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# Prospective Randomized Crossover Study of Telesimulation Versus Standard Simulation for Teaching Medical Students the Management of Critically Ill Patients

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## ABSTRACT

**Objective:** The objective was to evaluate the comparative effectiveness of telesimulation versus standard simulation in teaching medical students the management of critically ill patients

**Methods:** Prospective, randomized crossover study of 32 fourth-year medical students at a university medical simulation center. Students were randomized to the standard simulation (SIM) or telesimulation (TeleSIM) group between September 2014 and February 2015. The SIM group experience included participating in a live, fully immersive simulation case followed by debriefing with their SIM cohort and a live TV Internet connection to the TeleSIM group. The TeleSIM group experience included remotely observing the live simulation case at an off-site location, followed by a shared group debriefing via live TV Internet connection. Subject assessment was performed with a written evaluation tool. During a second instructional session, the students crossed over and participated in a different simulation scenario and assessment. Mean evaluation scores were calculated along with 95% confidence intervals (CIs) and were analyzed via linear regression. Our secondary outcome was a survey evaluating the perceptions and attitudes held between the two simulation modalities.

**Results:** Of 33 eligible students, 32 participated in the study (97.0%). We found no significant difference in the mean evaluation scores of the two groups: SIM group mean = 96.6% (95% CI = 94.5%–98.6%) and TeleSIM group mean = 96.8% (95% CI = 94.8%–98.9%). We also found no significant difference in the favorability of teaching modality (TeleSIM vs. SIM) on the survey.

**Conclusion:** In our prospective randomized crossover study evaluating telesimulation versus standard simulation, we found no significant difference in evaluation scores among the two groups. There was also no significant difference found in the favorability of one teaching modality on a posteducational session survey. Our data support and highlight the capability of telesimulation to provide educational benefit to learners who do not have direct access to simulation resources.

Telesimulation is a new and innovative concept and process by which telecommunication and simulation resources are utilized to provide education, training, and/or assessment to learners at an off-site location.<sup>1</sup> This new delivery method of content via simulation has its origins with the past decade and has seen rapid growth, being implemented in areas such as surgery, anesthesia, pediatric resuscitation, and emergency medicine.<sup>2–9</sup> Although telecommunication and simulation resources have been used in the past to provide distance education, only within the past decade has this term

been used to describe this specific niche in simulation. In 2016, a comprehensive and unifying definition was introduced to the simulation community at the Society for Simulation in Healthcare International Meeting on Simulation in Healthcare.<sup>1, 10</sup>

There are many benefits that telesimulation may provide to both healthcare educators and learners.<sup>1</sup> Telesimulation allows for the education, training, and/or assessment of learners at an off-site location. This simulation delivery method eliminates distance and time barriers to educational content delivery while simultaneously conferring the benefits of simulation beyond the walls of simulation centers. Telesimulation can also provide significant cost savings to individuals, programs, and institutions as well as revenue generation for simulation and education centers.

The benefits that telesimulation may provide in the delivery of educational content is one of the main reasons the simulation education community has seen a rapid rise in its use. However, there is a paucity of literature to support the evidence base for its systematic implementation in educational curricula. The current literature in the area of telesimulation has significant limitations, including (but not limited to) small sample sizes; the utilization of samples that are not representative of the intended target populations; heterogeneity in subjects, interventions, and outcome measures; and study designs that lack methodologic rigor. To our knowledge, there are no prospective randomized controlled studies comparing this new educational delivery method to standard simulation methods. The objective of our study was to evaluate the comparative effectiveness of telesimulation versus standard simulation in teaching medical students how to evaluate and manage critically ill patients.

## METHODS

### Study Design and Setting

We conducted a prospective, randomized, nonblinded crossover study from September 2014 to February 2015 in a simulation center at a University of California medical school. The study protocol is one of several studies being implemented in series at the simulation center multiyear telesimulation collaborative. The UC Irvine Medical Simulation Center is a 65,000-square-foot state-of-the-art medical education center that provides telemedicine and simulation-based educational programs and CME courses for thousands of healthcare providers each year.<sup>11</sup> Resources for education and training include but are not limited to a full-scale operating room, emergency department (ED) trauma bay, obstetrics suite, and a critical care unit. The simulation center has a compliment of full-time staff, including full-time simulation specialists.

### Selection of Participants

All fourth-year medical students enrolled in a required emergency medicine clerkship were eligible. Exclusion criteria were visiting students from foreign countries doing an observation rotation in the ED. These students were excluded, as we wanted to evaluate a sample representative of the population of medical students trained in the United States.

The emergency medicine clerkship rotation includes a simulation component that provides medical students with experience in education and training via simulation.

During clerkship orientation, students were offered voluntary participation in the study. Use of the simulator was not restricted to the study, and results of the study did not affect clerkship evaluation. The study was approved by the university institutional review board and subjects provided informed consent.

### Study Protocol and Measures

Participants were randomized to either the simulation (SIM) group or telesimulation (TeleSIM) group with a computerized random-number generator. After randomization, all students received an equivalent orientation to the human patient simulator (Laerdal SimMan 3G full-scale patient simulator; Laerdal Medical Corporation), which included introducing and reviewing simulator features as well as the physiologic monitoring devices available. Students were instructed to verbalize their thoughts, orders, and actions during the simulated patient scenario. The students were unaware of the simulation case they would manage. Simulation is incorporated into the medical school curriculum and as such all participants were familiar and had previous experience with the simulator.

The SIM group experience included participating in a live, fully immersive simulation case followed by a group debriefing with an instructor/moderator, their SIM cohort, and a live TV Internet connection to the TeleSIM group that was observing their scenario. The TeleSIM group experience included remotely observing the live simulation case at an off-site location, followed by a shared group debriefing with their instructor/moderator, their TeleSIM cohort, and a live TV Internet connection to the SIM group that participated in the scenario. Each scenario session, including high-fidelity simulation and debriefing, was carried out in a 60-minute time block.

The crossover study design allowed each participant to serve as their own control, experiencing one case with SIM training and another case with TeleSIM training. The two cases implemented in the protocol included a scenario on cardiac arrest from ventricular fibrillation and a scenario on anaphylaxis. The simulation case used for evaluating participants management of cardiac arrest was adapted from the American Heart Association ACLS SimMan scenarios set along with the latest updated ACLS guidelines during time of instruction.<sup>12</sup> The simulation case used for evaluating anaphylaxis was adapted from an anaphylaxis scenario used in a previously published randomized controlled trial evaluating the effectiveness of simulation training for teaching medical students the management of anaphylaxis.<sup>13</sup>

### Measures

The main outcome measure was a written evaluation tool to assess the learner's comprehension of the educational material delivered after their simulation session. The evaluation tool was designed to assess clinically relevant knowledge that would allow a healthcare provider to effectively manage a patient in the clinical setting. Owing to the fact that telesimulation is a new niche in simulation and this study is the first of its kind, there are no validated tools available in this area of simulation. In the absence of any validated tools available, we created a tool that was based on national and international guidelines pertaining to each scenario topic. The evaluation tool for the ventricular fibrillation scenario was based on the latest American Heart Association ACLS

guidelines available during time of instruction.<sup>12</sup> The evaluation tool for the anaphylaxis scenario was based on the National Institute of Allergy and Infectious Disease and Food Allergy and Anaphylaxis Network symposium on the definition and management of anaphylaxis. The definition devised at this symposium forms the basis of the current definition of anaphylaxis used in medicine today.<sup>15</sup>

Our secondary outcome was a survey evaluating the perceptions and attitudes the participants had toward their experience with standard simulation and telesimulation. The survey was distributed after their simulation session and individual evaluations were complete.

#### Data Analysis

We calculated a sample size of 30 subjects needed in this prospective randomized crossover study to have a power of 80% for detecting an effect size of three percentage points between outcome measures on TeleSIM training versus SIM training. Mean evaluation scores of the groups were calculated (point estimates) along with 95% confidence intervals (CIs) and were analyzed via linear regression, conditional on the student and controlling for simulation case. Survey data were reported as percentage of favorable responses to specific survey questions according to training modality (TeleSIM vs. SIM). A two-tailed alpha (type I error rate) of 0.05 was used as the threshold for statistical significance.

## RESULTS

Of 33 eligible subjects, 32 participated in the study (97.0%). We found no significant difference in the mean evaluation scores between the two training modalities. The SIM group had a mean score of 96.6% (95% CI = 94.5%–98.6%) and the TeleSIM group had a mean score of 96.8% (95% CI 94.8%–8.9%; Table 1). The odds ratio for the SIM group having a higher evaluation score was 0.82 (95% CI = 0.29–2.26).

We also found no significant difference in the favorability of teaching modality (SIM vs. TeleSIM) on the survey. Regardless of training modality (SIM vs. Tele-SIM), the learners reported that this type of simulation was an effective learning tool that was beneficial to their education and would enhance their ability to provide care for patients in the clinical setting. The learners also shared similar favorability responses to the belief that this simulation experience deepened their insight into patient care and added educational value above and beyond learning from standard lectures (Figure 1).

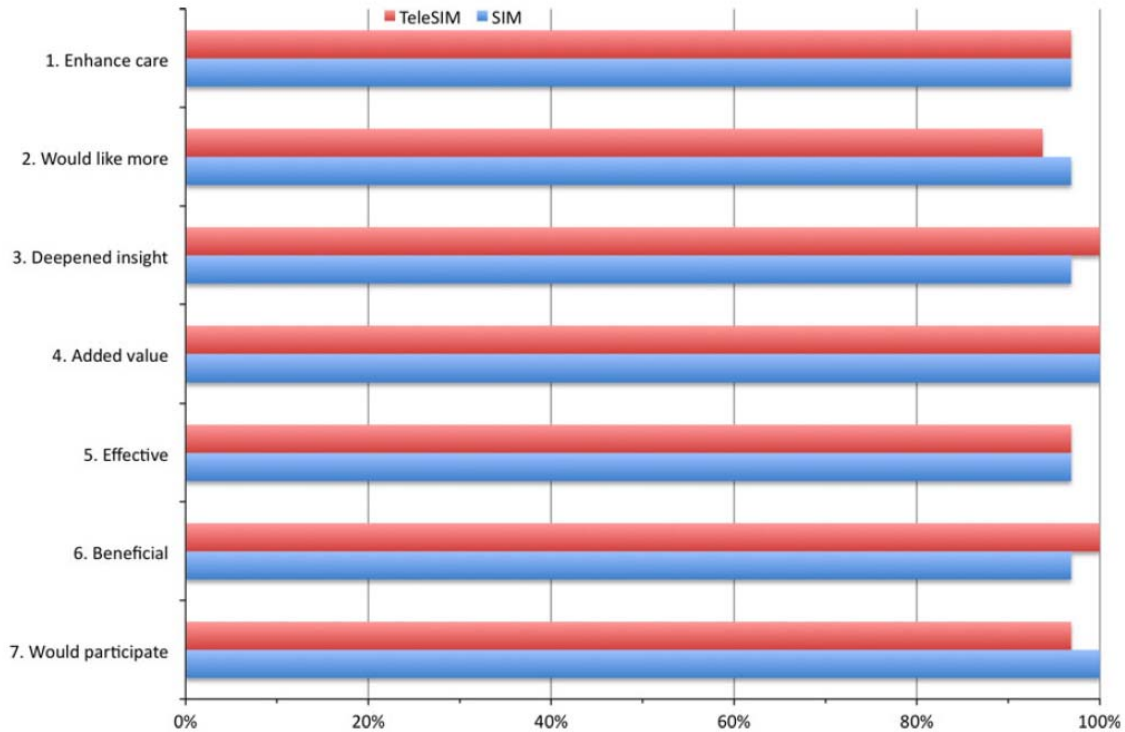


Figure 1. Percentage of favorable responses according to training modality. Survey questions: 1) I believe this type of simulation will enhance my ability to provide care for patients in the clinical setting; 2) I would like this type of simulation to be a larger component of my medical education; 3) I believe this type of simulation deepened my insight into patient care; 4) I believe this simulation experience added educational value above and beyond my learning from standard lectures; 5) I believe this type of simulation is an effective learning tool; 6) This type of simulation was beneficial to my learning; 7) I would participate in this type of simulation session in the future. SIM = standard simulation group; TeleSIM = telesimulation group.

Table 1  
Mean Scores (%) According to Training Modality

Training Modality	Mean Score	95% CI
TeleSIM	96.8	94.8–98.9
SIM	96.6	94.5–98.6

SIM = standard simulation group; TeleSIM = telesimulation group.

## DISCUSSION

In our prospective randomized crossover study evaluating the comparative effectiveness of telesimulation studies evaluated the use of telesimulation for the

performance of a specific task, such as intraosseus line insertion. Procedural tasks fall within the psychomotor domain of learning. Our content focused on teaching the evaluation and management of a patient presenting with a critical condition that requires complex decision making in a relatively short period of time, which falls within the cognitive domain of learning.

Our study extends the findings of previous nonrandomized studies evaluating the effectiveness of telesimulation within the cognitive domain of learning in the field of critical care medicine. In a study using telesimulation to provide transatlantic medical education with high-fidelity simulators, the authors exposed trainees to emergency scenarios with a remote expert providing instruction and found overwhelming satisfaction scores with the simulation-based distance training even when access to the simulator was only remote.<sup>17</sup> The authors concluded that simulation-based distance medical training proved to be a highly effective tool in improving emergency medical skills of junior physician trainees and that international simulation-based training may ultimately provide the most realistic platform for largescale training of emergency medical personnel in less developed countries and in rural/remote regions of the globe.<sup>17</sup> In a military study using a quasi-experimental study design to assess the efficacy and feasibility of training isolated emergency medical personnel at a Naval Hospital in Puerto Rico, the authors report that perceived preparedness and self-efficacy improved overall and for each of the scenarios in the course provided.<sup>18</sup> The authors concluded that off-site training was feasible and that human patient simulation improves perceived preparedness and self-efficacy in U.S. Navy emergency medical personnel and that simulation and distance education allows isolated medical personnel the opportunity to practice skills unconstrained by time or distance.<sup>18</sup>

Our secondary outcome was a survey evaluating the perceptions and attitudes the participants had toward their experience with standard simulation and telesimulation. We found no significant difference in the favorability of teaching modality (SIM vs. TeleSIM) on the survey. Regardless of training modality (SIM vs. TeleSIM), the learners reported that this type of simulation was an effective learning tool that was beneficial to their education and would enhance their ability to provide care for patients in the clinical setting.

We believe that our findings support the notion that the benefits of simulation can be conferred to learners beyond the walls of simulation centers with regard to content that falls within the cognitive domain of learning. This belief is consistent with and supported by the educational theoretical models that underpin high-quality simulation-based training. Experiences, either real or simulated, serve as a catalyst for learning, which occurs during the reflection and debriefing that follows each experience. The process of having an experience (concrete experience), reflecting on that experience (reflective observation), developing mental models that drive behavior (abstract conceptualization), and then testing that mental model (active experimentation) is based on what is known as Kolb's experiential learning cycle.<sup>19,20</sup> Providing educational experiences to learners at off-site locations can be accomplished with telecommunication and simulation resources, as the theoretical models that serve as the foundation for effective simulation training do not require the student and instructor to physically be in the same location.

## LIMITATIONS

Our study did not evaluate the educational intervention on actual patients in cardiac arrest or anaphylactic shock. As such, our study shares the limitation of educational interventional studies with outcome metrics not specifically measuring actual patient data. To our knowledge, there are no studies in existence implementing the educational modality we studied with the main outcome measured on real patients. Owing to the fact that telesimulation is a new niche in the field of simulation, there are currently no validated measurement tools to evaluate the phenomena of interest under study, the students' demonstrable knowledge base and skill set in managing critically ill patients in the specific content area chosen. In light of the absence of any available validated tools, we chose to measure knowledge within the cognitive domain of learning that was created and based on national and international guidelines with specific regard to our chosen content area (cardiac arrest and anaphylaxis). And finally, the very nature of telesimulation precludes the ability to blind the learner or instructor to the educational delivery method implemented.

## CONCLUSION

In our prospective randomized crossover study evaluating the comparative effectiveness of telesimulation versus standard simulation for teaching medical students the management of critically ill patients, we found no significant difference in evaluation scores among the two groups. There was also no significant difference found in the favorability of one teaching modality on a posteducational session survey. Our data support and highlight the capability of telesimulation to provide educational benefit to learners at off-site locations who may not have direct access to simulation resources.

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