

The Evidence-Base for Using Simulation in Medical Education: Selected Readings and Executive Summary

*Executive summary written by Linda Spillane, MD (for the EBM review to 2003)
Edited by James A. Gordon, MD, MPA (with comments on the selected studies after 2003
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Selected Readings

HISTORICAL EVIDENCE-BASED REVIEW TO 2003—ABSTRACT APPENDED

Issenberg SB, McGaghie WC, Petrusa ER, Gordon DL, Scalese RJ. (2005) Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. *Medical Teacher* 2005 27:1; 10-28

RECENT PROCEDURAL SIMULATION SUMMARY—EXCERPT APPENDED

Gallagher AG, Cates CU. Approval of virtual reality training for carotid stenting: what this means for procedural-based medicine. *JAMA*. 2004 Dec 22;292(24):3024-6.

RECENT TEAM TRAINING SIMULATION STUDY—ABSTRACT APPENDED

Shapiro MJ, Morey JC, Small S, et al. Simulation-based teamwork training for emergency department staff: does it improve clinical team performance when added to an existing didactic teamwork curriculum? *Qual Saf Health Care*. 2004 Dec;13(6):417-21.

RECENT COGNITIVE/KNOWLEDGE SIMULATION STUDY—ABSTRACT APPENDED

Gordon JA, Brown DFM, Armstrong EG. Can a Simulated Critical Care Encounter Accelerate Basic Science Learning Among Preclinical Medical Students? A Pilot Study. *Simulation in Healthcare* 2006 Jan; 1(inaugural): 13-17

The purpose of this selected readings and the executive summary is to satisfy Objective #3a for the Task Force: **Summarize the educational research supporting this teaching technique, and the settings in which it may be used.**

Rather than re-survey the historical literature, the Task Force decided to provide the Board with a recent comprehensive evidence -based review on the topic by Issenberg, et al. The executive summary of that article follows, along with a summary of more recent articles in the fields of procedural medicine, team-training, and cognitive/knowledge acquisition.

EXECUTIVE SUMMARY

With the surge to create simulation centers, one might assume that the evidence supporting the use of simulation for teaching and evaluation is substantial. Although simulation makes sense (practice makes perfect) and has worked in other environments (aviation and nuclear industries) the evidence to support its effectiveness in medical training is limited but growing.

Issenberg, et al , recently published a comprehensive evidence-based review of the simulation literature to address the question, “What are the features and uses of high-fidelity medical simulations that lead to most effective learning?” This article includes a definition of simulation and background information regarding the use of simulation in professional education; a detailed methodology section; and a summary of the findings including a rating of the strength of the evidence. One hundred nine (109) studies were included in the analysis. Ten features of high-fidelity simulation thought to lead to effective learning were identified. Providing feedback to the learner was the most frequently cited benefit of the simulation exercise. Other benefits include the opportunity for repetitive practice; integration into the existing medical curriculum; variability in the range of difficulty; adaptability to multiple learning strategies; ability to capture clinical variation; provision of a controlled environment, encouragement of active individualized learning; use of defined educational goals and outcomes; and the power of validated processes and measures. The authors conclude that high-fidelity simulations facilitate learning. The studies reviewed, however, were noted to be of highly variable quality. As a result, certainty of the outcomes as judged by the reviewers was in the uncertain range greater than 80% of the time. This EBM review is a “must read” to those

interested in educational research on simulation. It will motivate the reader to be rigorous in designing educational research in simulation based upon theory, and emphasizing the attainment of knowledge/learning. In the future it may be possible to complete the cycle and actually link educational outcomes to better patient care.

The JAMA article by Gallagher and Cates details the recent FDA decision to require simulation training prior to certification to perform carotid stenting. It contains a summary of references documenting the efficacy of simulation as a training tool in procedural medicine (particularly for laparoscopic surgery).

The article by Shapiro (a TF member) et al, is recent study on simulation-based team training, suggesting that simulation can play a role in enhancing team performance in emergency medicine.

The article by Gordon (a TF member) et al, is a recent pilot study suggesting that simulation can accelerate the acquisition of cognitive skills and medical knowledge-base.

SELECTED READINGS: ABSTRACTS/EXCERPTS

EBM (ISSENBERG) ABSTRACT:

REVIEW DATE: 1969 to 2003, 34 years. BACKGROUND AND CONTEXT: Simulations are now in widespread use in medical education and medical personnel evaluation. Outcomes research on the use and effectiveness of simulation technology in medical education is scattered, inconsistent and varies widely in methodological rigor and substantive focus. OBJECTIVES: Review and synthesize existing evidence in educational science that addresses the question, 'What are the features and uses of high-fidelity medical simulations that lead to most effective learning?'. SEARCH STRATEGY: The search covered five literature databases (ERIC, MEDLINE, PsycINFO, Web of Science and Timelit) and employed 91 single search terms and concepts and their Boolean combinations. Hand searching, Internet searches and attention to the 'grey literature' were also used. The aim was to perform the most thorough literature search possible of peer-reviewed publications and reports in the unpublished literature that have been judged for academic quality. INCLUSION AND EXCLUSION CRITERIA: Four screening criteria were used to reduce the initial pool of 670 journal articles to a focused set of 109 studies: (a) elimination of review articles in favor of empirical studies; (b) use of a simulator as an educational assessment or intervention with learner outcomes measured quantitatively; (c) comparative research, either experimental or quasi-experimental; and (d) research that involves simulation as an educational intervention. DATA EXTRACTION: Data were extracted systematically from the 109 eligible journal articles by independent coders. Each coder used a standardized data extraction protocol. DATA SYNTHESIS: Qualitative data synthesis and tabular presentation of research methods and outcomes were used. Heterogeneity of research designs, educational interventions, outcome measures and timeframe precluded data synthesis using meta-analysis. HEADLINE RESULTS: Coding accuracy for features of the journal articles is high. The extant quality of the published research is generally weak. The weight of the best available evidence suggests that high-fidelity medical simulations facilitate learning under the right conditions. These include the following: providing feedback--51 (47%) journal articles reported that educational feedback is the most important feature of simulation-based medical education; repetitive practice--43 (39%) journal articles identified repetitive practice as a key feature involving the use of high-fidelity simulations in medical education; curriculum integration--27 (25%) journal articles cited integration of simulation-based exercises into the standard medical school or postgraduate educational curriculum as an essential feature of their effective use; range of difficulty level--15 (14%) journal articles address the importance of the range of task difficulty level as an important variable in simulation-based medical education; multiple learning strategies--11 (10%) journal articles identified the adaptability of high-fidelity simulations to multiple learning strategies as an important factor in their educational effectiveness; capture clinical variation--11 (10%) journal articles cited simulators that capture a wide variety of clinical conditions as more useful than those with a narrow range; controlled environment--10 (9%) journal articles emphasized the importance of using high-fidelity simulations in a controlled environment where learners can make, detect and correct errors without adverse consequences; individualized learning--10 (9%) journal articles highlighted the

importance of having reproducible, standardized educational experiences where learners are active participants, not passive bystanders; defined outcomes--seven (6%) journal articles cited the importance of having clearly stated goals with tangible outcome measures that will more likely lead to learners mastering skills; simulator validity--four (3%) journal articles provided evidence for the direct correlation of simulation validity with effective learning.

CONCLUSIONS: While research in this field needs improvement in terms of rigor and quality, high-fidelity medical simulations are educationally effective and simulation-based education complements medical education in patient care settings.

PROCEDURAL (GALLAGHER) ABSTRACT: (Note: this is a verbatim excerpt from the article): State-of-the-art training in many other high-skill professions, such as aviation, involves virtual reality simulation. First proposed as a method for surgical procedural skills training in 1991 by Satava, [6](#) acceptance of this training approach has been slow partly because of skepticism within the medical community and the lack of well-controlled clinical trials to demonstrate its efficacy. Frequently referred to as virtual reality (VR) training for the operating room (OR), “VR to OR” is the benchmark study for any medical virtual reality simulator. In the last 2 years, 2 such studies have been reported using a prospective, randomized, double-blind design and have shown that residents who were trained using a low-fidelity virtual reality trainer made significantly fewer intraoperative errors than a standard-trained group during the performance of laparoscopic cholecystectomy. [7,8](#) The first of the studies [7](#) showed that virtual reality-trained residents made 6 times fewer intraoperative errors and performed the procedure 30% faster when dissecting the gallbladder from the liver bed. What both trials demonstrated is that a significant part of the learning curve can be acquired through virtual reality training outside the OR. While all of the trainees in these studies were residents, when their videorecorded operative performance was compared with that of experienced attending surgeons, the performance of the trained resident did not differ significantly from that of the attending physicians. That is, the residents had acquired technical skills through training on a virtual reality simulator that approximated those of experienced attending surgeon operators.

TEAMWORK (SHAPIRO) ABSTRACT:

OBJECTIVE: To determine if high fidelity simulation based team training can improve clinical team performance when added to an existing didactic teamwork curriculum. **SETTING:** Level 1 trauma center and academic emergency medicine training program. **PARTICIPANTS:** Emergency department (ED) staff including nurses, technicians, emergency medicine residents, and attending physicians. **INTERVENTION:** ED staff who had recently received didactic training in the Emergency Team Coordination Course (ETCC) also received an 8 hour intensive experience in an ED simulator in which three scenarios of graduated difficulty were encountered. A comparison group, also ETCC trained, was assigned to work together in the ED for one 8 hour shift. Experimental and comparison teams were observed in the ED before and after the intervention. **DESIGN:** Single, crossover, prospective, blinded and controlled observational study. Teamwork ratings using previously validated behaviorally anchored rating scales (BARS) were completed by outside trained observers in the ED. Observers were blinded to the identification of the teams. **RESULTS:** There were no significant differences between experimental and comparison groups at baseline. The experimental team showed a trend towards

improvement in the quality of team behavior ($p = 0.07$); the comparison group showed no change in team behavior during the two observation periods ($p = 0.55$). Members of the experimental team rated simulation based training as a useful educational method. **CONCLUSION:** High fidelity medical simulation appears to be a promising method for enhancing didactic teamwork training. This approach, using a number of patients, is more representative of clinical care and is therefore the proper paradigm in which to perform teamwork training. It is, however, unclear how much simulator based training must augment didactic teamwork training for clinically meaningful differences to become apparent.

COGNITIVE/KNOWLEDGE (GORDON) ABSTRACT:

PURPOSE: To explore whether a simulated critical care encounter can accelerate basic science learning among preclinical medical students. **METHOD:** Using a high-fidelity patient simulator, we "brought to life" a paper case of a myocardial infarction among a convenience sample of first-year medical students ($n=22$ [intervention]). Students discussed the case as part of a routine tutorial session, and then managed the case in the simulator laboratory. Using an identical six-item test of cardiac physiology, students were evaluated immediately after the simulator session and at 1 year ($n=15$). Performance was compared with controls (case discussion but no simulator session) at both baseline ($n=37$) and 1 year ($n=48$). **RESULTS:** Performance among simulator-exposed students was significantly enhanced on immediate testing (mean score 4.0 [control], 4.7 [intervention], $P = .005$). Gains among the simulator cohort were maintained at 1 year (mean score 4.1 [control], 4.7 [intervention], $P = .045$). Multivariable analysis confirmed that the intervention was a significant determinant of performance across time ($P = .001$).

CONCLUSION: Compared with controls in this pilot study, an additional simulation exercise improved immediate performance on a short written test of cardiovascular physiology. Enhanced performance was again seen at 1 year, raising the possibility that the extra teaching session produced accelerated and sustained learning compared with the routine teaching method. Given the preliminary nature of this investigation, further study is required to distinguish transient from lasting effects of simulation versus alternative teaching approaches in the basic medical sciences.