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Simulation-Based Training for Patient Safety: 10 Principles That Matter

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Abstract: Simulation-based training can improve patient care when factors influencing its design, delivery, evaluation, and transfer are taken into consideration. In this paper, we provide a number of principles and practical tips that organizations in health care can use to begin implementing effective simulation-based training as a way to enhance patient safety. We commend the health care community for their efforts thus far. We hope that the information provided in this paper will encourage thinking beyond the “bells and whistles” of the simulation and bring to light full potential of simulation-based training in health care and patient safety.

Key Words: training, simulation-based training, patient safety

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Simulations are being widely used by the military and aviation communities, likely the largest investors in using simulations for training. Because of its success in training individuals and teams in these sectors, simulation-based training (SBT) is now being used in health care. Specifically, simulations offer a safe and realistic environment in which to learn and practice skills taught and experience mistakes without direct contact with a patient.^{1,2}

One example of a widely documented use of simulation-based team training in the health care setting is in conjunction with Anesthesia Crisis Resource Management Training. Anesthesia Crisis Resource Management is a form of team training adapted from the aviation community^{3,4} that uses crisis management scenarios obtained from critical incidents (e.g., patient complications during surgery and system failures) to train anesthesia teams. These teams practice the knowledge and skills learned in a number of scenarios that are recreated in a high-fidelity simulated environment.

Simulation-based training ranges from low-cost- and low-technology-based settings to high-cost- and high-technology-based settings. For example, low-cost and low-technology manikin

simulators are relatively simple trainers that can be used to teach anatomical procedures (e.g., breast examinations), basic life support (e.g., chest compressions), first-aid procedures, and insertion of intravenous catheters.⁵ An alternative low-cost and low-technology option is the use of standardized patients (SPs or trained individuals who accurately simulate various patient illnesses in a standardized manner⁶) used to train medical students as a part of objective structured clinical examinations. Currently, SPs are used to train functional assessment and communication skills on geriatric patients ready for discharge (e.g., study by Williams et al⁷). Animal models and human cadavers are alternatives for practicing more complicated procedures, for example, aorto-aortic bypass⁸ and intubation,⁹ respectively. Other areas of health care are using technology-based systems such as screen-based simulators to train cardiology and pulmonary medicine diagnoses,⁵ realistic task trainers (i.e., anatomical manikin or simulator) to train acute care setting ultrasound (e.g., study by Knudson and Sisley¹⁰), and virtual reality to train surgical procedures.¹¹ Although there are still many unanswered questions, research indicates that SBT (both high- and low-technology based) has improved performance with actual patients.^{12–14} For example, Simons et al¹⁵ found that the use of SPs (a low-technology-based simulation) is a beneficial tool for developing clinical skills in medical students.

Over the past decade, the popularity of using SBT has grown. However, using simulation as a part of training is not the solution; it takes more than simulation to lead to learning.¹⁶ Simulation-based training should be designed and delivered based on the science of training¹⁷ and learning.^{18,19} There are proven principles available that will help to guide its design, delivery, evaluation, and transfer. Our past experiences and reviews of the health care literature have shown that some SBT programs may be sending mixed messages to participants. For example, while reviewing the crisis (or crew) resource management training literature within the field of health care, we found several training programs that focused on the technical skills needed to operate the simulation, although they stated that their purpose was to improve teamwork skills (e.g., studies by Ellis and Hughes²⁰ and Halamek et al²¹). Such training programs divert the focus of the training, and as such, trainees spend more time learning how to use the simulation rather than learning the teamwork skills the training is said to address.²² Paradoxically, these programs may not be investigating the competencies that they originally meant. One reason for this is that the health care community is lacking guidance on how to design and deliver SBT, which is cause for concern. Several major works indicate

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that more extensive training is necessary but do not provide a framework for how to get there. For example, review of *An Organization with a Memory* refers to the “ambivalent approach to team research and training.”^{23(p1684)} This implies that the focus of training is buried beneath a focus on individual-system dynamics. Although health care professionals realize that training is important, the health care community as a whole (e.g., training designers, managers, and clinicians) has not adequately addressed the methodological issues needed to implement it for effective training.

In attempting to enhance the optimal use of SBT in health care, the purpose of this paper is to help guide the health care community by providing the principles that are critical to SBT’s design, development, implementation, and transfer. In addition, we provide a number of tips that the health care community can use to assist in applying these principles to their organizations. Before we discuss the principles that matter, we first begin with a brief discussion of SBT.

WHAT IS SBT?

Simulation-based training is an instructional strategy that focuses on providing trainees the opportunity to develop required competencies and to receive feedback. This is accomplished by practicing in an environment that simulates actual operational conditions.²⁴ The SBT “life cycle” consists of a number of interrelated and critical stages that assist trainees in learning the requisite competencies (i.e., knowledge, skills, and attitudes [KSAs]), demonstrating proficiency in these competencies through crafted scenarios (i.e., practice), and receiving feedback on performance to improve in the future. We refer the reader to Salas and colleagues²⁵ for a more thorough discussion of SBT because they provide a number of guidelines for SBT to improve patient safety. Here, we seek to expand what has been previously published and to provide practical guidance to researchers and practitioners.

What Principles Matter?

Principle 1: SBT Should Focus on Reinforcing and Promoting the Needed Competencies (i.e., KSAs)

Tips:

- Train competencies, not tasks.
- Conduct a training needs analysis.
- Conduct job/task analysis.
- Conduct a cognitive task analysis to uncover cognitive aspects of the job.
- Use Anesthesia Crisis Resource Management as a guide.
- Develop learning outcomes which will serve as a guide.

Simulation-based training should be more than just a strategy for training a task. It should also be used to train requisite competencies (i.e., KSAs) for performing that task. The first step when designing an SBT program is to identify the critical requirements of the training.²⁶ To determine these requirements, a training needs analysis should be conducted consisting of a person analysis, job/task analysis, and an organizational analysis. First, a person analysis is necessary to specify both who needs to be trained and what they should be trained on.²⁷ Next, a job/task analysis will indicate the job

description (i.e., essential work functions and resources needed), task specifications (i.e., specific tasks that need to be completed), and task requirements (i.e., competencies required). There are a number of techniques available to help uncover the tasks and competencies to be trained including cognitive task analysis²⁸ or team task analysis.²⁹ Once the training needs have been established, training objectives must be specified. From here, the type of simulation can be determined. Simulations can range from high-fidelity simulators to low-fidelity PC-based games to role-playing exercises, and the necessary type is dependent on the goals of training. For example, if the goal of training is to build teamwork skills among trainees, SPs may be effective; however, training more complex skills (such as how to use a new surgical device) will require a higher fidelity trainer that mimics the real world system.³⁰ In addition, the resources available within an organization may also dictate the type of simulation used (i.e., role playing, case studies, and part-task trainers are low-cost alternatives to using full-mission simulators).³⁰

Principle 2: Adopt a Systems Approach

Tips:

- Think about “before,” “during,” and “after” influences on SBT.

For SBT to be successful, it requires more than just a well-designed training program, more than just a simulation. We know what it takes to systematically design an effective training program. However, the training program itself is just 1 piece of the puzzle. Rather, there are a number of factors that are present before, during, and after the training program that affect its success and cannot be ignored. For example, preparing trainees for training (see principles 4 and 5), creating a suitable training environment (see principle 8), and ensuring a rewards system for trainees who transfer what they learned to the actual task environment (see principle 9) will impact training’s effectiveness.

Principle 3: Prepare the Organization for SBT

Tips:

- Pay attention to organizational factors.
- Make sure you have top-level support.
- Send positive messages about simulation.
- Help employees see value of simulation.
- Ensure key players are on board.

Just as you need to prepare the organization for training in general, the same should be done for SBT. It should come as no surprise that organizational factors influence the outcomes of training. The environment in which training takes place is critical (albeit on- or off-site) to guarantee training effectiveness (see principle 8); training therefore should occur only after it has been determined that an organization is ready (i.e., the culture supports training³¹). Preparing an organization for training is more than simply designing the program and recruiting trainees, although they are essential steps. An organizational analysis needs to be conducted to decipher the components (e.g., norms and climate), resources (e.g., equipment), and constraints (e.g., monetary) of the organization that

may support or hinder the training.²⁶ These factors will influence the value that trainees place on training. In addition, an organizational analysis describes the elements within the organization that will facilitate the transfer of training (see also principle 9).

For example, when the organization establishes a climate for learning and sends positive signals to trainees that training matters, it will be more effective (e.g., study by Barling and Zacharatos³²). In addition, these messages must start from the top and spread through all levels of the organization, down to the “sharp end” providers. When physicians are on board with training, they can be especially critical in helping to prepare employees for training, in that it is the physicians who often lead health care teams and help set the tone in the organization.

Principle 4: Set Up Appropriate Presimulation Conditions

Tips:

- Prepare trainees for training through preparatory information.
- Set an appropriate presimulation climate.

Just as a preoperative brief is crucial to a surgical procedure to ensure that all team members are on the same page, so is the presimulation environment to effective SBT. There are 2 main characteristics of the environment that need to be considered: (1) prepractice conditions and (2) presimulation climate.¹⁷ The first characteristic, *prepractice conditions* are aspects of the presimulation environment that help prepare trainees for practice during training. For example, trainees should be provided with as much preparatory information as possible.³³ Preparatory information should include instruction on how trainees will feel, what they will do, and what strategies they can use to help them learn.³⁴ Rall et al³⁵ suggest that presimulation briefings should include the following: (1) an explanation that the session is about learning and not performance assessment, (2) assurances that confidentiality will be maintained, and (3) instructions that making errors is a part of the learning process.

In addition to prepractice conditions, the presimulation climate can also influence training's success. For example, how a training is framed (e.g., remedial or advanced) will influence trainee's motivation and learning.^{36,37} It is also believed that the attendance policy (i.e., voluntary versus mandatory) of the training program will affect the outcomes of training.³⁸ Literature suggests that previous training experience will not only shape the trainees' ability to learn information but will also influence their ability to retain information.³⁹ In other words, making trainees feel comfortable and not threatened by the training environment will be beneficial.³⁵

Principle 5: Ensure Trainee Motivation

Tips:

- Show value of SBT.
- Send positive messages about SBT.

This is the most powerful predictor of learning and transfer.⁴⁰ Motivation is crucial to training. Trainees who are

motivated to learn are not only more likely to actively participate in training but will also seek out further learning opportunities.⁴¹ For example, in 1 study, nurses were more likely to attend continuing professional education courses if they saw value in the training, namely, the course would increase their knowledge and skills, lead to greater job satisfaction, and lead to a greater expectation of promotion.⁴² After the demands of work and home life, the factor most likely to inhibit employees from attending a continuing professional education course was lack of support from employer (i.e., insufficient leave or financial support, lack of recognition, and lack of possibility to transfer learning to the job). When supervisors send the message that training is not important, staff lack the motivation to attend. In other words, if supervisors (who serve as role models in the organization) do not care about the training, trainees will fail to see the value of the training program, thereby leading to a lack of motivation. Similarly, Bartlett and Kang⁴³ found that nurses' perceived access to training, support for training from supervisors, motivation to learn from training, and perceived value of training were positively related to organizational commitment.

Principle 6: Apply Sound Instructional Principles to the Design of SBT

Tips:

- Tailor instructional strategy to learning objectives.
- Present relevant information.
- Demonstrate skills to be learned.
- Match fidelity to task (if possible).
- Provide guided hands-on practice.
- Provide constructive and diagnostic feedback.

As always, science should be used. Regardless of type (e.g., simulation- or classroom-based) or context (e.g., health care or military), training must be designed and developed systematically using what is known about the science of training and learning.^{17,26,44} Each component is foundational to the next—from the specification of training objectives to developing training content and scenarios to diagnosing performance and providing feedback. Lacking 1 component (or when components are not aligned with each other) will affect the outcome of all the others. Furthermore, trainees must be presented with the information needed (e.g., lecture), given a demonstration of what is to be learned (e.g., video) and the opportunity to practice in a realistic environment (e.g., simulation), and provided with constructive and diagnostic feedback on performance (e.g., debriefing and after-action review). Without these, trainees will be less likely to learn the requisite KSAs.

Principle 7: Develop Performance Measures

Tips:

- Create scenarios to elicit the desired KSAs.
- Focus on process measures.

Seek to diagnose KSA deficiencies. Performance measurement (i.e., assessment and feedback) is critical to learning and understanding the effectiveness of SBT.^{44,45} Without it, SBT is merely a simulation. There are 3 criteria for

good performance measurement. First, performance scenarios must be designed a priori (in other words, prescribed) to ensure that the competencies trained are being elicited and can be observed. Specifically, trigger events are embedded within the scenarios requiring trainees to demonstrate what they have learned (e.g., a seemingly stable patient begins to code, requiring the trauma team to be flexible and adaptable to respond effectively). Furthermore, knowing when these trigger events will occur eases the burden on the instructors and/or observers when observing and recording performance.

Second, it is not enough to just measure performance outcomes (e.g., number of errors). Although some simulators offer the capability to collect these data automatically, it does little to tell us why the outcome occurred and how to improve performance in the future. As such, it is also imperative that the processes (e.g., communication and leadership) leading up to those outcomes are measured. We admit that these processes may not always be easy to capture, but the richness of the information gathered will be a vital component to providing trainees with feedback. There are a number of tools available to assist in the collection of process data. For example, targeted acceptable responses to generated events or tasks (TARGETS) is one such methodology that provides a standardized method for observing performance.⁴⁶ Observers use a checklist (which has been calibrated with the scenario's trigger events) to identify whether trainees demonstrated the expected KSAs.

Finally, it is critical to take multiple measurements throughout the simulation. Performance assessment should not only occur at the end of training but throughout its entirety, suggesting continuous assessment. This allows for an accurate picture of what and when processes are occurring, especially when collecting moment-to-moment data. Multiple measurements also allow for observers to identify changes in behaviors over time (in other words, to diagnose if performance is improving within and across simulations).

Principle 8: Set Up the Simulation Environment

Tips:

- Provide the appropriate training setting.
- Provide resources.
- Adequately train the instructors and observers.

Just as trainees and the organization must be prepared for training, so must the simulation environment where the actual training will take place. The SBT may occur on-site at the organization or off-site in a simulation laboratory. Regardless of its physical location, how it is set up will impact training effectiveness. This includes making sure that the setting is appropriate (e.g., proper lighting and spacing) and comfortable for trainees (e.g., seating).⁴⁴ In addition, the simulation environment should be prepared, so trainees have all of the necessary resources (e.g., training materials and equipment). Finally, it is important that the trainers/instructors are trained. Specifically, trainers must be knowledgeable about the material so that they can present the information coherently, encourage participation from trainees, and answer questions. In addition, instructors must be trained on how to provide constructive performance feedback. Rall and colleagues³⁵ suggest that feedback should be

friendly rather than critical by allowing for open discussions, showing alternative strategies and stressing that everyone makes errors. Additionally, an adequately prepared environment reinforces to trainees that the organization values the simulation (see principle 5).

Principle 9: Prepare the Transfer Environment

Tips:

- Create a continuous learning culture.
- Show management support.
- Create opportunities to practice what is learned.
- Provide incentives.
- Reinforce desired behaviors
- Keep sending positive signals.

Just because the simulation is over does not mean that training stops there. Furthermore, just because trainees learned the knowledge and skills does not mean that they will transfer them to the operational environment. As such, the posttraining environment is an important component in fostering the transfer of learned KSAs to the actual job. Critical to this is support from the supervisor (e.g., chief resident and program director) and a climate that fosters the learned behaviors (e.g., studies by Rouiller and Goldstein⁴⁷ and Ford and Weissbein⁴⁸). It is suggested that when trainees perceive a positive transfer climate (e.g., organizational support and continuous learning culture) they will be more likely to apply learned competencies on the job (e.g., studies by Rouiller and Goldstein⁴⁷ and Tracey et al⁴⁹). For example, a continuous-learning culture is one in which the acquisition of knowledge and skills is encouraged, opportunities to demonstrate competencies are provided, achievement is reinforced, and innovation and competition are considered positive attributes.⁴⁹⁻⁵¹ If the purpose of training is to improve patient safety through a reduction in errors, the organization can also support the transfer of training by creating a nonpunitive and voluntary reporting system. This system will allow trainees to report when an error occurs, thus giving the organization the opportunity to observe and diagnose where problems are occurring and thus be enabled to provide feedback to providers on their progress.

Supervisors are a key factor in creating a positive transfer climate. Supervisors can show their support for the transfer of training in several ways. First, supervisors can reinforce the learned behaviors on the job by providing opportunities to demonstrate them—positive reinforcement will lead to repetition.⁵² Reinforcement should also occur soon after the training is completed and the new behaviors are demonstrated. Waiting too long to provide support will deter the trainee from continuing to exhibit the desired behavior. Reinforcement can include verbal praise, monetary reward,⁴⁷ or another form of positive reinforcement. Additionally, when supervisors act as role models on the job by demonstrating the desired behaviors, this will also serve as support for trainees (e.g., always conducting a debriefing after surgery).⁵² The positive messages that both the organization and supervisors send out are imperative for ensuring training effectiveness.

Principle 10: Determine Training Effectiveness

Tips:

- Examine training objectives and link evaluation criteria to them.
- Measure at multiple levels (reactions, learning, behavior, and results).

The simulation is complete, and trainees are back on the job. The question remains: did training work? To determine if the program was effective, organizations must evaluate the training program. To get a complete picture of its effectiveness, a multilevel approach should be taken. Researchers have long studied how to evaluate a training program (e.g., studies by Alliger and Januck,⁵³ Alliger et al,⁵⁴ and Kirkpatrick⁵⁵). According to Kirkpatrick's⁵⁵ typology, training should be evaluated at 4 levels. First, trainee reactions must be evaluated (i.e., did trainees like training? Was training useful?). Next, it is vital to assess learning (i.e., did trainees gain any knowledge and skills from the training? Is knowledge retained? Did trainees' attitudes toward trained concepts change?). Additionally, behaviors require evaluation (i.e., do trainees apply what they learned in a simulation and/or on the job?). Lastly, it is suggested that results be assessed (i.e., did training impact the organization? Was patient safety improved?). Most organizations assess training at the lower levels (i.e., reactions or learning) (e.g., studies by Salas et al^{22,56}). However, to truly understand whether training was effective, it must be evaluated at the higher levels (e.g., behaviors) and not only the lower levels. Salas and colleagues²² conducted a review of the CRM training evaluations conducted in the health care community. These researchers found that trainees liked training and found it useful. However, because of the mixed results reported and a lack of multilevel evaluations conducted, it was difficult to determine whether trainees learned the knowledge and skills and if this learning was successfully transferred to the work or simulated environment. We submit that training evaluation is not easy—it can be labor and resource intensive—but the benefits to the organization in the long term will be worth the effort. Furthermore, we commend those in health care who have taken this first step toward understanding their training program's effectiveness.

CONCLUSIONS

Simulation-based training can improve patient care when factors influencing its design, delivery, evaluation, and transfer are taken into consideration. In this paper, we provide a number of principles and practical tips that organizations in health care can use to begin implementing effective SBT. We commend the health care community for their efforts thus far. We hope that the information provided in this paper will encourage thinking beyond the "bells and whistles" of the simulation and bring to light SBT's full potential in health care.

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