildings on the University's Health Campus (Figure 1B). During this time, 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 every year.

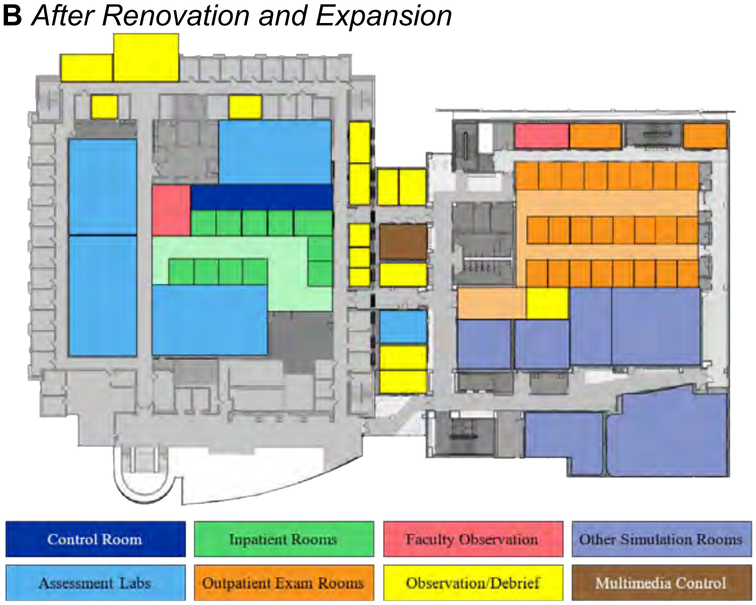
Figure 1

Simulation Center Layout Before and After Renovation and Expansion

A *Before Renovation and Expansion*



B *After Renovation and Expansion*

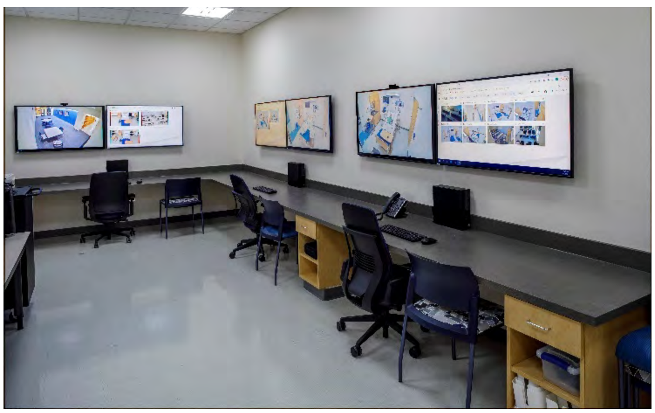


The renovated GVSU Interprofessional Simulation Center features 24 outpatient exam rooms, an in-patient hospital suite, a simulated operating room, an Interprofessional Simulation Training Lab with a three-bed ward and ceiling-mounted patient lift and ambulation systems, multiple assessment labs with varying capabilities, a Model Living suite, an anatomy lab, an Immersive Interactive technology suite, faculty observation rooms, student observation rooms, debrief rooms, and several other spaces to support simulation operations. The in-patient hospital suite contains nine medical-surgical rooms, one ICU room, and one maternity suite.

During the renovation, a dedicated multimedia control room (Figure 2) was created, allowing the center's multimedia managers to monitor all events from a central location near the control room between the inpatient and outpatient suites. The multimedia managers ensure student and faculty observation rooms stream the correct simulation room, manage the AV system, and ensure control room workstations have the correct microphone and monitor patched. Given the variety of simulation needs, the solution for this simulation center was one central control room with 12 individual workstations.

Figure 2

Multimedia Control Room After Renovation



Designing the Control Room

While there are benefits to having one central control room, some challenges include sound mitigation and individual space considerations (Sekandarpoor et al., 2019). At GVSU, standardized technical communicators (STC), part-time members of the interprofessional simulation staff, reside in the control room to operate patient simulators and communicate with faculty and students (Branch et al., 2023). Each STC workstation in the control room has soundproofing dividers and noise-cancelling headphones. These measures help prevent distracting sounds from interfering with their focus during scenarios. The workstations are spacious enough for the STC to sit comfortably without feeling crowded. With the STCs in one central location, the simulation technology managers and multimedia managers are close enough to help with scenario questions or technical issues with minimal delay.

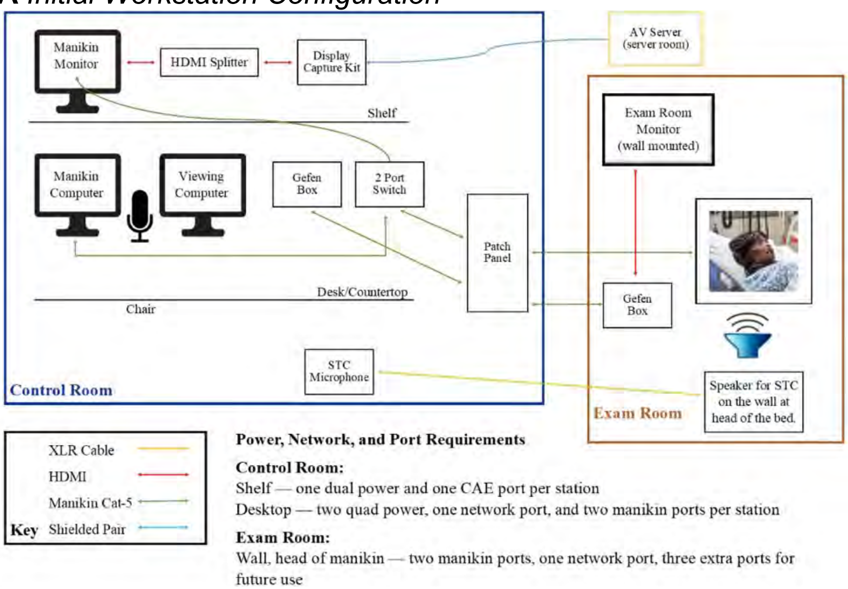
To support simulations in the inpatient suite, outpatient exam rooms, operating room, and the ward, there are 12 individual workstations in the control room. Each workstation has a desktop, a microphone, the simulator operator's laptop/tablet, and the simulator's vitals monitor. This setup supports multiple simulation modalities needed to meet the learning objectives for patient simulator, standardized patient, or mixed method events ("Healthcare Simulation Dictionary," 2020). This control room provides support to run 12 simulation rooms simultaneously, each operated by an STC.

During the early design stages, a wiring diagram was established to identify the needs both in the control room and patient care rooms (Figure 3A). As the renovation planning continued, the control room diagram was revised to streamline equipment needs (Figure 3B). The purpose remained the same, but input from expert collaborators led to adjustments. For example, additional power and Cat5 ports were included to accommodate future growth (Sekandarpoor et al., 2019). Also, a dedicated network was established for all wireless patient simulator devices and other simulation equipment.

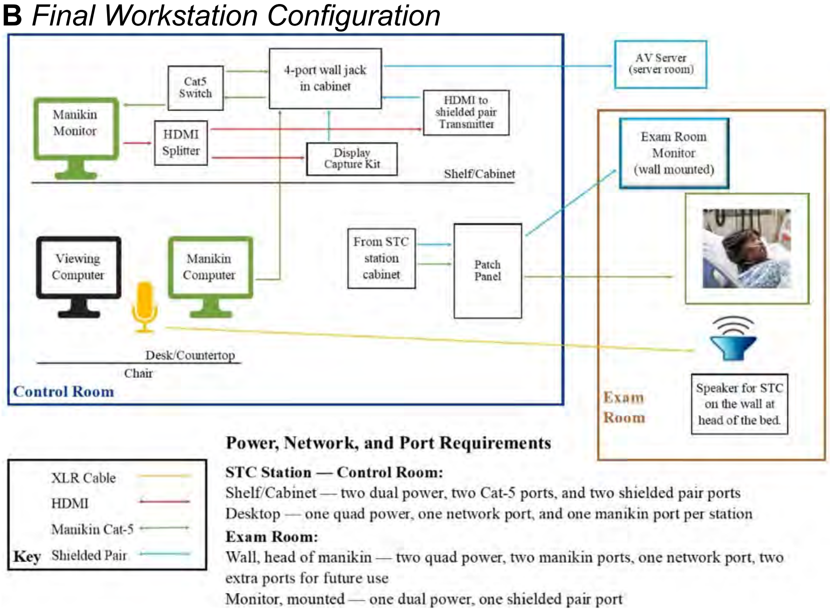
Figure 3

Initial and Final Workstation Configurations in the Control Room

A *Initial Workstation Configuration*



B *Final Workstation Configuration*



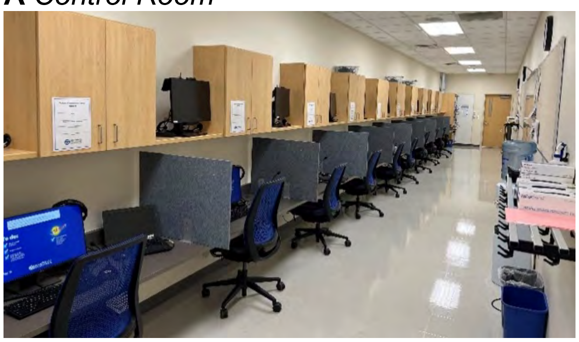
Note. *HDMI: high-definition multimedia interface; AV: audio-visual; STC: standardized technical communicators.*

In the control room (Figure 4A), the STC workstation (Figure 4B) is set up to allow STCs to view the simulation room through the desktop via live stream, speak as the patient in an exam room through a microphone, control the vitals monitor for both manikin-based scenarios and standardized patient scenarios, and communicate via Zoom chat with the faculty observation room. All 12 workstations are identical and can be patched to any room in the inpatient suite, four of the outpatient exam rooms, the operating room, and the three-bed ward in the Interprofessional Simulation Training Lab (Figure 4C-E). This setup ensures STCs and simulation staff operate in an environment with adequate lighting. This eliminates the necessity to work in dimly lit control rooms designed with one-way observational windows. This setup also eliminates the need to move patient simulator vitals monitors from room to room, reducing the risk of equipment damage or staff injuries.

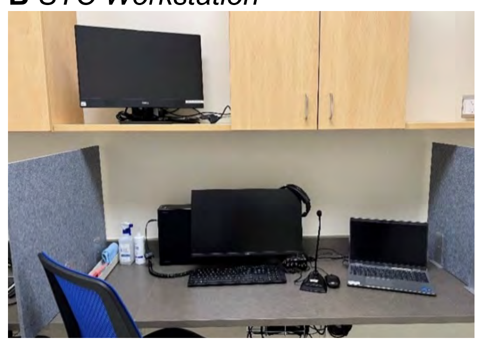
Figure 4

Control Room with STC Workstations and Various Simulation Room Designs After Renovation

A *Control Room*



B *STC Workstation*



C *Inpatient Room*

D *Outpatient Exam Room*

E *Three-bed Ward in the Interprofessional Simulation Training Lab*

Power and Cat5 ports were an important design consideration. On the shelf above each STC workstation, there is a dual power outlet and patient simulator vitals monitor. Next to the patient simulator vitals monitor, the cabinet houses a Cat5 switch, a high-definition multimedia interface (HDMI) switch, a display capture kit, a transmitter, two Cat5 ports, two shielded pair ports, and a dual power outlet (Figure 6).

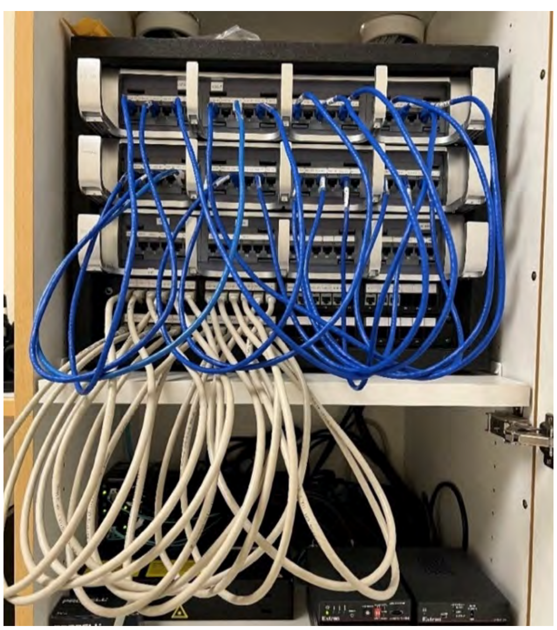
Figure 6

Control Room STC Station Cabinet

Any STC workstation can control any of the simulators in the eleven inpatient rooms, the four connected outpatient rooms, the operating room, or the three beds in the ward through the patch panel located in the control room. Patient simulator laptops/tablets at the workstations are connected to the patient simulator via Cat5 through the patch panel (Figure 7). Patient simulator vitals monitors are patched with shielded pair to the vitals monitor mounted in the simulation room. The patient simulator vitals monitor signal is sent via the AV server for observers to view the vital signs as well as the simulation room.

Figure 7

Control Room Patch Panel



Faculty and Student Observation Rooms

The faculty observation room is located between the control room and the inpatient hospital suite. There are 11 identical faculty observation workstations (Figure 8) each with a desktop, headphones, and internal phone connected to the inpatient simulation rooms. Faculty can view the simulation room and vitals monitor through the AV system. The headphones are equipped with a microphone to communicate with students through the overhead speakers. The phone allows students to call faculty who can portray a provider, pharmacy, or other healthcare professional during the simulation. Faculty can communicate with the STC via Zoom chat to answer questions or request a change in vitals.

Figure 8

Faculty Observation Workstation

There are ten student observation rooms with varying occupancy capacities (Figure 9). Each room is equipped with a monitor that enables students to observe the simulation room and vitals monitor. Students and faculty meet in an observation room with their small group to pre-brief the scenario and assign roles, alternating roles between simulations. After students complete the scenario, faculty inform the students via intercom to review key points and return to the observation room for debriefing.

Figure 9

Student Observation Rooms

A *Five-seat capacity* **B** *10-seat capacity* **C** *13-seat capacity*

Conclusion

Control rooms and simulation centers are all unique and should be designed to meet the needs of the programs they support. As technology progresses and educators modify their use of technology in classrooms, labs, and simulation spaces, it is essential to design control rooms that can accommodate upgrades and enhancements. In the process of designing the simulation center at GVSU, an open line of communication was maintained with both internal and external stakeholders, as well as staff from other simulation centers, were consulted.

Centralizing operations offers advantages such as improved coordination and immediate technical assistance. Each STC workstation is equipped with soundproofing barriers and noise-canceling headphones to help mitigate distractions. The design enables simultaneous management of 12 simulation rooms using 12 workstations, equipped with desktops, microphones, patient simulator laptops/tablets, and vitals monitors. This setup enables STCs to remotely monitor and control simulations, using live streams and Zoom to communicate with faculty. This integrated method not only boosts operational efficiency but also enriches the learning experience by offering a reliable, adaptable infrastructure for various simulation modalities.

The control room design strikes a strategic balance between technical functionality, ergonomic considerations, and operational efficiency, customized to support various simulation scenarios. The creation of a space that streamlines operations, caters to current and future programming needs, is flexible, and is ready to support a broad range of programs throughout the University was a significant focus in the design of this Center. Standardizing the control room, simulation room, and observation rooms ensures that STCs, students, faculty, and simulation staff have consistent and effective simulation experiences.

References

Branch, K. C., Ayers, D. J., & Baker, S. K. (2023). *Standardized technical communicators: A novel simulation center staffing model*. The Society for Simulation in Healthcare, Simulation Spotlight. https://www.ssih.org/Home/ctl/ArticleView/mid/54750/articleId/2521/Standardized-Technical-Communicators-A-Novel-Simulation-Center-Staffing-Model

Crofut, J.A., Kopp, S., & Walston, C.D. (2020). Designing Simulation Centers for Health Education. In Palaganas, J., Ulrich, B., Mancini, M. (Eds.), *Mastering Simulation: A Handbook for Success* 2e (pp. 277–296). Sigma Global Nursing Excellence. https://apn.mhmedical.com/content.aspx?bookid=3169&sectionid=265359726

Dleikan, C. T., Lakissian, Z., Hani, S., & Sharara-Chami, R. (2020). Designing a simulation center: an experiential guide. *Journal of Facilities Management*, 18(5), 487–504. https://doi.org/10.1108/JFM-02-2020-0011

Huang, L. (2020). Audiovisual and LMS. In Seropian, M., Keeler, G., Naik, V. (Eds.), *Comprehensive Healthcare Simulation: Program & Center Development* (pp. 69-80). Springer, Cham. https://doi.org/10.1007/978-3-030-46812-5_11

Healthcare Simulation Dictionary. (2020). In Lioce, L. (Ed.), *Agency for Healthcare Research and Quality eBooks* (2nd ed.). https://doi.org/10.23970/simulationv2

Sekandarpoor, F., Luevano, E. R., & Crawford, S. B. (2019). Infrastructure and Simulation Center Design. In Crawford, S., Baily, L., Monks, S. (Eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice* (pp. 111-144). Springer, Cham. https://doi.org/10.1007/978-3-030-15378-6_9

Simulation Operations Problem-Solving Tool: Anticipate, Act, Amend

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Brief Description

Problem-solving is essential for success as a simulation operations and technology professional; gaining this skill comes with experience on the job over time. Critical thinking during problem-solving is necessary to support success, but limited tools exist to develop this skill for simulation operations and technology professionals. Steps for problem prevention, solving, and corrective action are necessary, regardless of the simulation environment and available resources. This paper outlines the development of a tool that integrates best practices in simulation operations, specifically designed to assist with problem-solving in the design and delivery of healthcare simulation activities.

Introduction

Problem-solving is a desirable trait and a fundamental skill for healthcare simulation operationists and technicians (Roche et al., 2022). This desire is emphasized by the inclusion of problem-solving, corrective action, and maintenance as integral components of the Certified Healthcare Simulation Operations Specialist (CHSOS) Blueprint, a competency framework for simulation operations specialists with two years of experience (Society for Simulation in Healthcare, 2023). The CHSOS Blueprint defines problem-solving as the ability to "apply processes and procedures to identify technical problems/errors and initiate corrective action" (Society for Simulation in Healthcare, 2023). Enhancing the problem-solving skills of simulation operationists will improve simulation quality and enhance team satisfaction. This article delves into the pivotal role of problem-solving in the healthcare simulation field and presents a tool to enhance these skills.

Healthcare simulation professionals share a responsibility beyond addressing simulation failures. Healthcare simulation users entrust simulationists with implementing problem-prevention and problem-solving strategies. Problem-prevention and problem-solving strategies are not individual tasks but shared responsibilities among simulationists, such as technicians, operations specialists, and educators. In 2019, this group united as a community of simulation experts to present at the SimOps conference on simulation operations failures and share our collective problem-prevention and problem-solving strategies. A collaborative approach to problem-solving is a defining characteristic of the field of simulation operations.

As a collective of healthcare simulation professionals, the group recognized the need for a tool to enhance problem-solving skills in simulation operations for simulationists. The group identified gaps in the critical thinking and problem-solving skills of both experienced and newer simulation operations specialists. Our shared objective was to develop a tool that would support problem-solving collaboratively during a simulation activity by applying a standardized process. With this tool's introduction, the group hopes to bridge the skill gap between experienced and newer simulation operations specialists, fostering a sense of community and shared learning.

The team created this tool to apply a comprehensive approach to the critical thinking process of problem-solving to prevent, prepare for, and follow up on problems no matter when or where they occur. The tool's development was guided by best practices in healthcare simulation to ensure its relevance and applicability. Developing the problem-solving skills of simulation operations professionals may improve the quality of simulation events and enhance learner experiences and team satisfaction. The Simulation Operations Problem-Solving Tool supports the link between learning objectives and problem-solving prioritization during a simulation activity, fostering a sense of community and shared learning.

Methods

Simulation Operations Problem-Solving Tool Design

The development of the Simulation Operations Problem-Solving Tool was a rigorous process. The group reviewed existing technology troubleshooting tools, checklists, and algorithms. Existing problem-solving tools were reviewed from Lean methodologies, CompTIA, and CHSOS review materials (Bassuk & Washington, 2013; Chartered Management Institute, 2020; Ferrill, 2015; Society for Simulation in Healthcare, 2023). The team created two options for a problem-solving tool framework from this extensive research. The first option was a walkthrough of the troubleshooting process in chronological order. The second option was to divide the troubleshooting into categories with specific prompts most relevant to each category. The team chose to fully build the first option, presenting a chronological framework.

When building the tool, problem-solving steps were generalized to all potential problem categories, making it versatile for various simulation environments. The team identified four categories:

- Things and Technology
- Ideas and Planning
- People and Communication
- Places and Environment

The tool provides suggestions relevant to challenges in the identified categories. It supports a comprehensive approach to preventing, preparing for, and following up on problems by supporting critical thinking skills. The team then organized the tool chronologically, providing different steps and suggestions based on whether the issue occurred before, during or after an event. The timeline was divided into three phases:

- Anticipate Challenges in Advance of a Simulation Event
- Act to Solve Problems During an Event
- Amend Problem Causing Issues After an Event

Each section continues to support the development of critical thinking skills, so when the unplanned happens, and the simulation must go on, the problem-solving toolbox is ready to support the success of the education session.

Simulation Operations Problem-Solving Tool Revision

The tool was revised based on feedback from several rounds of presenting the tool. Each time the tool was shared, the team collected survey data and audience feedback. The team carefully analyzed the feedback and updated the tool address the specific needs and suggestions of the users, ensuring it remains a relevant problem-solving tool for healthcare simulation operations.

A Google Forms survey was utilized to collect feedback regarding the tool following each presentation. Course attendees were not required to complete the survey, which was distributed using a QR code at the end of each course. The number of survey responses is as follows (Table 1).

Table 1

Number of survey responses for each presentation of the tool

Event	Number of Responses
IMSH 2020	29
SimGHOSTS 2020	9
IMSH 2021	16
SimOps 2022	22
Total Number of Responses	**76**

An open-ended question on the survey asked for additional feedback or comments on the Simulation Operations Problem-Solving Tool. The team collected many comments and suggestions for improvement. Suggestions included additional prompts, space for documentation, and an electronic or app version of the checklist (Table 2). As detailed below, the team updated the checklist to incorporate as much of this feedback as possible. The group reviewed the feedback to determine which suggestions were feasible and beneficial based on the goals of the tool.

(Continued on next page)

Table 2

Additional feedback from survey

Positive feedback	Suggested changes
Great interactive meeting. So many creative minds and scenarios but also many unique cases to learn from.	The checklist format is a little confusing to follow…in theory not all checks would be crossed off which for basic users can indicate incompleteness. Maybe incorporate a flow chart with check boxes so that it's a more flowy
Would you allow others to amend the tool but still cite your work?	
I will try using it and see if it makes a difference. Thanks for the work out into developing the checklist	The Amend (green) section needs a "Who needs to be told?" Blank so the right person is informed of the issue.
Very well done and interesting on the small stuff	Middle section needs room to write stuff down.
This checklist looks to be a great asset to our program!	I think finding the time to fill this out with each problem is difficult. I think this is great for larger scale problems and great in theory for the small everyday problems but difficult to do when sims are back-to-back/filled schedule if that makes sense
I am the sole person in my Simulation Center and so any tools I use are used only by me.	
Will probably adapt but this is a fantastic approach	Create an electronic/tablet version or app that allows for real time completion. And then a place to store the sim type and solutions that everyone can access. We can see how others solved the problem and hopefully won't need to reinvent the wheel
I like the categories of timing	
Will be good if we add more simulation staff to our team	
Sim Hacks Online Blog may be helpful for facilitators, operationists, faculty and coordinators - especially novice ones - for managing failures! Thank you for your session today!	

The team first shared the tool during a workshop course at IMSH 2020. Feedback was collected in a survey and directly from participants during the workshop. From this, the tool was updated to include space to list learning objectives and a problem-solving notes section.

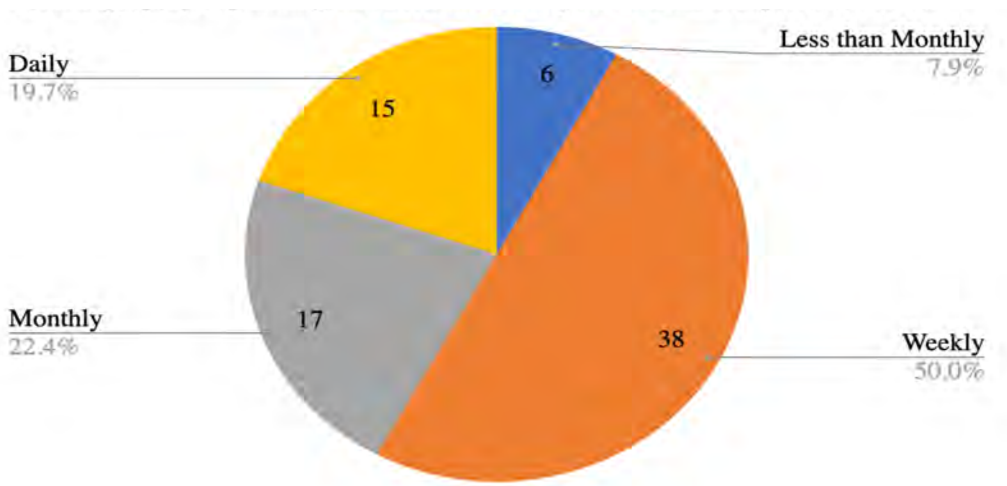
The tool was then presented at a SimGHOSTS 2020 virtual workshop and an IMSH 2021 virtual course. After these presentations, the tool's title was updated from "Simulation Operations Specialist Problem Solving Checklist" to "Simulation Operations Problem Solving Checklist" to be more inclusive of potential tool users. The team also created a version without full-color boxes to reduce the ink needed to print the tool.

Finally, the team shared the tool at an in-person workshop course at SimOps 2022. Based on feedback, the name was updated from “Simulation Operations Problem Solving Checklist” to “Simulation Operations Problem-Solving Tool” to better represent its function.

To gauge the need for the Simulation Operations Problem-Solving Tool, survey respondents were asked the frequency of problems in their simulation experience. The results from all four surveys showed that the most common answer was "Weekly,” with 38 responses. The highest response was “Monthly,” with 17 responses, followed closely by “Daily,” with 15 responses. Less than Monthly received six responses (Figure 1).

Figure 1

Frequency of problems related to technology, people, planning, and environment



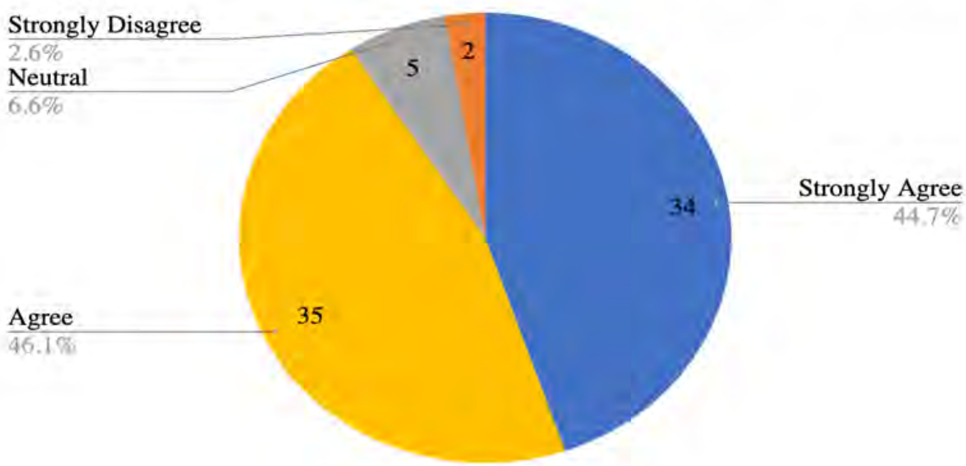
Note. This pie chart represents survey responses to the question: “What is the frequency of the occurrence of problems related to technology, people, planning, and environment in your simulation experience?”

To assess the relevance of the Simulation Operations Problem-Solving Tool, course attendees were asked if it applies to their jobs. “Agree” received 35 responses, and “Strongly Agree” received 34 responses. “Neutral” received five responses, and “Strongly Disagree” received two responses (Figure 2).

(Continued on next page)

Figure 2

This simulations operations problem-solving checklist is applicable to my job



Note. This pie chart represents survey responses to the statement: "This simulations operations problem-solving checklist is applicable to my job."

Results

How to Use the Tool

The Simulation Operations Problem-Solving Tool is setup in chronological order, starting with *Anticipate Challenges in Advance of a Simulation Event* (Appendix A). The tool is intended to be used for a specific case or simulation event. This is because the backup strategies and threshold to make changes is tied to the learning objectives for each specific simulation event.

The tool's planning section identifies potential problems before a simulation activity and develops solutions. For instance, if a specific manikin is known to have issues connecting to the monitor, the tool prompts you to plan workarounds, such as printing an image of the vitals to display or communicating vitals to an embedded participant. These proactive measures can help prevent disruptions during the simulation and support the learning objectives.

Another key element of the *Anticipate Challenges in Advance of a Simulation Event* section is communication with other members of the team in advance. This communication provides opportunity for other team members to share additional back-up plans. This section recommends the team determines a threshold for implementing a back-up plan. Continuing with the previous example, the backup plan of using printed vitals would be implemented if the connectivity issues are still occurring two minutes before the learners arrive.

The *Act to Solve Problems During an Event* section of the tool is designed to empower users to take practical steps when a problem occurs during simulation event delivery. The first item listed in this section is the learning objectives for the event. Maintaining alignment with the learning objectives of a simulation activity is crucial for the subsequent steps in the tool. The impact of a problem on these objectives encourages users to consider the urgency and timeline for resolution. Recommendations indicate when the problem should be addressed: immediately between cases, or by the end of the day.

The importance of communication continues during active problem-solving. The tool prompts users to communicate with the team, providing suggested topics. The communication prompts include identifying if team members are needed to get extra supplies or equipment, assist with the instructors or learners, or provide support based on their experience with the issue. Additional communication with instructors or learners may be necessary depending on the impact of the issues on the event.

The final section of the tool *Amend Problem Causing Issues After an Event* contains steps often missed after a challenge has been resolved. This section of the tool is designed to carry the user through the iterative process of establishing a theory of probable cause, testing the theory, and adapting it as necessary. The goal is to identify the roof cause of an issue and determine options for preventing it from recurring.

A theory of probable cause is identified and tested until enough information is gained to establish an action plan to fully resolve or prevent a challenge. This verification should include full system functionality. Communication and documentation are essential steps to resolving and preventing problems. Without these steps, there is no record of how previous issues were solved, making it difficult to prevent similar challenges from arising in the future.

Benefits of Using the Tool

Using the tool to brainstorm and communicate about potential issues prior to a simulation activity provides contingency plans in the event of challenges for all team members involved. Completing the *Anticipate Challenges in Advance of a Simulation Event* supports critical thinking when considering alternative options to challenges in advance. This proactive approach provides more time and reduces stress compared to problem-solving as challenges arise during the simulation. Documenting proactive solutions with the tool creates a valuable resource to refer to during the event, as it can be difficult to remember them in the moment.

When challenges occur during a simulation event, it can be difficult to think clearly about next steps or potential solutions. The *Act to Solve Problems During an Event* section reminds users of the learning objectives to align problem-solving action with learner group needs. The prompts can help both new and experienced simulationists who struggle when issues occur during an event. This sections also provides guidance on next steps for the timing and communication required for problem-solving.

The *Amend Problem Causing Issues After an Event* section of the tool supports full system resolution and prevention of problems in the future. It is easy to perceive a problem as resolved without considering how it affects the broader system. This section leads users to identify the underlying cause of an issue and communicate and document as needed. Effective documentation and communication can help ensure solutions do not just live with one person but are available to a full simulation team.

Discussion

Half of the survey respondents reported troubleshooting problems on at least a weekly basis, with an additional 20 percent experiencing problems daily (Figure 1). This frequency of problems in simulation operations suggests a need for a problem-solving tool. Ninety percent of survey respondents agree or strongly agree that the Simulation Operations Problem-Solving Tool described in this paper applies to their job (Figure 2), making it widely applicable for the simulation operations community.

The Zamierowski Institute for Experiential Learning (ZIEL) simulation team is using the Simulation Operations Problem-Solving Tool in standardized course planning documents for simulation activity delivery. It has been added as the last page of the document, so it is easily accessible to everyone delivering a simulation activity. The no color version of the checklist was designed to be printed in black and white and use less ink for this purpose (Appendix B).

Before a simulation, the assigned simulation operations technologist completes the *Anticipate Challenges in Advance of a Simulation Event* section and fills in potential solutions for possible problems. Common problems the ZIEL team creates back-up plans for include problems with audio playback, simulated vitals monitor connection, patient voice microphone and manikin presentation of symptoms. This tool is particularly beneficial for large-scale simulation activities involving all ZIEL technical operations team members. For large-scale simulation events, completing the *Anticipate Challenges in Advance of a Simulation Event* section with backup options, along with filling in the *Act to Solve Problems During an Event* section with the learning objectives, allows team members who were not involved in the initial planning or who lack background knowledge on those details to effectively contribute to problem-solving efforts.

For ZIEL, the inclusion of the Simulation Operations Problem-Solving Tool in standardized course planning documents starts the conversation between the technical operations team and the learning and design team on potential challenges related to events. This leads to early collaboration on back-up plans and thresholds for implementing solutions during an event. Communicating challenges and back-up plans involves instructor team members who will be impacted by problems during a simulation event. This promotes acceptance from all stakeholders when adapting the initial simulation plan. The Simulation Operations Problem Solving Tool has improved the simulation operations problem-solving communication and process in ZIEL.

The University of Texas Southwestern Medical Center's High Reliability Team (HRT) conducts in-situ simulations to improve teamwork and communication with interdisciplinary teams throughout their healthcare system. The team aims to promptly capture and report any safety threats or knowledge gaps observed during the simulation to the appropriate leadership.

The HRT's modern approach is evident in their use of the Simulation Operations Problem-Solving Tool. They have adapted the tool by adjusting questions to support the program's objectives and to collect valuable data. The tool was converted into a Microsoft Forms "Debriefing" survey to support the team's mobility and completion rate after each group of learners. After each simulation, the team fills out the form and uses this time for a team debrief, creating a shared mental model for those responsible for action items.

For each simulation group, the HRT diligently answers questions about the need to file event reports, open service tickets, address manikin issues, or improve the simulation modality. If any action items are identified, the task is assigned to a team member based on their expertise and availability. The team member then takes responsibility for the task and promptly completes it. This approach focuses on any issues with the equipment, instructional design, knowledge gaps, or safety threats.

The data collected by HRT catalyzed positive change across the organization. It has been used in several ways to support individual units, specialized disciplines, hospital administration, code blue teams, and education departments. For instance, it aided in identifying and addressing specific knowledge gaps in different units, improve the efficiency of code blue teams, and enhance the quality of education and training programs. It has also been presented at hospital-wide committees to improve patient safety. Implementing this form has positively affected the HRT dynamics and their goal of supporting a highly reliable organization, our colleagues, and improving patient care.

Limitations

A limitation of the research study was the small sample size. Although the data was collected from conference audiences nationwide, this is a small sample of simulation operation specialists in practice. This article provides an editable version of the Simulation Operations Problem-Solving Tool to reach a wider audience and improve the sample size. The goal is to reach a wider variety of simulationists worldwide who can use the tool to enhance their practice.

Conclusion

Although problem-solving in simulation operations is critical, limited tools exist to support it. The Simulation Operations Problem-Solving Tool may be relevant for various simulation problems. Future iterations of the tool could include an electronic version, allowing modifications to fit multiple problems. Furthermore, an electronic version would allow for easy adaptation to support simulationists in various ways and languages. Expanding its use in simulation centers and collecting feedback for improvement will allow for the continuation of feedback to be gathered on this tool. Future plans for the Simulation Operations Problem-Solving Tool include a webinar presentation aimed at promoting the resource within the simulation operations community and gathering additional feedback for ongoing improvements.

References

Bassuk, J. A., & Washington, I. M. (2013). The A3 problem-solving report: A 10-step scientific method to execute performance improvements in an academic research vivarium. *PloS one*, 8(10), e76833. https://doi.org/10.1371/journal.pone.0076833

Chartered Management Institute. (2020). Solving problems. In *Chartered Management Institute* (Checklist 012). Retrieved December 19, 2022, from https://www.managers.org.uk/wp-content/uploads/2020/03/CHK-012-Solving_Problems.pdf

Ferrill, B. (2015, March 17). *Pace IT Troubleshooting Theory* [Slide show]. SlideShare. https://www.slideshare.net/paceitonline/pace-it-troubleshootingtheoryswnm

Roche, A. F., Condron, C. M., Eppich, W. J., & O'Connor, P. E. (2023). A mixed methods study identifying the competencies of health care simulation technicians. Simulation in healthcare: *The Journal of the Society for Simulation in Healthcare*, 18(5), 293–298. https://doi.org/10.1097/SIH.0000000000000682

Society for Simulation in Healthcare. (2023). *CHSOS*. https://www.ssih.org/Credentialing/Certification/CHSOS

Appendix A

Simulations Operations Problem Solving Tool with color

Simulation Operations Problem Solving Tool

Anticipate Challenges in Advance of a Simulation Event

Simulation Event Name/Case:____

- ❏ Consider element(s) of event most likely to fail
  Examples: Vitals monitor, manikin pupil dilation, learner schedule, inexperienced faculty
  ____
  ____
- ❏ Plan for possible backup strategies for issues identified above
  ____
  ____
- ❏ Communicate with instructors in advance on possible issues and backup plans identified above
- ❏ Agree on threshold to move to backup plan
  ____
  ____

Act to Solve Problems During an Event

- ❏ Always consider the learning objectives for the event.
  ____
  ____
- ❏ If problem(s) don't impact learning objectives or safety, continue with the event.
- ❏ If backup plan exists from planning, move to it as necessary.
- ❏ If problem(s) impact learning objectives and/or safety, determine the ideal time to attempt a solution.
  - ❏ Immediately, in between cases, end of day
  ____
  ____
- ❏ Communicate with the team as necessary.
  - ❏ Is someone needed to get extra supplies or equipment?
  - ❏ Is someone needed to help with instructors/learners?
  - ❏ Is there someone that has experience with the issue and can help?
  ____
- ❏ Communicate with instructors/learners on impact issues have on the event.

Amend Problem Causing Issues After an Event

- ❏ Establish a theory of probable cause.
  ____
  ____
- ❏ Test theory of probable cause to determine actual cause.
  - ❏ If probable cause proves to not be the actual cause, start again with new probable cause.
- ❏ Establish action plan and execute it.
  ____
  ____
- ❏ Verify full system functionality.
- ❏ Document the process to resolve or prevent the problem in future events.
- ❏ Communicate the problem and solution to the team.

Note. The document is available for download as a pdf at:
https://drive.google.com/file/d/1lmLU6ca3VMPsbZXoPCX32jwOQjEHLIY9/view?usp=sharing
The document is available for download as word document at:
https://docs.google.com/document/d/1qrEiCGHH_vLmRQnJunDIwtsNs8NMxYCh/edit?usp=sharing&ouid=113041553607474554404&rtpof=true&sd=true

Appendix B

Simulation Operations Problem Solving Tool without color

Simulation Operations Problem Solving Tool

Anticipate Challenges in Advance of a Simulation Event

Simulation Event Name/Case:____

- ❑ Consider element(s) of event most likely to fail
  Examples: Vitals monitor, manikin pupil dilation, learner schedule, inexperienced faculty
  ____
  ____
- ❑ Plan for possible backup strategies for issues identified above
  ____
  ____
- ❑ Communicate with instructors in advance on possible issues and backup plans identified above
- ❑ Agree on threshold to move to backup plan
  ____
  ____

Act to Solve Problems During an Event

- ❑ Always consider the learning objectives for the event.
  ____
  ____
- ❑ If problem(s) don't impact learning objectives or safety, continue with the event.
- ❑ If backup plan exists from planning, move to it as necessary.
- ❑ If problem(s) impact learning objectives and/or safety, determine the ideal time to attempt a solution.
  - ❑ Immediately, in between cases, end of day
  ____
  ____
- ❑ Communicate with the team as necessary.
  - ❑ Is someone needed to get extra supplies or equipment?
  - ❑ Is someone needed to help with instructors/learners?
  - ❑ Is there someone that has experience with the issue and can help?
  ____
- ❑ Communicate with instructors/learners on impact issues have on the event.

Amend Problem Causing Issues After an Event

- ❑ Establish a theory of probable cause.
  ____
  ____
- ❑ Test theory of probable cause to determine actual cause.
  - ❑ If probable cause proves to not be the actual cause, start again with new probable cause.
- ❑ Establish action plan and execute it.
  ____
  ____
- ❑ Verify full system functionality.
- ❑ Document the process to resolve or prevent the problem in future events.
- ❑ Communicate the problem and solution to the team.

Note. The document is available for download as a pdf at: https://drive.google.com/file/d/1QL8o6jWyYcmY8kYbWTM27gGQrejMF-R_/view?usp=sharing
The document is available for download as a word document at: https://docs.google.com/document/d/1j9w27Nf7YW5erbfmvc-1I2iQsQqEeSA5/edit?usp=sharing&ouid=113041553607474554404&rtpof=true&sd=true

Innovative and Inexpensive Designs for Wound Packing Task Trainers

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Conflict of Interest Statement

The authors of this manuscript declare no conflicts of interest. Innovations were designed at the STRATUS Center for Medical Simulation when author BFQ was employed there.

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Brief Description

With the number of mass casualty incidents increasing worldwide (Zhao et al., 2019), the role of bystander intervention is becoming increasingly important to ensure positive patient outcomes (Hoyme & Atkins 2016). Prehospital tourniquet use, direct pressure, and wound packing are proven to be safe and effective measures for treating uncontrolled hemorrhage (Parry, 2021). Between the years 2003 and 2015, over 382,376 trauma cases relating to penetrating injuries by stab or gunshot wounds were reported to the National Trauma Data Bank (Zeineddin et. al, 2021). With these alarming statistics, it is imperative bystanders, medical personnel, and first responders are prepared to care for such injuries. In our project, we designed and built an innovative, cost-effective task trainer to teach users how to efficiently and effectively care for traumatic wounds. The cost-effective materials used to create this model aim to provide equitable access to clinical training, as commercial simulators may not be readily available in under-resourced areas. The model allows learners to practice treating various injuries including gunshot wounds, stab wounds, and lacerations.

Introduction

In recent years, failure to manage severe traumatic injuries has been a leading cause of preventable death amongst surgical and trauma patients in the prehospital setting (Smith et al. 2018). Educational interventions are needed to minimize the occurrence of deaths and to improve patient care delivery. Medical simulation training has been shown to increase participant understanding of clinical knowledge and management for difficult medical conditions (Zhang et. al, 2015, Lauffenburger et. al 2022, Vattanavanit et. al, 2017). Notable educational programs like Stop The Bleed (STB) by The American College of Surgeons are designed to teach students the basics of wound packing and hemorrhage control (Gowen et al. 2020; Lei et al. 2019).

Since traumatic injuries can occur unexpectedly, knowing how to stop bleeding before significant blood loss occurs is an essential life-saving skill in times of crisis (Latuska et al. 2019;

Sidwell et al. 2018; Zwislewski et al., 2019). However, access to this training may be limited by financial and economical constraints, particularly in lower resource settings (Martinerie et al. 2018; Nitin et al. 2022). The highest quality commercial wound packing task trainers cost approximately $700 (USD). However, these trainers represent only one specific injury, making it more challenging and costly to train learners in managing multiple injuries.

Another limitation of commercial simulators is the requirement of a second operator to initiate active bleeding. However, in resource-limited areas, a second operator may not be available, underscoring the need for a trainer that can actively bleed without additional personnel. To help address this issue, we propose methods to design realistic and inexpensive wound packing task trainers using ballistics gel and repurposed materials. We hope to expand the access of high-fidelity STB training at a lower cost without sacrificing educational or technical quality (Pringle et. al, 2015). The following methods will provide instruction on creating task trainers with injuries representing a deep laceration, a gunshot wound (GSW), and a stab wound.

Objective

Simulated task trainers are efficient training modalities that help clinicians practice clinical skills in a low-risk, psychologically safe environment. Our purpose for creating these models is to provide an affordable and efficient wound packing task trainer to teach lay responders and health care workers the proper application of combat and bandage gauze when handling different types of traumatic injuries.

Materials

Three wound packing task trainers were created using repurposed materials to serve as an affordable adjunct to expensive commercial wound packing trainers sold in the medical simulation market (Table 1). Ballistics gel was chosen as the medium for the model due to its likeness to human biological tissue (Caldwell & Mooney 2019; Filipchuk & Gurov 2015), creating a higher fidelity experience for the learner. A GladWare Salad & Soup Storage Lunch Box was used as the mold. Models created represent a deep laceration, a singular GSW, and a penetrating trauma injury from a pocketknife.

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Table 1

Total Cost of Materials

Model Components	Quantity for 3 simulators	Cost per unit (in USD)
10% Ballistics Gel FBI Block	1	$89.98
Silicone Pigment (Color Paint)	1	$6.88
Rubber Latex Surgical Tubing 5/16"IDx1/2"OD (8x12mm)	1	$13.90
Chefmaster Super Red Liqua-Gel Food Coloring	1	$6.49
Pocketknife	1	$9.90
Electric Slow Cooker	1	$46.49
1 Liter Simulated IV Fluid Bag	3	$3.88
Baxter IV Administration Sets	3	$7.68
Cardinal Health Salem Sump Nasogastric Tube	3	$ 2.78
GladWare Soup & Salad Food Storage Lunch Box (64 oz)	3	$3.49
Total Cost for Three Simulators		**$223.53**
Total Cost for One Simulator		**$74.51**

Note. Items are typically bought in bulk and individual units are used to create the model. Prices are reflective of USD as of August 2024 and may be subject to change over time. The total cost for three simulators was calculated by multiplying each component's price by the quantity and summing the prices. The total cost for one simulator was calculated by dividing the total cost for the three simulators by three.

Preparing the Ballistics Gel

For detailed instructions, please refer to the full protocol (see Appendix A). For all three task trainers, we made one incision on the lateral side of the mold, a 64-ounce Gladware soup and salad storage lunch box. The incisions were large enough to fit the rubber latex tubing through and create a tight seal, preventing ballistics gel from leaking. The mold is suspended above the table to allow any excess ballistics gel to drain without sticking to the surface.

Then, we cut the ballistics gel into smaller pieces to allow even melting in an electric slow cooker. Silicone pigment was mixed into the melted ballistics gel to simulate skin tone. The melted gel was then poured into the lunch box in differing methods depending on the trainer, described below. Briefly, for the deep laceration and stab wound task trainers, we filled the mold in one pour, creating the injury after the ballistics gel set. For the GSW model, additional latex tubing was placed in the mold prior to pouring the ballistics gel, allowing the gel to set around it and form a circumferential entry point. The hot ballistics gel should take no more than forty-five minutes to completely solidify at room temperature. Following the same steps used to create the wound packing models, the ballistics gel can be remelted and repurposed to produce new simulators featuring different injuries than those in the original trainer.

Preparing Simulated Blood

The intravenous (IV) fluids and the latex tubing from the models were bound together using a lumen cut from a Cardinal Health Salem Sump nasogastric tube to prevent leaking. Red food coloring was injected into IV fluids in varying amounts to simulate the colors of arterial and venous blood. For lighter arterial blood, 10 cubic centimeters (cc) of food coloring was added to a saline bag, while 25cc was used for the darker venous blood. Before use, IV fluids must be opened, hung above the trainer, and connected to an administration set to enable effective blood flow and simulate active bleeding.

The models actively bleed using the methods described and can be easily operated by a single learner. Simulated wounds can be packed and stabilized efficiently with cotton roll gauze, combat gauze, or other adjuncts necessary for bleeding control, depending on the simulation setting and situational need. When the bleeding is successfully controlled, the IV tubing must be locked to prevent the continuous flow of fluid for all task trainers. The standard setup used for all three models and completed wound packaging trainer is shown below (Figure 1).

Figure 1

A *Standard Setup* **B** *Completed Wound Packaging Trainers*

Note. Panel A: Standard setup allows for single person use of task trainers. Sample items provided for the learner includes gauze rolls, purple nitrile gloves, an IV pole to hang simulated blood, towel, and adjustable table. Panel B: Preliminary models were created using plastic containers of different sizes; however, the final models described in these instructions are uniform in size across all three trainers.

Deep Laceration Model Design

For the deep laceration task trainers, we prepared the mold, latex tubing and ballistics gel as described above. Melted ballistics gel was poured into the container and filled to the top of the lunch box mold in one pour. The cooled ballistics gel was removed from the mold and flipped upside-down. A large laceration was made by cutting down the center of the ballistics gel with a pocketknife, partially exposing the latex tubing underneath. To create the laceration, external pressure was applied to the interior of the newly created gash to create space for wound packing. Simultaneously, the ballistics gel near the opening of the wound was pulled inwards to create a high-fidelity deep laceration (Figure 2). The IV tubing to simulate bleeding was attached as described above.

Figure 2

Deep Laceration Wound Model

Gunshot Wound Model Design

For the gunshot wound task trainers, we prepared the mold, latex tubing and ballistics gel as described above. In addition to the previously described lateral incisions, an incision was made on the bottom side of the mold to accommodate the latex tubing. Melted ballistics gel was poured three-quarters of the way to the top of the mold and left to completely solidify. Once the ballistics gel set, the tubing on the bottom side was removed completely and reinserted partially near the top of the opening to create depth for the simulated GSW. A final layer of ballistics gel was poured to fill the mold to the top (Figure 3). This final layer must cover the latex tubing to prevent angulations in the model's shape and to minimize risk of tubing breaking from the bottom side. In future designs, a lunch box with multiple lateral and bottom incisions can be made and the above process can be repeated to create multiple actively bleeding GSWs on the same model. The IV tubing to simulate bleeding was attached as described above.

Figure 3

A *Bleeding Gunshot Wound Model*

B *Packed Gunshot Wound Model*

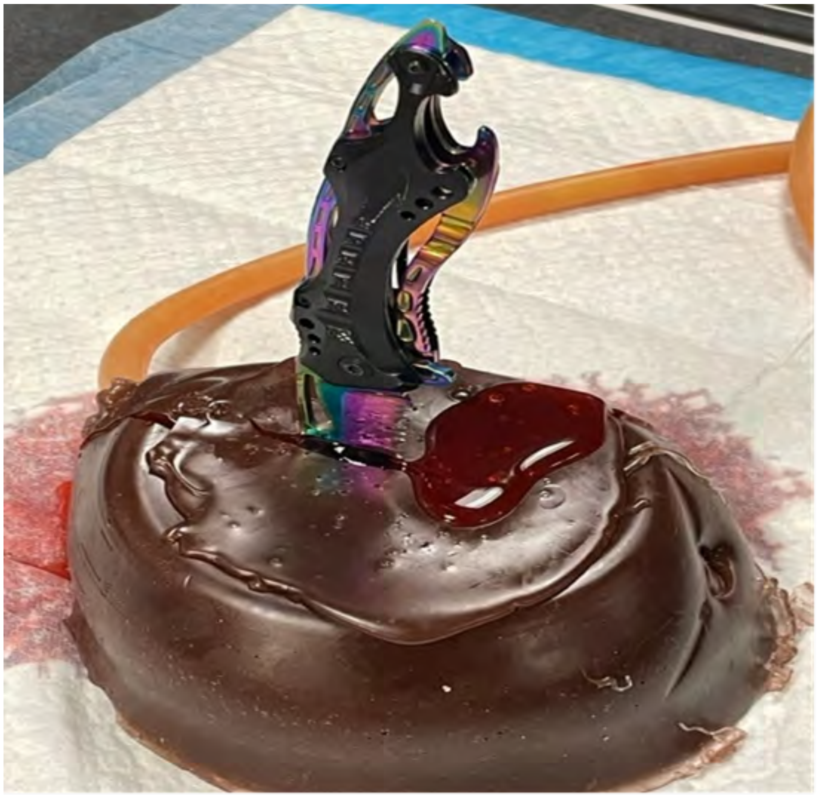
Note. Panel A: Depth of the wound is approximately 2.5 inches deep. Blood exits exclusively from the entry wound of this model. Exit wound and simulated bullets were not included in the design of this model. Panel B: This image shows the gunshot wound model packed with cotton roll gauze.

Stab Wound Model Design

For the stab wound task trainers, we prepared the mold, latex tubing and ballistics gel as described above. Melted ballistics gel was poured into the container and filled to the top of the lunch box mold in one pour. Once the ballistics gel set, a small incision was made on the top of the model until the latex tubing underneath was visible. The model was then pierced with a pocketknife to create slits in the latex tubing for blood to leak out of. The pocketknife was then carefully inserted through the tubing and into a deeper section of the ballistic gel to prevent accidental dislodging (Figure 5). The IV tubing to simulate bleeding was attached as described above. Practical uses for this model can include the application of cotton roll gauze for impalement, wound stabilization, and hemorrhage control. Although a stab wound with a pocketknife was used to exemplify the penetrating trauma, the knife can be substituted with other objects common in penetrating injuries like scissors and rebar rods.

Figure 5

Stab Wound Model



Note. It is important to use care when handling and using this task trainer to avoid unintentional injury from the penetrating objects.

Discussion

Stopping a major bleed is a lifesaving intervention that requires a realistic and affordable trainer, both of which these trainers could deliver. When packing a wound from a traumatic injury, applying adequate pressure is crucial. Each of the three wound packing models was designed to replicate realistic injuries, featuring a bleeding function that creates a sense of urgency and allows learners to see when proper wound-packing technique has successfully stopped the bleeding. The total cost for all three simulators was $223.53 USD with no anticipated maintenance costs.

The models successfully demonstrate appropriate bleeding and can be constructed with only one operator. These models can be used to create a hybrid simulation with a live actor or low fidelity model, providing a higher fidelity learning experience in managing active bleeding wounds. Additionally, the durability of the ballistics gel increases the likelihood of the task trainer's longevity. However, this model does require access to electricity to use the slow cooker, and in areas of conflict or poverty, electricity may be a costly resource. The simplicity of the design and general construction allows for each creator to adapt the functionality and appearance to meet specific learning objectives. Currently, the model is designed for rapid trauma response to stop the bleed, but it has the potential to expand its reach to different specialties. For example, the deep laceration model could be modified for dermatologists to practice deep tissue suture repair using mesh and distinct layers of tissue. The GSW model could also include the bullet itself that would be removed by a surgeon in a simulated surgical scenario. Lastly, the penetrating trauma model could include different potential contaminants of which nursing could practice cleaning and dressing the wound.

Limitations of Simulators

There are several limitations present in these simulators. First, due to the lack of structural integrity, these bleeding models are not effective for training the psychomotor skills of tourniquet application. Tourniquet application is a trauma care skill that functions to inhibit blood flow to a wounded limb and is essential for stopping massive hemorrhages. This skill, in addition to wound packing, has been shown to lower patient complication rates when applied correctly in clinical settings (Inaba et. al, 2015, Passos et. al, 2014). Due to the lack of firm surfaces within the model, compressing the latex tubing is limited, resulting in no change in blood flow when a tourniquet is applied. To practice this skill, we suggest using a secondary trainer for tourniquet application like a simulated limb or foam roll.

Second, because latex tubing and IV fluid are used to create the bleeding mechanism in these simulators, blood pools into the injury site at a fixed speed, effectively simulating a venous bleed. However, there is no way to simulate an arterial bleed which spurts blood from the injury site rhythmically. This may be resolved by adding a pumping mechanism in future designs. Additionally, we recognize that latex can be a potential allergen to some users and understand the risk of including it in our model design. Prior to use, users should be made aware of the latex tubing and given latex-free exam gloves for practice. Furthermore, the latex tubing can be substituted with latex-free tubing.

Lastly, using dyed IV fluid to simulate human blood may slightly compromise the fidelity. Human blood, unlike the IV fluid, is generally more viscous and may even contain thrombi. To remedy this, commercial simulated blood products may provide learners a more realistic experience with our simulators, albeit more expensive.

Conclusion

Using inexpensive and repurposed materials, we successfully constructed three wound packing task trainers for approximately $74.51 USD per trainer. The models can be used to teach the basics of wound packing without sacrificing the fidelity that comes with more costly trainers. We anticipate using these new models to provide a high-quality learning experience in our interdisciplinary training center. Those who could greatly benefit from learning basic STB skills with these trainers include medical providers in emergency medicine and surgical fields, as well as public safety personnel such as security officers, police, and firefighters. Lastly, we hope to provide an affordable and customizable alternative to expensive wound packing simulators and to make STB training more accessible to lower resource areas.

References

Caldwell, J., & Mooney, J. J. (2019). Analysis of soft tissue materials for simulation development. *Simulation in Healthcare the Journal of the Society for Simulation in Healthcare*, *14*(5), 312–317. https://doi.org/10.1097/sih.0000000000000382

Filipchuk, O. V., & Gurov, O. M. (2015). Peculiarities of applying ballistic gel as a simulator of human biological tissues. Theory and Practice of Forensic Science and Criminalistics, 15, 367-373. https://doi.org/10.32353/khrife.2015.46

Gowen, J. T., Sexton, K. W., Thrush, C., Privratsky, A., Beck, W. C., Taylor, J. R., Davis, B., Kimbrough, M. K., Jensen, H. K., Robertson, R. D., & Bhavaraju, A. (2020). Hemorrhage-Control Training in Medical Education. *Journal of Medical Education and Curricular Development*, 7. https://doi.org/10.1177/2382120520973214

Hoyme, D. B., & Atkins, D. L. (2017). Implementing Cardiopulmonary Resuscitation Training Programs in High Schools: Iowa's Experience. *The Journal of Pediatrics*, *181*, 172-176.e3. https://doi.org/10.1016/j.jpeds.2016.10.037

Inaba, K., Siboni, S., Resnick, S., Zhu, J., Wong, M. D., Haltmeier, T., Benjamin, E., & Demetriades, D. (2015). Tourniquet use for civilian extremity trauma. *Journal of Trauma and Acute Care Surgery*, *79*(2), 232–237. https://doi.org/10.1097/ta.0000000000000747

Latuska, K. M., Graf, R. L., Zwislewski, A., Meyer, L. K., & Nanassy, A. D. (2019). Stop the bleed training improves knowledge, skills, and confidence among school nurses. *The Journal of Continuing Education in Nursing*, *50*(11), 501-507. https://doi.org/10.3928/00220124-20191015-06

Lauffenburger, J. C., DiFrancesco, M. F., Barlev, R. A., Robertson, T., Kim, E., Coll, M. D., Haff, N., Fontanet, C. P., Hanken, K., Oran, R., Avorn, J., & Choudhry, N. K. (2022). Overcoming decisional gaps in High-Risk prescribing by junior Physicians using Simulation-Based Training: Protocol for a randomized controlled trial. *JMIR Research Protocols*, *11*(4), e31464. https://doi.org/10.2196/31464

Lei, R., Swartz, M. D., Harvin, J. A., Cotton, B. A., Holcomb, J. B., Wade, C. E., & Adams, S. D. (2019). Stop the bleed training empowers learners to act to prevent unnecessary hemorrhagic death. *The American Journal of Surgery*, *217*(2), 368-372. https://doi.org/10.1016/j.amjsurg.2018.09.025

Martinerie, L., Rasoaherinomenjanahary, F., Ronot, M., Fournier, P., Dousset, B., Tesnière, A., Mariette, C., Gaujoux, S., & Gronnier, C. (2018). Health care simulation in Developing countries and Low-Resource situations. *Journal of Continuing Education in the Health Professions*, *38*(3), 205–212. https://doi.org/10.1097/ceh.0000000000000211

Nitin, K., Tetali, S., Ramachandra, G., Kanagala, M., Puppala, S., Ram, S., & Nadkarni, V. (2022). Are High School Students Ready to Stop the Bleed from Injuries? Needs Assessment in a Low Resource Country. *Open Journal of Epidemiology*, *12*(03), 317–328. https://doi.org/10.4236/ojepi.2022.123026

Parry, N. G. (2021). Stopping extremity hemorrhage: More than just a tourniquet. *Surgery Open Science*, *7*, 42–45. https://doi.org/10.1016/j.sopen.2021.11.003

Passos, E., Dingley, B., Smith, A., Engels, P. T., Ball, C. G., Faidi, S., Nathens, A. & Tien, H. (2014). Tourniquet use for peripheral vascular injuries in the civilian setting. *Injury*, *45*(3), 573-577. https://doi.org/10.1016/j.injury.2013.11.031

Pringle, K., Mackey, J., Modi, P., Janeway, H., Romero, T., Meynard, F., Perez, H., Herrera, R., Bendana, M., Labora, A., Ruskis, J., Foggle, J., Partridge, R., & Levine, A. (2015). "A short trauma course for physicians in a resource-limited setting: Is low-cost simulation effective?" *Injury*, *46*(9), 1796–1800. https://doi.org/10.1016/j.injury.2015.05.021

Sidwell, R. A., Spilman, S. K., Huntsman, R. S., & Pelaez, C. A. (2018). Efficient hemorrhage control skills training for healthcare employees. *Journal of the American College of Surgeons*, *226*(2), 160-164. https://doi.org/10.1016/j.jamcollsurg.2017.11.003

Smith, E. R., Shapiro, G., & Sarani, B. (2018). Fatal wounding pattern and causes of potentially preventable death following the pulse night club shooting event. *Prehospital emergency care*, *22*(6), 662-668. https://doi.org/10.1080/10903127.2018.1459980

Vattanavanit, V., Kawla-Ied, J., & Bhurayanontachai, R. (2016). High-fidelity medical simulation training improves medical students' knowledge and confidence levels in septic shock resuscitation. *Open Access Emergency Medicine*, *Volume 9*, 1–7. https://doi.org/10.2147/oaem.s122525

Zeineddin, A., Williams, M., Nonez, H., Nizam, W., Olufajo, O. A., Ortega, G., Haider, A., & Cornwell, E. E. (2020). Gunshot injuries in American Trauma Centers: Analysis of the lethality of multiple gunshot wounds. *The American Surgeon*, *87*(1), 39–44. https://doi.org/10.1177/0003134820949515

Zhang, M., Cheng, X., Xu, A., Luo, L., & Yang, X. (2015). Clinical simulation training improves the clinical performance of Chinese medical students. *Medical Education Online*, *20*(1), 28796. https://doi.org/10.3402/meo.v20.28796

Zhao, K. L., Herrenkohl, M., Paulsen, M., Bulger, E. M., Vavilala, M. S., Moore, M., & Pham, T. N. (2019). Learners' perspectives on Stop the Bleed: A course to improve survival during mass casualty events. *Trauma Surgery & Acute Care Open*, *4*(1), e000331. https://doi.org/10.1136/tsaco-2019-000331

Zwislewski, A., Nanassy, A. D., Meyer, L. K., Scantling, D., Jankowski, M. A., Blinstrub, G., & Grewal, H. (2019). Practice makes perfect: The impact of Stop the Bleed training on hemorrhage control knowledge, wound packing, and tourniquet application in the workplace. *Injury*, *50*(4), 864-868. https://doi.org/10.1016/j.injury.2019.03.025

Appendix A

Step by Step Instructions for Model Making

https://docs.google.com/document/d/1g1uH2Q8oV2Al2tNA0EBZ3mXq-aPAFiIREkuwC-PVox4/edit?tab=t.0