Simulation-Based Medical Education in Pediatrics

Joseph O. Lopreiato, MD, MPH; Taylor Sawyer, DO, MEd

From the Uniformed Services University of the Health Sciences, Bethesda, Md (Dr Lopreiato); and University of Washington School of Medicine and Seattle Children's Hospital, Seattle, Wash (Dr Sawyer)
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Address correspondence to Joseph O. Lopreiato, MD, MPH, Uniformed Services University of the Health Sciences, Val G. Hemming Simulation Center, 4301 Jones Bridge Rd, Bethesda, MD 20814 (e-mail: Joe.Lopreiato@simcen.usuhs.edu).
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ABSTRACT

The use of simulation-based medical education (SBME) in pediatrics has grown rapidly over the past 2 decades and is expected to continue to grow. Similar to other instructional formats used in medical education, SBME is an instructional methodology that facilitates learning. Successful use of SBME in pediatrics requires attention to basic educational principles, including the incorporation of clear learning objectives. To facilitate learning during simulation the psychological safety of the participants must be ensured, and when done correctly, SBME is a powerful tool to enhance patient safety in pediatrics. Here we provide an overview of SBME in pediatrics and review key topics in the field. We first review the tools of the trade and examine various types of simulators used in pediatric SBME, including human patient simulators, task trainers, standardized patients, and virtual reality simulation. Then we explore several uses of simulation that have been shown to lead to effective learning, including curriculum integration, feedback and debriefing, deliberate practice, mastery learning, and range of difficulty and clinical variation. Examples of how these practices have been successfully used in pediatrics are provided. Finally, we discuss the future of pediatric SBME. As a community, pediatric simulation educators and researchers have been a leading force in the advancement of simulation in medicine. As the use of SBME in pediatrics expands, we hope this perspective will serve as a guide for those interested in improving the state of pediatric SBME.

KEYWORDS: curriculum integration; mannequin; pediatric medical education; simulation; standardized patients; task trainer

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SIMULATION-BASED MEDICAL EDUCATION (SBME) has been defined as any educational activity that utilizes simulation aides to replicate clinical scenarios.[1] At its most basic, SBME uses simulators, or human beings, to serve as an alternative to real patients, and it provides an educational environment in which educators can create realistic yet well-controlled clinical experiences that simulate real-life patient care. SBME is a form of experiential learning and is thus an excellent homologue to the experiential learning gained during real-life clinical encounters. A recent meta-analysis showed that simulation is a highly effective instructional modality for pediatric education.[2]

Similar to other instructional formats used in medical education (eg, bedside teaching, lectures), SBME is an instructional methodology that facilitates learning. However, a unique aspect of SBME is that the interactions of learners during and after the simulation experience contribute significantly to the final learning gains derived from the experience. To facilitate learning during simulation, the psychological safety of the participants must be ensured.[3] Psychological safety refers to the feeling among learners that it is safe to experiment and to make mistakes as a way to learn. When done correctly, SBME is a powerful tool to enhance patient safety in medicine, including pediatrics.[4] Table 1 provides a brief overview of what SBME is and what it is not on the basis of these premises.

The use of SBME in pediatrics has grown over the past 2 decades. As a result of many factors. Perhaps the most significant is the increasing focus in medicine on patient safety and the ability that SBME provides for trainees to make mistakes and learn from them without the fear of harming patients.[4,5] Another factor is the continued need for skill acquisition and practice in the face of limitations in clinical exposures as a result of duty-hour restrictions. Additional factors include the desire for training program directors to acquire measureable learning outcomes on their trainee's performance and the need to provide just-in-time training. All of these factors have conspired to create an ideal environment for the growth of simulation in pediatrics today.

In this review, we provide an overview of SBME methodologies and review several key topics in the field of SBME. We will highlight the various types of simulators that can be used in pediatric SBME followed by a discussion of several key principles. Then we explore several

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Table 1. Simulation-Based Medical Education

Simulation is…
• A tool for learning.
• A learning event with goals and objectives.
• A safe place to learn.
• A tool to enhance patient safety.
Simulation is not…
• A replacement for clinical experiences.
• Something that just happens.
• A place to belittle or embarrass learners.
• The answer to all our problems.

key principles of effective learning when using simulation methods. Where applicable, we provide references of how these learning methods have been successfully applied to pediatric simulation. Finally, we discuss the future of pediatric SBME and the expected changes that will take place. An important caveat of this report is that there is not a unique pediatric simulation theory that differs in principle from adult or other simulation. Rather, we focus on how the field of pediatric SBME can adapt general simulation principles to the unique contexts found in caring for children.

TYPES OF SIMULATORS USED IN PEDIATRIC SBME

There are 4 types of simulation methods used in pediatric SBME: human patient simulators, task trainers, standardized patients, and virtual reality. These types of simulators should be thought of as tools an educator can use to facilitate learning. As with any educational tool, each type of simulator has unique characteristics that make it beneficial for use to fulfill specific educational objectives or to evaluate clinical competency at various levels.

HUMAN PATIENT SIMULATORS

One of the most commonly used simulation modalities in pediatric SBME is a whole-body human patient simulator. These pediatric simulators are designed to provide an accurate anatomic representation of pediatric patients at various ages, from a premature infant to a young child. Late teen and young adult patients can feasibly be simulated using adult simulators. Modern pediatric simulators can display physiologic signs and physical cues, including variant heart rate; pulse strength; blood pressure; visible cyanosis; visible chest rise; increased work of breathing; adventitial breath sounds; bowel sounds; pupillary constriction/dilation; seizurelike movements; secretions from eye, nose, and mouth; and urination. These various physiologic signs can be remotely controlled by an operator through the use a computer control module or handheld remote. Most pediatric simulators also allow the ability to perform a wide variety of medical procedures including airway maneuvers (bag-valve mask ventilation, intubation, needle cricothyrotomy), various forms of vascular access (intravenous access, interosseous access), and pediatric life support procedures (cardioversion, defibrillation).

Many simulation reports refer to modern computer-controlled simulators as high fidelity. Simulator fidelity has traditionally been used to describe the degree to which the simulator looks, feels, and acts like a human patient.[6] Some experts, however, have suggested more specific terms to describe fidelity, including engineering fidelity, referring to whether the simulation looks realistic, and psychological fidelity, referring to whether the simulator can accurately simulate the critical elements and demand the specific behaviors required to complete a task.[7] When describing computer controlled simulators we prefer the term "high technology" over "high fidelity," as each specific simulator may or may not poses a high degree of either engineering or psychological fidelity. Although some simulation scenarios may benefit from a high-technology simulator capable of displaying many physiologic cues, in most cases, beneficial learning environments can be achieved and learning outcomes demonstrated using simpler low-technology simulators with basic functions, such as the ability to do chest compressions or insert an airway or intravenous line. On the basis of available research, there little evidence to suggest that high-technology simulators provide significant educational benefits over less expensive and low-technology simulators.[6–8] Some evidence suggests that the level of simulation fidelity (engineering, psychological) should be matched to learners' levels along the continuum of training, with low levels of fidelity used for novice and early-stage learners and higher levels applied to scenarios for more advanced learners.[9]

Advances in electronics have led to the development of smaller, more portable human patient simulators that can replicate newborn, infant, and child physiology. Some pediatric-specific examples of learning activities that can now be conducted using SBME include newborn delivery simulations, pediatric cardiopulmonary arrest simulations, and simulations involving diagnosis and evaluation based on physiologic cues provided by the simulator (eg, severe asthma, septic shock, seizure)[10–12] In these scenarios, the simulator creates the focal point of team-based interactions and treatment decisions, as the patient does in real life. The simulator also provides an integrated model upon which medically appropriate procedures can be performed, and the coordination among and communication between team members can be practiced.

Given the complexities of manipulating a modern high-technology simulator, conducting a simulation using this type of device generally requires a specific person assigned to operate it: a simulation operations specialist. Close coordination between the facilitator conducting the simulation and the operations specialist running the simulator is required to ensure that appropriate changes are made to the physiology of the simulator as the simulation progresses. Alternatively, a high-technology simulator can be preprogrammed with specific changes in physiology (eg, heart rate, saturations, blood pressure) driven by participant actions or inactions within a specific span of time (eg, heart rate drops from 100 to 30 bpm over 1 minute if tension pneumothorax is not relieved with needle