# Millennium Conference 2005 on Medical Simulation: A Summary Report

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**Introduction:** Medical simulation takes advantage of contextual and experiential learning by allowing trainees to practice in realistic environments prior to actual patient care. Although proponents argue that patient simulation can fundamentally enhance both medical education and patient safety, large-scale experience with advanced simulation technologies is limited. To explore expert opinion on the topic, we convened a conference of educational leaders and simulation experts to provide recommendations for how this field should be directed on a broad scale to improve the training of future health professionals. This document summarizes the proceedings of that conference.

**Methods:** We issued a request for applications to all U.S. and Canadian medical schools within the Association of American Medical Colleges (AAMC), seeking a diverse group of institutional teams committed to an in-depth exploration of the topic. Of 33 applications, nine medical schools were selected to participate. Once on site, eight working groups were formed, each comprised of representatives across sites and roles, including deans, clerkship and program directors, content experts, and trainees. We addressed four key topics, which are subsequently summarized for presentation in this report: 1) education (How can medical simulation contribute to the education of trainees?), 2) assessment (What is the role of simulation in evaluating trainees in the context of general competencies?), 3) research (How should we develop a research agenda to evaluate simulation?), and 4) implementation (How should simulation technologies be developed and managed within and across institutions?).

**Results:** Participants in the conference generally agreed that simulation offers a conducive environment for focused reflection and critical thought. Although there was consensus that medical simulation can provide a robust platform for performance assessment, most participants thought that the research basis for high-stakes assessment was still too immature for widespread implementation. Participants generally agreed that sufficiently powered research will require interinstitutional collaboration on uniform curricula and meaningful outcome tools, and that both biomedical and social science research paradigms will need to be applied to the questions at hand. Common barriers to medical simulation include both real and perceived lack of resources, poor understanding among faculty regarding the nature of the tools and techniques, and the inherent complexity of multidisciplinary collaboration.

**Conclusions:** Medical simulation can and should be used to complement current methods of medical education. Educators should make thoughtful choices among simulation modalities to help trainees most effectively achieve learning objectives. Simulation researchers should prioritize the development and validation of clinical performance tools and other defined outcome measures on which meaningful large-scale research can be anchored. Finally, national collaboration should be encouraged and fostered by institutions and funding agencies.

(*Sim Healthcare* 2:88–95, 2007)

Although economic forces and biomedical advances are creating shifts in the delivery of health care away from acute care and into the ambulatory setting, the bulk of medical training still occurs in the hospital.[1] Consequently, trainees have diminishing exposure to patients and experience cases less reflective of the general population. A trainee simply cannot be expected to see and help manage the totality of patients he or she might encounter in independent practice. While the ever-expanding fund of biomedical knowledge and increasingly specialized approaches to care force residents to train for longer and longer periods of time, their clinical experiences are still largely dictated by chance encounters with a limited pool of patients. Moreover, faculty physicians, facing pressure to increase clinical volume, are often forced to focus primarily on managing patient flow, depriving students of educational mentors and role models. As a result, trainees may have inadequate access to the best parts of their education: pa-

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The authors have indicated they have no conflict of interest to disclose.



DOI: 10.1097/SIH.0b013e318053e066

tients and faculty. Out of this environment, educators must consider innovative ways to restructure medical education.

One proposed innovation is medical simulation,[2,3] particularly the newest generation of technology-enhanced modalities:

- **Concept simulation**: illustration of complex physiological principles using computer-based algorithms and animation
- **Virtual patient simulation**: interactive computer screen-based programs that mimic real-life clinical scenarios to allow the user to interview, examine, diagnose and treat a patient
- **Part-task training**: mechanical or virtual reality simulations focusing on procedural or psychomotor skills
- **High-fidelity patient simulation**: the use of robot-mannequins to reproduce complex environments to learn about the real-time delivery of health care

Although proponents argue that medical simulation can fundamentally enhance medical education and patient care through safe experiential learning, large-scale experience with advanced simulation technologies is limited. Critics argue that investment in such technology thus lacks scientific foundation. To explore the topic in the face of limited evidence, we convened a conference of medical education leaders, experts in simulation, and trainees to provide recommendations for how this field should be directed on a broad scale to improve the training of future health professionals. We brought this group together to discuss educational, assessment, research, and operational issues associated with medical simulation. To foster balanced discussion, we intentionally chose participants who would represent a wide spectrum of perspectives.

In this report, we present the summary and recommendations of this conference, entitled "Millennium Conference 2005 on Medical Simulation." The conference was organized as part of the Millennium Conference series jointly sponsored by the Association of American Medical Colleges (AAMC) and the Carl J. Shapiro Institute for Education and Research at Harvard Medical School and Beth Israel Deaconess Medical Center. During the program, we focused on the aforementioned advanced simulation modalities, which, while growing in popularity, are not currently considered the "standard" in traditional medical education. In this spirit, we chose not to discuss standardized patients (SP) as a primary educational tool, recognizing that SPs have already come to assume a primary role in assessment and training. With the understanding that discussions would naturally gravitate toward student education and resident training, we also asked participants to consider the entire continuum of medical education, from undergraduate medical education to graduate medical education to faculty development and continuing medical education.

Of note, this document represents neither a review of the literature nor the opinion of the conference planners or authors. Rather, it intends to summarize the proceedings of the conference based on an analysis of notes, videotape, and work products, hoping that the deliberations and thoughts of the assembled group will help inform subsequent work in the field.

## METHODS

### Participant Selection Process

In the fall of 2004, we issued requests for applications (RFAs) to the deans of all medical schools belonging to the AAMC, the cosponsoring organization. Medical school membership in the AAMC is limited to those schools in the U.S. and Canada accredited by the Liaison Committee on Medical Education. The RFA solicited competitive proposals for institutional teams to participate in the conference. Thirty-three schools submitted applications, which consisted of a two-page letter of interest, biosketch profiles of proposed team-members, and a letter of support from the medical school dean. In the letter of interest, applicants were asked to describe current institutional work in medical simulation, detail challenges faced in the development of their simulation programs, and summarize their organization's rationale for wanting to advance medical simulation.

Applications were reviewed by a selection committee comprised of senior Shapiro Institute faculty members familiar with the nature and goals of Millennium Conferences. Nine schools were selected to attend based on the following criteria: 1) demonstrated interest in examining the educational principles underlying medical simulation, 2) demonstrated interest in scholarly examination and assessment of simulation programs, 3) commitment to and educational soundness of a proposed and/or ongoing simulation initiative, and 4) commitment to active participation in both interinstitutional working groups and school teams. Selection committee members also sought a programmatic focus on educational principles over technology and team participation by experienced faculty and institutional leaders. In addition, we made a conscious effort to diversify the types and locations of the participating schools, which were, in alphabetical order: Baylor College of Medicine, Harvard Medical School, Indiana University School of Medicine, New York University School of Medicine, Pennsylvania State University College of Medicine, Stanford University School of Medicine, University of Louisville School of Medicine, University of Pittsburgh School of Medicine, and University of South Florida College of Medicine.

Sixty-five people (45 school team members and 20 conference faculty/staff/guests) participated in the conference, which was held over 4 days from April 28 to May 1, 2005 at Babson College Executive Conference Center in Wellesley, Massachusetts. Prior experience with simulation among the schools ranged from nascent, decentralized efforts to comprehensive and coordinated use across the continuum of medical education. The school teams each consisted of 5 members chosen to represent the spectrum of perspectives from learners to senior administrators, specifically: 1) a dean or associate dean for Medical Education/Curriculum or Director of Graduate Medical Education, 2) a clerkship director or residency program director, 3) a senior leader in educa-

tional technology or simulation, 4) a student or resident with demonstrated interest and commitment to curricular issues in medical education, and 5) an assessment specialist.

### Conference Structure

The conference content was divided into four core topics to be addressed during the course of the conference: education, assessment, research, and implementation. Topic domains and guiding questions (Table 1) were developed by a conference program committee, which consisted of Shapiro Institute faculty, AAMC representatives, and senior simulation faculty from the Center for Medical Simulation and Harvard Medical School. Content experts spoke before each of the four plenary sessions to place the topic into the appropriate educational context, to orient the participants to the major issues of concern, and to clarify the objectives of the session.

We divided participants into eight working groups composed of team members from different schools (six or seven participants per group including special guests, plus a dedicated facilitator/faculty from the conference team). The working groups met after each plenary to discuss one ques-

**Table 1.** Discussion Questions by Plenary Session

During each breakout session, we used these questions to stimulate discussion.

**Plenary 1 – EDUCATION:**
**How can medical simulation contribute to the education of trainees?**

E1. What are the primary deficiencies in medical education/practice (*vis-a-vis* the learning needs of the students and the demands of the curricula) that simulation can address better than other teaching methods? What benefits does simulation offer compared to real patient care settings?

E2. What is the rationale for the use of simulation over simpler educational tools? Considering the wide diversity of learner needs, cognitive styles, and the broad continuum of capability, how can we justify the investment?

E3. Discuss several strategies to integrate basic science into clinical training using simulation. How do we ensure that simulation will effectively enhance learning of basic science versus merely assessing retention of knowledge?

E4. How can simulation encourage reflective practice among trainees? What forms of debriefing in medical simulation may best enhance self-directed learning?

**Plenary 2 – ASSESSMENT:**
**What is the role of simulation in evaluating trainees' general competencies?**

A1. Should simulation be used in the summative assessment of learners? Does simulation validly assess students' learning?

A2. How may we use simulation to assess the competencies of systems-based practice as well as practice-based learning and improvement? Propose an example for each.

A3. What aspects of clinical reasoning (from data gathering to formulation of differential diagnoses to therapeutic intervention) may be evaluated with simulation? Which simulation tools are best used for assessing different aspects of clinical reasoning?

A4. Which aspects of relationship-building and communication skills may be assessed with simulation for both patient-provider and provider-team interactions? Which simulation tools are best used for assessing different aspects of communication?

**Plenary 3 – RESEARCH:**
**How should we develop a research agenda to evaluate simulation?**

R1. Should research in simulation be directed towards patient outcomes, such as patient mortality or adverse events? What would be required within academic medical centers to make these investigations possible or feasible?

R2. Can/should simulation-based teaching and learning be assessed by randomized controlled educational trials? Should such trials be done prior to broad implementation of simulation technologies or in parallel with such implementation?

R3. What are the challenges and strategies for multicenter collaboration in simulator-based research? Discuss a few strategies to foster the use of standardized curricular materials and validated evaluation tools to promote multi-center research.

R4. Can we use simulation to assess the quality of educational programs? What are considerations in selecting assessment tools to evaluate simulator-based learning? How do we choose between paper-and-pencil tests, expert global rating systems, or checklist assessment? Is it fair to employ simulator-based evaluation of simulator-based learning?

**Plenary 4 – IMPLEMENTATION:**
**How should simulation technologies be developed and managed within and across institutions?**

I1. How do you engender faculty support and readiness to use simulation effectively? How do you then develop faculty to participate in simulation-based education? What are the advantages and disadvantages of the following models of faculty involvement in simulation: a) core group of dedicated faculty, b) medical school-based faculty, c) hospital-based faculty?

I2. How should simulation be financed? What are the advantages and disadvantages of the various funding mechanisms: a) from philanthropy, b) at the departmental level (e.g., via a per resident/student user fee), c) through the operating budget of the academic medical center (hospital and medical school), d) through an independent organization, e) via relationships with commercial vendors, f) through revenues generated by continuing medical education programs (e.g., charging participants when taking a simulation course), g) through insurance companies willing to offer discounts?

I3. What are the challenges and strategies for integrating simulation-based teaching into an existing clinical curriculum? How will you justify the use of time for simulation learning in an already dense curriculum?

I4. What are the challenges and strategies for integrating simulation into a single academic medical center? What strategies exist to foster collaboration and cost sharing by multiple institutions and departments?

tion from each of the four major topic areas. At the completion of each working group session, the teams presented the major points that arose during their deliberations to the entire group of conference participants, after which a general discussion ensued.

### Reporting Methodology

The data for this summary come from three sources: notes taken by conference staff during the event, videotape review of all conference events, and summary documents created by school teams. Both the body of a draft report and summary recommendations were sent to representative participants (the "team leader" or designee for each school) for review and approval.

## RESULTS

Conference attendees included 11 associate/assistant deans, 10 residency or clerkship directors, 8 directors of educational programs, 7 simulation experts, 2 assessment professionals, and 7 trainees (student or resident).

We present here a summary of the main themes by topic.

### Conference Topic 1: Education—How Can Medical Simulation Contribute To the Education of Trainees?

Medical simulation can help achieve important goals in medical education that have become increasingly difficult to address. Rooted in adult learning theory, simulation can effectively meet the need for adults to be active learners, to learn in relevant contexts, and to individualize their own learning plans. By compelling reflection both during and after the exercise, simulation training fosters reflective practice. It can educate learners about integrative elements of health care delivery such as team-based approaches to care, resource and systems utilization, and longitudinal monitoring. From a curricular standpoint, it offers a platform for standardized education and assessment of learners in a meaningful context, can ensure uniformity of curricula, and supports and helps develop critical thinking. From an ethical standpoint,[4] simulation can promote patient safety by allowing risk-free training in a realistic environment. It can ensure exposure to both rare and common events, promote task repetition for performance improvement, and potentially accelerate the acquisition of expertise over time.

Simulation should be used in a developmentally appropriate manner. While students, for example, may gain crucial anatomic context from performing "surgery" using expensive virtual reality simulators, many simple psychomotor tasks do not need to be taught using expensive equipment. The range of available technologies for simulation allows educators to use them synergistically, rather than relying on one form of simulation to try and address a range of different learning objectives. One kind of multimodality simulation environment, for example, places a high-fidelity mannequin simulator on a stretcher in a traditional classroom, along with a large-screen computer display connected to the web.[5] In this integrated environment, learners can use simple tutorial processes and computer-based resources to review content and then move on to higher fidelity equipment to apply higher-order skills. Simulations that hybridize SPs with procedural models can also allow simultaneous assessment of both psychomotor and interpersonal skills.[6,7]

One core simulation approach that offers great opportunities for clinical teaching and practice is structured reflection.[8] Human patient simulation in particular involves debriefing sessions that provide dedicated time and psychologic space for reflection on action. The controlled setting of simulation offers additional advantages not present in the clinical setting, such as the ability to stop a scenario in midstream, the opportunity to introduce purposeful errors to trigger discussion, and an environment to discuss difficult issues openly with minimal threat to the learner. The integration of reflective practice more deeply into actual practice may result in a culture of productive feedback and an approach to error-reporting that emphasizes principles of process improvement while striving for high performance standards. By modeling self-reflective practice, faculty can foster the development of the skills necessary for lifelong learning.

### Conference Topic 2: Assessment—What Is the Role of Simulation in Evaluating Trainees' General Competencies?

The literature supporting the efficacy of simulation as a training tool exists primarily in anesthesiology[9] and in surgery, with some surgical data correlating simulator training to improved operative performance.[10] Formal simulation-based assessment approaches, however, have even less of a demonstrable correlation to real-world performance. For this reason, most participants thought that the research basis for high-stakes assessment was yet too immature for widespread implementation in the United States. However, the U.S. Food and Drug Administration requirement for simulator-based proficiency in carotid stenting,[10] anesthesia certification initiatives abroad,[11] and the United States Medical Licensing Examination experience with computer-based case simulations (Step 3)[12] are evidence that simulation is increasingly recognized as an important component of performance assessment. Nevertheless, the psychometric challenges of validating simulation for use in high-stakes assessment remain substantial.[13]

The major advantage in using medical simulation for assessment may be in its ability to capture behaviors in contexts similar to actual practice, in essence, measuring the behavioral levels of Miller's pyramid ("shows how" and "does").[14] Similar to Objective Structured Clinical Examinations (OSCEs), the setting is reproducible and allows measurement of skills, such as communication and professionalism, which are otherwise difficult to evaluate.[15] Moreover, a variety of conditions and scenarios can be introduced without harm to the standardized patient. A common example is the use of high-fidelity simulation environments to evaluate performance in ethical dilemmas or crisis situations.[16] One should also not overlook the potential for computer-based simulations to create "virtual" clinical practices,[17] permitting educators to teach and assess skills in coordination of care, cost-effective resource utilization and patient relations, as well as adherence to quality guidelines.

As with other tools, the simulation-based assessment should be aligned with key learning objectives and used in conjunction with other assessment methods, with specific attention to matching the evaluation tool with the skill to be measured and the resources available. Particular care is required prior to the use of simulation for high-stakes assessment to ensure that the learner is familiar with the testing method and that the environment reproducibly portrays a realistic practice environment.

The use of simulation to screen candidates for acceptance into a training program is controversial.[18] Some program directors have considered using part-task trainers to screen surgical residency applicants, hoping to identify candidates who have innate eye-hand coordination. Others argue that this mechanism neglects the importance of nonpsychomotor skills in becoming a competent surgeon and cannot predict the overall potential and manual skill profile of the candidate. This issue raises the additional dilemma of whether some skills are remediable.

### Conference Topic 3: Research—How Should We Develop a Research Agenda to Evaluate Simulation?

Research toward "validating" simulation must address the same challenges as other types of educational and social science research.[19] In addition, however, such research carries with it expectations inherent to the biomedical paradigm. While educators tend to use proximal outcomes such as knowledge gains and standardized behavior, changes in clinical standards of care are typically driven by randomized controlled trials and multicentered studies. Educational studies designed to shed light on such clinically relevant outcomes will require large cohorts of learners followed for many years to deal with the many confounders that lie between the educational intervention and the effects on the patient – variability in students, curricula, institutional culture, resource availability, and subsequent training, to name a few. Such studies require resources that go beyond the capabilities of any single medical center or medical school, and some of these studies may never be done given statistical power limits and resource requirements. In fact, great debate exists over the prioritization of such resource demands, both within the field of simulation (should such resources be spent on perfecting the science of simulation?) and within the overall healthcare enterprise (how do educational priorities relate to those of basic bench and translational research?). Notably, randomized controlled trials have not been employed historically to justify the use of other instructional methods such as problem-based learning, textbooks, and lectures. The cost associated with the development and implementation of simulation training, however, may demand more rigorous studies of efficacy. And yet, important unproven and expensive technologies (including flight simulation) have been universally implemented despite lack of "definitive" evidence for efficacy, arguing for a careful balance of "common sense" and empiricism when human safety is at issue.[20]

Although many obstacles exist for multicentered trials, one possible approach would be to embrace the differences between institutions, choose them for very divergent approaches to education, and use a combination of biomedical and social science methods to assess the differences. Selecting outcomes related to high-profile patient safety issues might garner the level of interest and funding from the public sector that would be required for such a large undertaking.

Whatever the goal, be it patient-centered outcomes, randomized controlled trials, or multicentered trials, the research agenda would be well advanced by support of broad nation-wide efforts and the creation of a research infrastructure. Initiatives such as the Society for Simulation in Healthcare and its journal *Simulation in Healthcare,* along with activities by the Advanced Initiatives in Medical Simulation (AIMS) coalition[21] and individual specialty societies provide dedicated forums for further dialogue, collaboration, and action. Additional assistance may come from the linkage of national databases of patient outcomes to educational trials, the pursuit of further public and federal support for simulation, and the creation of national guidelines for the use of simulation in healthcare.

### Conference Topic 4: Implementation—How Should Simulation Technologies Be Developed and Managed Within and Across Institutions?

Three major issues that commonly confront new simulation programs are new expenses, institutional acceptance, and the need for interinstitution collaboration.

Many financial models for simulation exist, each associated with different benefits and risks. Current sources of funding include philanthropy, clinical departments, the medical center/school operating budget, foundations, commercial vendors, tuitions from continuing health education courses, and private malpractice insurers.[22] The overarching principles behind the financing of simulation are similar to, and as complex as, the funding of medical education in general. The mission and outcomes of simulation-based initiatives will drive prioritization of resources based on a host of competing priorities across the organizational spectrum.

Identification of people who are or will become champions for simulation is vital if one wishes to advance an institutional simulation agenda ("bottom-up" approach). In addition to demonstrating the advantages of simulation, this tactic should also focus on delivering a message of curriculum complementarity (rather than replacement), fostering student and resident interest groups, and providing academic incentives for faculty to create content for simulation. The "top-down" approach entails creating leadership-sanctioned opportunities to stimulate high-level interest and action. Many justifications for simulation exist that may resonate with curriculum leaders, such as the ability to address institutional and national curricular gaps, to replace inefficient methods of learning, and to promote interdepartmental collaboration and team-based learning. The success of either approach may depend on institutional structure, whether centralized (as in many medical schools) or decentralized (as in graduate medical education). Although top-down endorsement is desirable, bottom-up efforts may be the necessary first step in many traditional academic settings.

Despite the internal challenges confronting the efforts to integrate simulation into the curriculum, many external forces are already driving its adoption in medical education. Among these forces are the patient safety agenda, mandates like the Accreditation Council for Graduate Medical Education competencies, trainee enthusiasm, and regulatory and insurance industry interest. Of noteworthy comment, in 2006 the Agency for Healthcare Research and Quality awarded 5 million dollars in research funds to support simulation programs in patient safety. Public scrutiny of clinical care and training represents one of the strongest drivers for change, but proponents of simulation can also garner support for implementation through the use of financial incentives, the success of early adopters, and the promise that technology is advancing at a rate that ensures cheaper, better, and faster improvements.

In addition to journal publications, initiatives such as collaborative book authorship[23,24] and the AAMC's online repository of peer-reviewed educational materials (MedEdPORTAL, http://www.aamc.org/mededportal) create faculty incentives by fostering educational scholarship and allowing dissemination of simulation curricula and methods. Efforts sponsored by medical specialty societies further promote sharing of simulation resources, and, in turn, interinstitution collaboration (for example, American Society of Anesthesiologists [http://www.asahq.org/SIM]; Society for Academic Emergency Medicine [http://www.saem.org; go to education/simulation]; American College of Surgeons [http://www.facs.org/education/accreditationprogram]).

## DISCUSSION

The Millennium Conference 2005 on Medical Simulation convened a group of institutional leaders, simulation experts, and leading educators to discuss medical simulation: 1) as an educational intervention, 2) as a means of assessment, 3) as a research environment, and 4) as an opportunity to examine the challenges of introducing innovative educational technology across the curriculum. This forum allowed us to exchange ideas about broad-based implementation of medical simulation, in the hopes of meaningfully advancing medical education in a new era of technology.

The consensus of the conference participants was that simulation is supported by principles of adult learning and should be increasingly used as a component of medical education. Particular themes of agreement included:

- Medical simulation represents a powerful technique that has the potential to revolutionize medical education. It aims to better meet the needs of adult learners and also to enhance current curriculum by integrating basic and complex concepts and by probing reflective practice.
- Medical simulation has been and will increasingly be used for both formative and summative assessment of learners. The ability to recreate the clinical environment provides educators with a wealth of information about and insight into how trainees and physicians may behave in actual practice.
- Medical simulation faces similar challenges as other educational practices in demonstrating meaningful and patient-centered outcomes, which emphasizes the need to perform rigorous multidisciplinary research. Such research, however, will require the allocation of significant resources. Institutional experimentation with simulation should not be placed "on hold" pending large-scale validation trials. Rather, simulation, as it meets institutional needs, should be explored and studied simultaneously. Definitive scientific evidence for simulation is but one of several components of an argument for using it.
- Many forces are driving the adoption of medical simulation, most notably the emphasis on enhanced patient safety arising from the public, healthcare providers and regulatory agencies. To maintain momentum, leaders and educators must be thoughtful about how simulation can be employed to advance medical education and professional development while using the technology to advance patient care in a safe, cost-efficient, and collaborative way.

The benefits and challenges ascribed to simulation could, in fact, apply to many kinds of educational innovation; simulation is but one tool of many. As such, those who wish to implement simulation broadly into medical training can glean much from the widespread experience with problem-based learning, standardized patients, and OSCEs.

Nevertheless, medical simulation does present unique challenges. As a single entity, medical simulation is itself composed of a heterogeneous group of technologies (concept simulation, virtual patient simulation, part task training, and high-fidelity patient simulation) that historically have been used in isolation. As a result, synergies of use may be lost and simulation proponents can become divided. In addition, the natural resistance that faculty may have towards new ways of teaching can be exaggerated when it relates to technology. Medical education has traditionally been less progressive compared with industry in the widespread adoption of technology to deliver a service. Faculty unfamiliar with equipment or with computers may be reluctant to rely on them when students' education is at stake. Lastly, infrastructure requirements to implement medical simulation can be greater (both real and perceived) than existing educational methodologies. While allocations for facilities, technical and engineering support, audiovisual equipment, mannequins, software development, computer clusters, curricular development, and personnel (the greatest portion) will all appear on any simulator budget request, these line items are not new to the academic medical center. In fact these kinds of requirements and resources are standard in the modern era but have not typically been consolidated or unified as part of an integrated simulation-based approach.

Both the strength and limitation of this summary document lies in its representation of voiced comments from a very heterogeneous group of stakeholders from only 9 out of 142 eligible North American medical schools. Because our sample of participants was drawn from AAMC-member institutions only, perspectives from international, osteopathic,

nursing, or allied health professional schools were not directly represented, although many participants were familiar with work done at these teaching institutions and included them in the discussion. The points raised are not meant to represent a commitment of the participants to a particular policy about the use of simulation, nor is this document intended to provide a review of the literature on medical simulation. Rather, we have attempted to document the level of understanding voiced at Millennium Conference 2005, a forum that was convened to leverage the expertise of selected schools and participants and create an open dialogue about how medical simulation can be meaningfully advanced.

### Summary Recommendations

Summary recommendations from the conference are listed below, each followed by a statement about the relative strength of the recommendation and the tenor of discussion (in parentheses):

1. Medical simulation should be thoughtfully used and supported as a complement to current teaching methods for medical students, resident trainees, and faculty (recommendation strongly supported, with widespread agreement).
2. The integrated use of various modes of simulation should be a priority in simulation efforts. Developmentally appropriate tools and curricula are essential as learners build upon a foundation of skills. Depending on the learning objectives, lower fidelity simulation alone may be appropriate, such as for learning and practicing simple cognitive or psychomotor tasks. In other circumstances, the use of high-fidelity approaches, alone or in combination with lower fidelity methods, can be more suitable for fostering advanced cognition or complex team-training and assessment. Increasing expertise among participants, and higher stakes of participation (ie, certification testing) may necessitate more realistic immersive environments (recommendation generally supported, with discussion over the level of integration, realism, and cost required to achieve intended objectives).
3. Medical simulation research should pursue performance-based and patient-centered outcomes, using robust quantitative and qualitative measures. Such efforts, however, will require substantial foundation and/or governmental support. Assistance may come in the form of linking national databases of patient outcomes to educational trials, pursuing further public and federal support for simulation, and national standards for the use of simulation (recommendation generally supported, with a note of caution about the inherent difficulty of studying educational interventions in the context of relatively rare, multifactorial patient outcomes).
4. Advocates of medical simulation should prioritize multicenter collaboration as a means to stimulate the use of simulation technology and to study its efficacy. Strategies to foster such collaboration include the creation of "centers for excellence" for simulation programs, the support of accreditation agencies and certification bodies in the use of standardized curricula and testing instruments, and greater support among academic societies and funding agencies in fostering simulation-based curricula and research (recommendation generally supported, with debate surrounding issues of advocacy and research).

## REFERENCES


1. Ad Hoc Committee of Deans: Educating doctors to provide high quality medical care: a vision for medical education in the U.S. Washington, DC, Association of American Medical Colleges, Institute for Improving Medical Education, July 2004.
2. Gaba DM: The future vision of simulation in health care. *Qual Saf Health Care* 2004;13:i2–10.
3. Cooper JB, Taqueti VR: A brief history of the development of mannequin simulators for clinical education and training. *Qual Saf Health Care* 2004;13 Suppl 1:i11–i18.
4. Ziv A, Wolpe PR, Small SD, Glick S: Simulation-based medical education: an ethical imperative. *Acad Med* 2003;78:783–788.
5. Gordon JA, Oriol NE, Pawlowski J, et al: Moving the patient bedside into the tutorial room: a medical classroom for the future [abstract #1486]. *Simul Healthcare* 2006;1:114.
6. Kneebone R, Nestel D, Wetzel C, et al: The human face of simulation: patient-focused simulation training. *Acad Med* 2006;81:919–924.
7. Kneebone R, Nestel D, Yadollahi F, et al: Assessing procedural skills in context: Exploring the feasibility of an Integrated Procedural Performance Instrument (IPPI). *Med Educ* 2006;40:1105–1114.
8. McMahon GT, Monaghan C, Falchuk K, et al: Development of a simulator-based curriculum to promote comparative and reflective analysis in an internal medicine clerkship. *Acad Med* 2005;80: 84–89.
9. Gaba D, Howard S, Fish K: Simulation-based training in anesthesia crisis resource management (ACRM): A decade of experience. *Simul Gaming* 2001;32:175–193.
10. Gallagher AG, Cates CU: Approval of virtual reality training for carotid stenting: what this means for procedural-based medicine. *JAMA* 2004;292:3024–3026.
11. Berkenstadt H, Ziv A, Gafni N, Sidi A: Incorporating simulation-based objective structured clinical examination into the Israeli National Board Examination in Anesthesiology. *Anesth Analg* 2006;102:853–858.
12. Dillon GF, Boulet JR, Hawkins RE, Swanson DB: Simulations in the United States Medical Licensing Examination (USMLE). *Qual Saf Health Care* 2004;13 Suppl 1:i41–i45.
13. Boulet J, Swanson D: Psychometric challenges of using simulations for high-stakes assessment. In Dunn WF, ed. Simulators in Critical Care and Beyond. Des Plains, IL, Society for Critical Care Medicine Press, 2004.
14. Miller GE: The assessment of clinical skills/competence/performance. *Acad Med* 1990;65:S63–S67.
15. Blum R, Raemer D, Carroll J, et al: A method for measuring the effectiveness of team-based training for improving communication skills. *Anesth Analg* 2005;100:1375–1380.
16. Gaba DM, Fish KJ, Howard SK: Crisis Management in Anesthesiology. New York, Churchill Livingstone, 1994.
17. Henderson JV: Comprehensive, technology-based clinical education: the "virtual practicum". *Int J Psychiatry Med* 1998;28:41–79.
18. Wanzel KR, Ward M, Reznick RK: Teaching the surgical craft: from selection to certification. *Curr Probl Surg* 2002;39:573–659.
19. Issenberg SB, McGaghie WC, Petrusa ER, et al: Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. *Med Teach* 2005;27:10–28.

20. Smith GC, Pell JP: Parachute use to prevent death and major trauma related to gravitational challenge: systematic review of randomised controlled trials. *BMJ* 2003;327:1459–1461.

21. Eder-Van Hook J: Building a National Agenda for Simulation Based Medical Education. Available at: http://www.medsim.org/articles/AIMS_2004_Report_Simulation-based_Medical_Training.pdf. Accessed June 23, 2006.

22. Foubister V: Simulation in Medicine. Quality Matters. Available at: http://www.cmwf.org/publications/publications_show.htm?doc_id=266916. Accessed June 23, 2006.

23. Dunn WF: Simulators in Critical Care and Beyond. Des Plains, IL, Society for Critical Care Medicine Press, 2004.

24. Loyd GE, Lake CL, Greenberg R: Practical Healthcare Simulations. Philadelphia, Elsevier, 2004.