

Simulation in Medical School Education: Review for Emergency Medicine

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Supervising Section Editor: Christopher Kang, MD

Submission history: Submitted March 17, 2010; Revision received August 3, 2010; Accepted October 18, 2010

Reprints available through open access at http://escholarship.org/uc/uciem_westjem

DOI: 10.5811/westjem.2010.10.1909

Medical education is rapidly evolving. With the paradigm shift to small-group didactic sessions and focus on clinically oriented case-based scenarios, simulation training has provided educators a novel way to deliver medical education in the 21st century. The field continues to expand in scope and practice and is being incorporated into medical school clerkship education, and specifically in emergency medicine (EM). The use of medical simulation in graduate medical education is well documented. Our aim in this article is to perform a retrospective review of the current literature, studying simulation use in EM medical student clerkships. Studies have demonstrated the effectiveness of simulation in teaching basic science, clinical knowledge, procedural skills, teamwork, and communication skills. As simulation becomes increasingly prevalent in medical school curricula, more studies are needed to assess whether simulation training improves patient-related outcomes. [West J Emerg Med. 2011;12(4):461–466.]

INTRODUCTION

Currently, medical schools and their curricula are reflective of the current trend to use simulation as a teaching tool for evaluating and training their students.^{1,2} Emergency medicine (EM), in particular, also uses simulation to evaluate and train their residents and faculty members, as well as medical students. Although simulation is widely used in medical education, notable variation is found in the modalities used at different institutions and within different specialties. Furthermore, limited research has been conducted to explore the prevalence and types of simulation being used in EM clerkships. Our aim in this article is to perform a retrospective review of the current literature, studying simulation use in EM medical student clerkships. We performed a systematic literature search for relevant articles to provide a concise review of the literature.

Types of Simulation

Currently the types of simulators available for medical education are vast and varied, but most can be categorized as

standardized patients, partial-task trainers, mannequins (high-fidelity patient simulators), screen-based computer simulators, and virtual-reality simulators.

Standardized patients are actors trained to simulate various symptoms, give medical histories, and display various emotions during a medical examination. Partial-task trainers are a type of simulator used to teach specialized skills, such as intravenous placement, central-line placement, endotracheal tube placement, or other high-risk/low-prevalence procedures. Although standard criteria for distinguishing between high- and low-fidelity simulators have not been firmly established, these trainers are classified as low to high fidelity, according to how closely they imitate the circumstances under which the skill is typically performed.

The full-body robot mannequin is simply a “man-made man”: a high-fidelity simulator that mimics certain medical conditions by producing various signs and vitals generated by a computer managed by an individual behind the scenes.³ Screen-based simulation presents different clinical scenarios to

students on a computer screen. The student interacts with the virtual patient and, depending on the program, proceeds to obtain a history, direct the physical examination, and then evaluate and manage the patient's case. Virtual reality has become a ubiquitous and relied-on method of training for surgical fields, such as general surgery, ear, nose, and throat, and orthopaedics. This tool shows 3-dimensional images of organs and anatomy to help in training and preplanning the surgeries.

Support for Use of Simulation in Medical Education

Studies thus far show that use of simulation in training medical students and residents is helpful in strengthening students' knowledge base and in evaluating their performance.⁴ Students appreciate simulation-based education as "an opportunity to learn new skills in a safe environment."⁵ Use of simulation at the very beginning of the undergraduate medical curriculum has been shown to improve understanding of basic concepts of medical science, such as pharmacology and physiology, presumably because these simulated experiences help students to understand abstract concepts of basic science that are difficult to perceive with regular discourse.⁶⁻⁹

Several different medical disciplines have conducted studies to evaluate the efficacy of simulation in training residents and students in their particular field. Anesthesiology has been a forerunner in adopting simulation in the form of mannequins and screen-based simulators, by using them extensively for resident and faculty practice in endotracheal intubation, mask ventilation, and cricothyrotomy.^{10,11} Simulation in the field of obstetrics has been used to teach residents how to manage obstetric emergencies and how to recognize and avoid the pitfalls in managing difficult deliveries.¹²⁻¹⁴ Numerous studies conducted in the field of surgery have supported the efficacy of virtual reality as a method of training residents in operating room procedures such as cholecystectomy.^{15,16}

Although these studies were performed in fields other than EM, many of the skills taught and assessed, such as intubation, are also used in EM. Confirmatory studies within EM that repeat the studies performed in these other fields would provide more evidence that may support the expanded use of simulation beyond its current uses in EM.

Simulation in Emergency Medicine

EM, though a relatively young field, has been quick to join its colleagues in adopting simulation technology; however, most available studies have investigated simulation use in training residents, not medical students. The Society for Academic Emergency Medicine (SAEM) Simulation Task Force was established in 2005 to promote awareness in the field of EM of developments in this valuable technology.

A 5-year study by Okuda et al¹⁷ (2003-2008) on the growth of simulation training in EM residency programs showed an increase in the use of simulators for training

residents. Of the 134 EM residency programs that participated in the study, 122 (91%) programs used some kind of simulation equipment to train their residents. Notably, 58 (43%) programs documented that they used more than 10 hours of simulation per resident. The programs used simulation as a tool for teaching and assessing the residents and for training them in the areas of professionalism (59%) and teamwork (75%). Thus, simulation in EM has proved useful in both the academic and professional spheres of residency education. A 2006 review by McFetrich¹⁸ also supports this type of simulation training in EM, documenting that programs using these methods showed significant improvement in emergency airway management and surgical airway management of pneumothorax, as well as significant improvement in ethics application and team performance.

Several other studies indicate improvement in EM residents' efficiency after simulation-based training. In a study conducted by Langhan et al,¹⁹ residents were educated about critical resuscitation procedures by using simulators. The evaluation process consisted of 2 stages, 1 immediately after 8 hours of simulation, and the other, after 3 months. The residents showed improvement immediately and continued to demonstrate benefit after the 3-month washout period. Another study conducted with EM residents in 2008²⁰ demonstrated the efficacy of high-fidelity simulators in both summative and formative resident evaluation.

Simulation-based training has been used to teach advanced cardiac life support to medical students, residents, and paramedics.²¹⁻²⁴ In a study by Small et al,²⁵ high-fidelity simulation was used to introduce EM physicians to multiple patient scenarios. This type of simulation was shown to improve team coordination, leadership, and patient safety and also to decrease liability.

Although these and multiple additional studies support the assertion that simulation is a valuable tool in the training and assessment of EM residents, the body of literature supporting simulation use in EM undergraduate medical education is far from robust. In 2007, the SAEM Simulation Task Force published a research agenda²⁶ suggesting a wide variety of possible areas of research, including further exploration of the use of simulation in undergraduate medical education.

Simulation in Emergency Medicine Undergraduate Education: Literature Review

Whether in response to this published research agenda or simply by the natural thrust of a shared curiosity among academic EM physicians, more studies have been published in recent years on the use of simulation in EM clerkships. A literature search on PubMed using "education," "simulation," and either "clerkship, rotation, undergraduate education, or fourth-year medical students" in the "any field" search criteria yielded results showing a steady increase in published articles on this subject. After removing duplicate results but before reviewing the articles to confirm their relevance, the

cumulative results showed 2 articles published from 1988 through 1990, 1 article from 1991 to 1995, 4 articles from 1996 to 2000, 8 articles from 2001 to 2005, and 31 articles from 2006 to 2010. Many of these studies, on further inspection, had included medical students among the subjects used to evaluate a simulation modality or were studies using nursing or pharmacy students, and thus did not provide useful information for the purposes of this review. Further searches on PubMed and Web of Science to seek out more articles used the aforementioned search terms, as well as “simulator” in the place of “simulation,” “emergency department” in the place of “emergency medicine,” and “medical students” in the place of “fourth-year medical students.” The articles found in these searches that specifically pertain to medical student instruction or evaluation in EM clerkships are discussed subsequently.

A number of recent studies into the use of simulation in EM clerkships surveyed students on their perceptions of the educational quality of a simulator after instruction in using the simulator. In a study by Takayesu et al²⁷ in 2006, undergraduate medical students (n = 95) in internal medicine, surgery, and EM clerkships volunteered to participate in a 2-hour session of simulation training in the management of several acute scenarios. Afterward, the students were given the opportunity to assess qualitatively the value of the exercise. Ninety-four percent rated the simulator exercise “excellent,” and 91% suggested that the exercise be made a mandatory part of the curriculum.

In 2009, a prospective cohort study conducted at Loma Linda University²⁸ incorporated simulation into a training session of medical students to manage resuscitation during severe shock and sepsis. The students appreciated the teaching method and also reported that it gave a boost to their confidence level to handle similar cases in the future. Another study conducted in 2007 evaluating the efficacy of simulation training for undergraduate medical education²⁹ received a good response from the participating medical students. In this exercise, 41 students underwent interactive simulator training in a simulator laboratory to learn the basic management of a thoracic injury in the ED. After a 30-minute training session, the students showed a significant increase (about 14%) in knowledge level and preferred the use of simulation to traditional didactics.

Other studies have evaluated the educational efficacy of simulation by comparing student performance after simulation use with student performance after training by using more-traditional instructional methods. A comparative study conducted at University of California, Los Angeles,³⁰ compared problem-based learning (PBL) with simulation for efficacy in teaching fourth-year medical students the management and assessment of critical patients. This randomized control study with 31 subjects showed a greater

transfer of knowledge in the simulator-educated students compared with the PBL students.

A study conducted by Ten Eyck et al³¹ showed how including simulation in the EM curriculum improved medical student performance and satisfaction. The randomized control study consisted of 91 fourth-year medical students divided into 2 groups. The first group was exposed to simulation cases for 2 weeks and then crossed over to join the second group in discussions of sample cases. At the end of 4 weeks, both groups were tested for number of questions answered correctly and assessed for student satisfaction. Students from the simulation arm scored significantly higher than students in the case discussion-based training. Although students found the simulation exercise stressful, they preferred it to case discussions, stating that they found the approach safe and appropriate for their level.

Published in the *Canadian Journal of Emergency Medicine*, Franc-Law et al³² compared traditional didactic lecture plus disaster medical simulation to didactic lecture plus nondisaster simulation. Twenty-two students were divided into 2 groups, and then evaluated after the training. Performance of the students in the intervention group was significantly better than the control (nondisaster scenario) group. Subsequently, the students rated the simulation training highly (8 of 10 on a Likert scale) on satisfaction in preparing them for disaster management.

A randomized crossover study in 2007 by McCoy et al³³ evaluated the performance of 28 fourth-year medical students in the management of myocardial infarction (MI) and anaphylaxis after training with a human patient simulator (SIM) or a PowerPoint lecture (LEC). Half of the students were taught about MIs via LEC, whereas the other half learned on SIM, and then the students switched learning modules for instruction on anaphylaxis. Twenty-seven of the 28 subjects demonstrated better assessment and management skills after the SIM instruction in comparison to the LEC instruction.

Not all of the available research supports the assertion that simulation instruction is more effective for undergraduate medical education. A study performed by Schwartz et al³⁴ in 2005 assessed the performance of fourth-year medical students after a month of instruction during their required EM clerkship by using either a Human Patient Simulator (HPS) or Case-based Learning (CBL) modules. The students were randomly assigned to either the CBL (n = 52) or HPS (n = 50) groups, and each group was taught a chest-pain curriculum. At the end of the month, all of the students took the same examination evaluating their knowledge. The groups were analyzed and determined to have no significant differences in gender, age, or specialty preference. A multivariate analysis of variance showed no significant difference in student performance on the examination between the HPS or EBL groups.

A randomized control study by Gordon et al³⁵ used pretest and posttest evaluation of undergraduate medical students to

compare the educational efficacy of simulation with didactic lecture. Thirty-eight third-year medical students received either MI simulation followed by a lecture on reactive airway disease (RAD), or RAD simulation followed by an MI lecture. Although the students improved their performance from pretest to posttest, no significant differences in performance were found between the students learning via didactic instruction and those taught with the simulation modality.

A study conducted by Graber et al³⁶ investigating how simulator training of undergraduate medical students might affect patient perceptions suggested that simulation may improve patient perceptions of students performing procedures during their EM clerkships. This study surveyed patients (n = 151) after being seen in an ED at a Midwestern teaching hospital on whether they would agree to be a student's first procedure after that student had mastered the skill on simulator training for the following procedures: venipuncture, placement of an intravenous line, suturing the face or arm, performing a lumbar puncture, placement of a central line, placement of a nasogastric tube, intubation, and cardioversion. The results were then compared with those of a prior study regarding patients' willingness to be a student's first procedure without simulation training. Except for intubating and suturing, comparing the 2 surveys showed a higher percentage of patients reporting that they would agree to be a student's first procedure if they knew that the student had already mastered the procedure in simulation.

DISCUSSION

Simulation is touted as one of the most important teaching tools for medical curricula and has revolutionized how medical-science concepts are delivered to students.⁵ However, the available evidence on utility is still weak, and randomized controlled studies comparing currently used educational modalities with simulation training in undergraduate medical education are still needed to determine the most effective approach. The studies conducted thus far involving the use of simulation for education of undergraduate medical students in EM clerkships either assess approval by students, compare the educational efficacy of simulation versus didactic lecture, or, as shown by Graber et al,³⁶ explore benefits such as patient satisfaction. Although the superior efficacy of simulation for instruction of medical students over other modalities such as didactic lecture or problem-based learning has been supported in several low-powered studies, other similar studies, although demonstrating the equivalent utility of simulation, have not shown simulation to have superior efficacy. Perhaps simulation provides better instruction for certain tasks, such as professionalism and technical skills, whereas didactic or problem-based learning teaches patient assessment and treatment algorithms more effectively. Stratifying the simulation efficacy studies based on the task the simulator is

intended to teach or assess could elucidate the value of simulation for the instruction of specific tasks. This would provide invaluable information to future simulation designs and to the development of highly effective curricula for undergraduate medical education. Decisions on the application of simulator modalities for education in EM clerkships will continue to be based on sparse evidence, anecdotal support, and speculation until more studies are conducted to expand the body of literature, increasing the strength of evidence, and allowing a stratification of the studies.

Academic inquiry into the efficacy and popularity of simulation in EM clerkships has clearly increased greatly over the past decade, as demonstrated in the literature search. However, a need remains for documentation of the current state of simulation use in EM clerkships nationwide. Determining the prevalence of simulation use in EM clerkships, the types of simulators used, and the specific purposes the simulators fulfill in training or evaluating the students may provide a starting place for investigators to design studies that will prove the most relevant to EM clerkship directors and other educators.

As we embrace simulation-based medical education as a valuable tool for training and assessing medical students and residents, we need research into the impact of simulation on patient care, safety, and satisfaction, with only a few positive studies showing improvement in patient-care outcomes.^{37,38} Only after sufficient analysis of the impact of simulation on patient care can we fully advocate its further incorporation into medical curricula and recommend it for teaching purposes.

CONCLUSION

The use of simulation in EM clerkships has resulted in significant improvements in student knowledge, management skills, confidence, and satisfaction with the rotation. Future studies are needed to determine the efficacy of simulation training in medical student education in comparison to more traditional modalities and the influence of this training on patient care. Although different institutions will have different resources to bring to bear for undergraduate medical student education, based on this review, the allocation of some resources and the inclusion of some level of medical simulation seems prudent.

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Conflicts of Interest: By the WestJEM article submission agreement, all authors are required to disclose all affiliations,

funding sources, and financial or management relationships that could be perceived as potential sources of bias. The authors disclosed none.

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