INTRODUCTION
Simulation as a teaching and assessment tool has been around for quite some time. For well over three decades, industries requiring high-stakes competency such as the airlines, nuclear power facilities, and the military have been employing simulation.

Many factors have brought simulation to the center stage as a tool for education and assessment involving all aspects of clinical care. First, the increased pressure to correct errors in medicine has led many areas of health care to seek out alternative training methods and practices. This is indicated loud and clear in the Institute of Medicine’s hallmark publication on patient safety, To Err is Human, which made numerous recommendations on looking toward simulation as part of the solution.1

Second, over the past 10 years, technology that allows a fairly realistic representation of human anatomy and physiology has become increasingly more portable, sophisticated, and affordable. Research is beginning to emerge that supports its use.2 Along with the burgeoning technology, there has been concerted effort to determine how best to deploy it cost-effectively and efficiently. One realization is that curricula must be integrated with the deployment of simulation equipment, because the simulators alone have modest value at best.

Finally, the difficulty of placing students in meaningful clinical rotations has become an increasing challenge. This is particularly true in areas that are typically fraught with high liability for hospitals and physicians, such as anesthesia and obstetrical services. Clinical experience in these latter two areas is desperately needed, however, by prehospital care provider students as well as practicing field clinicians in ongoing training. Numerous studies have emerged that highlight concerns over some of the skills practiced by prehospital care providers.3,4 In addition, studies documenting the inability of paramedic programs to provide meaningful clinical exposures have surfaced.4

Simulation as a method is not new to the practice of EMS. Practical skills examinations have long been a part of modern prehospital care assessment, during which a clinical scenario is re-created and a trainee performs a skill or demonstrates the thought process in its management. Such an examination represents a form of simulation.

What is relatively new is the technology that allows for a preprogrammed re-creation of encounters with patients. Life-like replicas of humans with the computerized ability to alter vital signs and other physical examination findings and that enable procedures to be performed allow cases to be brought to life. This affords the opportunity for trainees to learn and demonstrate competence. There has been a steady trend of increasingly sophisticated equipment, along with substantial improvements in fidelity and cost.

The newer generation of equipment provides for scenarios to be created in a dynamic format that allows the simulator to alter its clinical presentation in response to the treatment being rendered by the trainee or trainees. Before such dynamic patient simulation existed, practical examinations of psychomotor skills ended with the trainee performing the procedure. By implementing simulation to assess psychomotor competence, one can also evaluate cognitive skills and decision-making. For example, if a trainee is attempting to place an endotracheal tube, the physical examination of the patient simulator can be manipulated to make it impossible because of airway swelling. The scenario can then facilitate the assessment of the student’s analysis of the situation and action taken to mitigate the situation. Simultaneously, an assessment...
of the psychomotor skills involved in the airway management procedures can be made.

In response to some of the factors discussed above, simulation efforts in the training of healthcare providers is increasing at an exponential rate. Research studies attempting to validate, quantify, and study the effectiveness of the use of simulation are beginning to emerge. A recent review\(^3\) published in *Medical Teacher* systemically analyzed 670 journal articles published over 34 years to attempt to guide best practices by addressing the question “What are the features and uses of high-fidelity medical simulations that lead to most effective learning?”

**THE TOOLS OF SIMULATION**

There are varying methods and modalities of simulation that are employed to create successful programs. A variety of levels of sophisticated equipment, moulage techniques, and associated equipment are needed to recreate clinical situations. The environments in which simulation-based programs are conducted vary tremendously. In general, they are selected on the basis of the goals and objectives inherent to the simulation program and are tempered by the human and financial resources available. Simulation equipment that is generally integrated into EMS training programs will be discussed in this section.

High-fidelity patient simulators are computer-controlled devices that resemble human qualities with varying levels of fidelity (see Figure 29.1). Computerized control of physical examination findings such as vital signs, cardiopulmonary sounds, and pupillary reaction are quite common. The examination findings can be altered to respond to the treatment being rendered or the clinical situation that is being re-created. Childbirth, chest tube insertion, needle chest decompression, and transcutaneous cardiac pacing can now be taught with high-fidelity simulators. Many patient simulators have sensing ability to be able to detect the treatment that is being provided and subsequently initiate preprogrammed changes to the physiology as displayed to the student.

Advanced high-fidelity human simulators have the ability to record and collect data reflecting the status of the simulators’ condition as well as data input received from the instructor, to create a historical record of the care that was provided by the trainee. This information is often used to structure and guide the debriefing after the scenario is completed. There are specialized human patient simulators to enhance a particular area of learning, such as the delivery of a neonate.

Partial task trainers are pieces of equipment that allow the demonstration of a psychomotor skill usually limited to one area of human anatomy. Examples of partial task trainers commonly used in prehospital care training include intravenous insertion training arms, chicken legs for demonstrating the placement of an intraosseous line, and standard, noncomputerized airway training heads. Some partial task trainers are computer controlled to allow varying certain parameters of performance to adjust the complexity of the skill, to provide haptic (tactile) feedback to the trainee, or to record performance metrics.

Standardized patients are trained human beings that play the part of a patient and are used in the course of a simulation. This technique is somewhat familiar to the prehospital educator; they are similar to the moulage victims that are often used during disaster-drill training exercises. However, standardized patient training programs have become increasingly more sophisticated and can now incorporate standardized patients, not only as a tool to add to the realism but also to actually participate in the grading and assessment of a simulated encounter. The use of standardized patients in EMS outside of disaster drills is largely uncommon, likely because of the costs associated with the training and maintenance of the program.

Audiovisual equipment with varying levels of capabilities usually is used in simulation exercises.
Sound effects, environmental cues, specialized lighting, and public address systems to control the center’s operations and student flow are quite common. The heart of the simulation center’s audiovisual system lies in the video recording abilities, for capturing the audio and images associated with simulated events. The video capabilities range from simple recordings of the simulated encounter to highly sophisticated tools that capture multiple camera angles, patient physiology information, and data about the performance of the trainee. The debriefing aspect of simulation is a cornerstone of the effectiveness of simulation-based education, and often selected aspects of the video capture will be used to guide the debriefing process.

There are currently no convincing data available indicating how much recreated fidelity is enough. There are varying levels of environmental immersion in use. Examples range from standard training rooms with no environmental stimulus to high-tech mock-ups of ambulances, helicopters, and field situations (see Figure 29.2) involving sound effects and virtual reality–augmented surroundings. Decisions regarding the scope of the simulation are predicated on the goals and objectives of the program as well as available funding. Creative avenues such as designing training areas with modular, convertible training rooms can be used to increase the utility of the space along with containing costs for the overall program.

The locations for conducting simulations vary tremendously. Recently there has been an emergence of dedicated, highly sophisticated simulation centers. Often, they are affiliated with large academic medical centers. Simulation programs can easily be executed in these dedicated centers that are designed and built for the purpose, but the programs can also successfully be employed by retrofitting wherever traditional training programs are held. The advantages of dedicated simulation centers include a dedicated simulation staff for support of such programs as well as the audiovisual recording devices that are incorporated into the infrastructure to facilitate programs.

Many of the large, dedicated centers are associated with academic medical centers, which can limit the availability of such training opportunities on the basis of geographic isolation. This has resulted in the development of highly sophisticated mobile simulation training centers. The mobile center can be taken on the road to areas without a nearby simulation center. Some of the more recently designed mobile units contain simulation equipment as well as classroom space and audiovisual technology that mimics that of large, fixed centers.

**SIMULATION AS AN EDUCATION TOOL**

Simulation can be employed as a powerfully effective learning tool. Whether it is used to reinforce and train the student in skills and decision-making during routine events or to recreate low-frequency, high-stakes events, simulation has many advantages. Well-designed simulation programs provide many of the features described in the Best Evidence in Medical Education (BEME) study. As compared to traditional clinical education methods, simulation brings forth the ability to structure the clinical encounters that trainees experience. Current clinical training methods are inefficient and rely on random opportunity to provide experience to...
the student. Consider an example in which a paramedic student is assigned to the obstetrics ward of a hospital for an eight-hour clinical rotation. During that period, the student might participate in only two or three deliveries, and then possibly only as an observer, depending on the circumstances. The same student could report to a simulation laboratory and perform four normal deliveries, two deliveries with scheduled complications, and the accompanying debriefing for each event in a four-hour block of time.

Team training is another example of an effective use of simulation that is generally not available in the clinical training environment involving real patients. Teams of people can be taught and evaluated on several different parameters. One can teach proper communications skills or teach discrete roles and goals to individual team members. Once the teaching is complete, assessment can commence in a similar fashion. Assessment can evaluate the outcomes based on the function of the entire team or drill down to evaluate each member’s ability to function as part of the team.

Simulation ultimately requires a suspension of disbelief on the part of the student. The re-creation of medical cases can be accomplished with varying degrees of fidelity with commonly available equipment.8 The trainees are asked to set aside the thought that they are performing in an artificial re-creation of the actual clinical environment. With this comes responsibility on the part of the program and its instructors to respect that the trainees are engaging in this manner. It is incumbent upon the instructors to provide the trainees a realistic presentation of the situation along with a safe environment in which to learn, explore, excel, and make mistakes.

Simulation has the unique ability to combine aspects of teaching and assessment. The care of a simulated patient can be rendered under observation, from which data are collected to evaluate the student’s performance. This type of simulated clinical encounter is most often followed by a debriefing that allows for a detailed review of the student’s performance. It serves as a springboard for discussion of related topics. The combination of the student’s performance, debriefing, teaching, and discussion, followed by the trainee’s own reflection, serves as a powerful learning tool. The entire process can be repeated to create mastery through repetitive practice (see Figure 29.3), along with maintaining clearly defined outcomes. This allows more time for some learners while allowing rapid learners to proceed to the next educational challenge.

Simulation can be implemented in a wide variety of ranges to accentuate the learning environment. On one end of the spectrum, computerized simulators can be used as a high-tech visual aid to augment existing lecture material and demonstrate physiological changes that can occur with various disease processes. On the other end of the spectrum, the simulator can be embedded into a teaching and assessment curriculum with which the student interacts and treats as if it were an actual patient. Simultaneously, the simulator and accompanying audiovisual equipment record the events for debriefing, analysis, and historical record.

Computer-based simulators and screen-based programs can be utilized in a self-discovery mode that allows a trainee or group of trainees to interact with an environment in a nonthreatening atmosphere. Students can explore the consequences and potential outcomes of their decisions, treatments, and actions—a

![Figure 29.3 Diagram of Mastery Learning through Repetitive Practice.](image-url)
SIMULATION AS AN ASSESSMENT OF INDIVIDUALS AND SYSTEMS

Taking true advantage of simulation would include using it for assessment-based activities. As mentioned previously, the design of the program can dictate the level of teaching versus assessment, but one must realize this combination is a particular strength of simulation as a tool.

Modern computerized human simulators have built-in data collection capabilities for assessment of the performance in a given scenario. Electronic checklists can be created within the software that allow for recording performance parameters that are desired for measurement but which the simulator cannot automatically sense. For example, if the trainee makes the observation that the “scene is safe,” this information can be entered into a time-stamped log of the performance with the click of a button. In contrast, if the trainee provides an adequate tidal volume mask ventilator, modern simulators are able to sense and record this type of interaction. At the conclusion of the scenario the assembled data file is available, and this can be reviewed as part of the debriefing (see Figure 29.4) and saved as part of the performance history.

When designing an assessment tool to be utilized during simulation sessions, it is important to begin with the end goals in mind. Whether watching a scenario live or reviewing a video of a simulation performance, there is a finite level of variables that can be assessed reliably. The assessment of a particular scenario begins with identifying the goals and objectives for the scenario. From this point, develop a scoring tool to focus chiefly on the main points trying to be achieved during the scenario.

For each assessment point it is important to attempt to provide a high level of detail as to what constitutes a completed vs. noncompleted score.

**FIGURE 29.4 Time-Stamped Output File with Structured Debriefing Comments from the SimMan System.**
This will serve to increase the level of inter-rater reliability that can be achieved. Items that are more global or more open to instructor interpretation will lower the agreement among instructors, thus lowering the reliability of the scenario as an assessment instrument.

Instructor training or calibration is an important component for assessment programs, particularly if the stakes are high (e.g., promotion, retention, or hiring). The instructor involved in the assessment must be trained and must recognize acceptable parameters of performance as well as those that are deemed unacceptable. Instructors must be taught to focus on the goals and objectives of the scenario, because it is easy to get lost in the details of the observation of a simulated clinical encounter. A formal process for instructor training and assessment should be put in place to increase the chances of a highly successful program. Many successful programs have developed instructor warm-up tools that allow assessment of instructors’ ability to record and report the events of a scenario within acceptable parameters.

Simulation has been successfully implemented as part of some systems’ quality assurance programs. Particular cases or situations that have been flagged by a quality assurance process can be recreated. This can afford the medical director or staff an evaluation of crew members, thereby allowing for retraining or perhaps revisiting the adequacy of a protocol for a given event.

Thus far, the discussion of assessment has largely been focused on the performance of an individual in a given scenario. However, simulation also can be employed as a system assessment tool. The measurement tools contained in simulators can be used to evaluate system parameters such as the ability of dispatchers to provide adequate prearrival instructions to lay persons. Other system-level decisions can be evaluated such as ideal crew configurations, as well as interface protocols between first-responder teams and primary arriving EMS units who will be transporting the patient.

In-hospital examples of the use of simulation to evaluate systems include evaluating efficiency of response by the code team to various locations within the hospital, in addition to the impact of various policies and alerting protocols of the team. After maximizing the internal efficiencies of the code team’s response capabilities, hospitals have then used information from mock code drills to determine the most effective places to install emergency equipment such as AEDs.

RESEARCH USING SIMULATION

The use of simulation as a research tool is common. Many prehospital care studies have been carried out using simulation equipment as a surrogate for an actual patient, clinical encounter, or system encounter. Simulation affords the ability to provide a reliable recreation of a clinical encounter, time and time again, thus lending itself well to experimental manipulations. The reliability of the presentation is a key factor, as it helps to control confounding variables on which decision-making is predicated. Investigations into the type of equipment best utilized for a given cohort of providers and of ideal crew configurations have been undertaken. In addition, studies to determine the ideal airway device for a particular system, as well as the effect of implementing simulation training on flight programs, have been published. The effects of fatigue on decision-making and the effect of training over time also have been evaluated.

CHALLENGES FOR THE IMPLEMENTATION AND USE OF SIMULATION IN PREHOSPITAL CARE

There are many challenges to the use of simulation in EMS. The cost of implementation is a prohibiting factor. The infrastructure costs of establishing a successful simulation program can often serve as a barrier to entry. Many successful programs have partnered with academic medical centers and others who have already established programs to help defray the costs.

The cost of the equipment is only one part of the equation, however. The hidden costs of the sustainment of simulation programs are the human resources required for carrying out the instruction. For simulation to be effective, it is best employed as a small-group or individual learning tool. This requires a low faculty-to-student ratio with instructors uniquely qualified and able to teach in the simulation environment.
Successful simulation programs must have a commitment from the leadership of the organization to provide the resources, both human and equipment, to conduct the training programs.

Simulation-based programs require extensive programmatic planning in advance. In addition to the specialized needs of the classroom and laboratory space to conduct the training, equipment may need to be procured and prepared. Often patient simulators need to be preprogrammed with the physiological data to bring the case scenarios to life. For programs that are attempting to employ high levels of environmental fidelity, specialty props, equipment, and personnel may need to be arranged in advance. The amount of preparation involved in simulation-based programs often far exceeds that required for traditional education programs.

The preparation of qualified, competent instructors is one of the major challenges to beginning and sustaining a simulation-based program. Instructors must be specially trained in the methods of simulation, even if they have extensive experience in traditional teaching methods. This is an important point that is often overlooked in the early days of new programs because of the amount of work involved.

Instructor preparation must include an introduction to the technology and logistics involved in the program as well as to the unique environment of implementing simulation-based education and assessment. Instructor programs must ensure the development of small-group facilitation skills and must introduce proper methods of debriefing. Instructor candidates must be made aware of the vulnerability that is often felt by students involved in simulation training and be able to incorporate this information into their debriefing techniques. Rigorous preparation of the instructors will help to ensure maximal effectiveness of the program.

The last and perhaps largest barrier to widespread implementation is maintenance of the status quo and avoiding change altogether. EMS training operations are no different than many areas of medicine, in which members are reluctant to change and are content to resist change. The thought process of defending the methods of the past is no longer acceptable. This is an important reason for existing programs to attempt to engage in research so that simulation can be utilized in the most cost-efficient ways to help to create and maintain a higher level of prehospital care provider training.

THE FUTURE OF SIMULATION

Because of liability issues and the increasing number of prehospital care training programs, clinical training opportunities will become more difficult to find, necessitating increased efficiency. The mandate for excellence in all sectors of medical care, including the prehospital environment, will continue as the public becomes less tolerant of errors and omissions in the provision of health care.

As the technology and fidelity of simulation equipment continue to improve and as incremental decreases in the cost of the equipment occur, embracement of simulation will become more widespread.

Future studies will continue to evaluate the effectiveness of simulation and the role it will play in primary as well as continuing education and in competency assessment and reassessment. This line of investigation will allow us to structure the retraining and recertification process in a far more objective manner in the future.

Simulation will allow for the evaluation of some commonly used, yet unproven, prehospital care practices. This will allow for more objective, evidenced-based deployment of EMS systems, resources, training, and education programs for the next generation.

SUMMARY

Leaders in EMS need to become familiar with the advantages and tools available for educating and assessing prehospital care providers and systems with simulation. Simulation offers the advantages of reliable, reproducible training encounters that can be effectively utilized to teach routine common skills and decision-making along with rare but critical events. Effective use of simulation will incorporate assessment into the program to facilitate mastery learning and measurement of the competence of individuals as well as teams. In addition to the training and assessment of individuals and teams, simulation can be implemented as quality assurance and system analysis tools to assist the medical director and the operational leadership with key information to make better decisions.
REFERENCES


