

# Setting a Research Agenda for Simulation-Based Healthcare Education

## A Synthesis of the Outcome From an Utstein Style Meeting

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**Key Words:** Simulation-based learning, Research, Instructional design, Outcome measurement, Translational research.

**A**lthough the use of simulation as a methodology for learning continues to grow at a rapid pace throughout all of the healthcare professions and disciplines, research in this field is still at an early stage. Increasingly, decision makers and stakeholders must see evidence that the use of such a methodology leads to desired and demonstrable learning outcomes. These include the assurance that simulation may serve as a complement and in some cases a substitute for clinical experience in improving the quality and safety of patient care. Research will be a key factor in advancing the field of simulation to the benefit of patients and healthcare professionals. The simulation community needs an improved understanding of conceptual issues and evidence for their effectiveness to guide simulation use in optimizing the interplay of healthcare professionals, technology, organizational systems, and patients. This recognition extends beyond those educators in the simulation community. In a recent publication summarizing the findings of a task force that identified priorities for medical education research based on their perceived national importance, feasibility, fundability, and amenability for multi-institutional research,<sup>1</sup> the no. 1 research issue to emerge was to study the impact of medical school simulation learning on residents' performance.

Within the simulation community, there have already been several initiatives involving systematic literature reviews, task forces, committees, and summits whose goal was to identify a research agenda for the use of simulation for learning.<sup>2–8</sup> Leadership from the Society in Europe for Simulation Applied to Medicine and Society for Simulation in Healthcare (SSH) sought to further these efforts with a special emphasis to include

broad international, multidisciplinary, and interprofessional representation. The Utstein Style Meeting process that has proven successful for catalyzing international, multidisciplinary, and interprofessional research in emergency medicine was adopted for a simulation expert meeting.<sup>9,10</sup> The organizers of this meeting recognized that the field of simulation is broad and considered a range of research categories including research about simulation (eg, learning effectiveness and methods, engineering of anatomy and physiology, theoretical frameworks on simulation, and sociological investigation) and research using simulation (eg, human factors oriented investigation, incident analysis, and usability studies).<sup>11</sup> While the organizers chose to focus on research related to simulation-based healthcare education, they recognized that in some instances research using simulation to study other factors (eg, using simulation to study the effects of fatigue on human performance) will be used to inform the educational focus. Within the educational domain, the overall goals were to (1) identify the state of the art of educational simulation-based research; (2) identify future directions for educational simulation-based research with headline topics and research questions; and (3) identify methodological issues when conducting educational simulation-based research and provide guidelines on reporting and publishing this research. This effort complements the SSH simulation research summit that took place in January 2011 in conjunction with the International Meeting on Simulation in Healthcare. This report has two sections: a summary of the process to develop a research agenda and a research agenda with proposed research questions.

### PROCESS TO DEVELOP SIMULATION RESEARCH AGENDA—UTSTEIN STYLE MEETING

#### Selection of Participants

For the selection of participants in the meeting, the aim was to build on existing collaborations and experience of simulation research experts with international, multidisciplinary, and multiprofessional representation. The organizers chose individuals with a strong research record, experience in participating in collaborative projects, and who represented key target stakeholder groups, reflecting a diver-

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The authors declare no conflict of interest.

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DOI: 10.1097/SIH.0b013e3182207c24

**Table 1.** Summary of Participants in the Utstein Meeting

Participant	Institution
John Boulet	Educational Commission for Foreign Medical Graduates, Philadelphia, PA
Ian Curran	London Deanery, London, UK
Peter Dieckmann	Danish Institute for Medical Simulation (DIMS), Copenhagen, Denmark
James Gordon	Harvard University, Boston, MA
Steven Howard	Stanford University, Palo Alto, CA
Elizabeth Hunt	Johns Hopkins University, Baltimore, MD
Barry Issenberg	University of Miami, Miami, FL
Pamela Jeffries	Johns Hopkins University, Baltimore, MD
Roger Kneebone	Imperial College, London, UK
Ralf Krage	VU University Medical Center, Amsterdam, The Netherlands
Vicki Leblanc	University of Toronto, Canada
Nikki Maran	Stirling Simulation Center, UK
William McGaghie	Northwestern University, Chicago, IL
Vinay Nadkarni	Children's Hospital of Philadelphia, PA
Doris Østergaard	Danish Institute for Medical Simulation(DIMS), Copenhagen, Denmark
Paul Phrampus	University of Pittsburgh, PA
Charlotte Ringsted	University of Copenhagen, Denmark
Jacob Rosenberg	Herlev Hospital, Copenhagen, Denmark
Georges Salvodelli	Geneva University Hospital, Switzerland
Stephen Sollid	Stavanger Acute Medicine Foundation for Education and Research (SAFER), Norway
Eldar Søreide	SAFER, Norway
Dimitris Stefanidis	Carolinas Medical Center, Charlotte, NC
Rachel Yudkowsky	University of Illinois, Champaign, IL
Amitai Ziv	Sheba Medical Center, Tel-Hashomer, Israel

sity of professional (eg, nursing, medicine, and psychology) and geographical backgrounds (eg, Europe, North America). Because the “traditional” size of Utstein Style Meetings is approximately 20 participants, and as this has proven to be a good balance between representativeness and effectiveness, a total of 20 participants (in addition to the four organizers) were invited to take part (Table 1).

### Preparation of the Utstein Style Meeting

The meeting organizers, consisting of the authors of this article, planned the meeting and its structure. A deliberate decision was made to work with the knowledge and expertise represented in the group by collecting it in an inductive process so that the topics and their priorities would be developed during the meeting. However, it was recognized that collection and synthesis of prior knowledge were important elements to inform the meeting. Consequently, participants were requested to send in recommendations for five references seen as important for the theme of the Utstein Style Meeting (Appendix).

### Process of the Utstein Style Meeting

The meeting took place in June 2010 in Copenhagen, Denmark, and began with an informal evening gathering to build an open, constructive, and trustful working relationship.

### Day 1—Introduction and Plenum Presentations

On day 1, the meeting began with an outline about the idea of the Utstein Style Meetings in general and of this specific one. Two plenum presentations sketched the state-of-the-art and the open questions in simulation-based educational research (noting that much of the research is not grounded in a theory) and presented a model outlining the concepts and challenges in theory-based educational simulation research. The model includes a core—the conceptual, theoretical framework—that is basic to any research approach and a rough clustering of research approaches in four main categories: exploratory studies (qualitative studies, psychometric studies, and descriptive studies), experimental studies (randomized controlled trials and quasi-experimental studies), observational studies (cohort, case-control, and associational studies), and translational studies (reviews and effect studies).<sup>12</sup> This framework was used to guide the discussions during the meeting.

### Day 1—Discussion Rounds

The groups were arranged to maximize the variety of expertise and, during each round, were facilitated by one of the authors. Discussion points were recorded on flip charts or using the electronic format and projection. In the first round, discussions followed a modified nominal group process.<sup>13</sup> Each participant reflected on general topic areas that “we need to know more about” in regard to education, research, and simulation. In an iterative process, each participant suggested a new topic until no new aspects emerged. The contributions of each group were presented and collected in plenum, allowing for clarifying questions by the other groups. During this session, the organizers independently began grouping each of the topics into different themes as they were discussed. During the subsequent break period, the organizers synthesized their notes and agreed that three major themes emerged: (1) instructional design, (2) outcome measures, and (3) translational research. (Based on the charge to the Utstein Meeting and the agreed relevance of the topic, a fourth group was also formed to specifically address guidelines for reporting research on simulation and education. This report does not include the results of the fourth group as that will appear elsewhere.) In the next round, the groups discussed research problems within the topic in an open group discussion and reported the results back to the plenum.

### Day 2—Discussion Rounds

At the beginning of day 2, the discussion round aimed to present a general outline of research questions for each topic. After that session, members of each group rotated to “critique,” “enlarge,” and “challenge” the findings of another group while two persons of each group stayed. In the following session, the original groups reconvened and refined the research questions along the challenges and newly developed ideas. Those refined research questions were subsequently presented in plenum and each briefly discussed.

### Day 2—Final Plenum

In a final step, the plenum reflected on the implications of the discussions for formulating a general research agenda for educational simulation research and opportunities for greater international collaboration. The authors have synthe-

sized and built upon the literature and the experts' contributions from the Utstein Style Meeting to present a research agenda relating to the three overall themes—Instructional Design, Outcome Measures, and Translational Research (Table 2).

## RESEARCH AGENDA WITH PROPOSED RESEARCH QUESTIONS

### Instructional Design

Deliberation by participants resulted in several topic questions they felt would provide focus and priority in the simulation research community. To facilitate grouping of the questions and to illustrate their interdependencies, an hourglass was chosen to represent this conceptually. Research related to learning theories and/or conceptual frameworks was placed at the top. At the next level down (neck of the hourglass), those research questions were placed that relate to resource requirements and systems challenges that often impact the theoretical application of simulation. At the bottom of the hourglass were research questions related to simulation program implementation that take into account the theoretical framework with the local resource challenges within a complex healthcare system.

### Learning Acquisition, Retention of Skills, and Cognitive Load

It is recognized that there is a range of simulation modalities available to choose which may address similar learning outcomes. Studies grounded in context-based learning can provide guidance on the level of authenticity required for a particular competency.<sup>14</sup> While there is ample evidence from the literature that the optimal use of a single modality such as mannequin-based simulation may lead to long-term retention of resuscitation skills and central venous catheter insertion skills,<sup>15,16</sup> it has yet to be demonstrated whether these and other outcomes can be achieved with different, often less costly and more flexible, simulation modalities such as virtual patients or hybrid task trainers with standardized patients. The intended purpose of researching this topic is not to show superiority of one modality over another. The intent is to provide evidence for a range of options with the expectation that individual simulation programs will possess (or choose) at least a single modality that can be used to achieve a desired outcome. Additional research may identify features unique to a particular modality and its use that impact acquisition and retention of skills (eg, availability of device and instructor feedback).

Over the past two decades, there has been significant work in cognitive psychology and in the science of learning that can inform the design of simulation systems and activities in which they are embedded. Wulf and Shea<sup>17</sup> have studied features related to the learning and practice of simple skills as compared with complex skill learning. Situations with low processing demand (eg, suturing) benefit from practice conditions that increase the cognitive load and challenge the learner. For instance, a series of several suturing scenarios could be designed with a range of difficulty that would be needed to be performed in a defined period of time or confined space. This is in contrast to scheduling a number of scenarios with high processing demand (eg, leading a team

response to care for a multihemorrhage trauma victim) where multiple challenges should be reduced to manageable levels so the learner is not overwhelmed.

### Research Questions—Learning Acquisition, Retention of Skills, and Cognitive Load

- How do theories of learning and teaching inform the design of simulation interventions (eg, frequency, timing, and deliberate practice)?
- How do theories of cognitive load inform the design and structure of simulation programs, courses, and concrete scenarios based on the complexity of tasks required for learners to acquire and maintain?
- How do different simulation modalities and their contextualized use affect skill development and retention?

### Debriefing

There is widespread recognition on the importance of debriefing in simulation learning, and as a result, there have been a range of debriefing models reported in the literature, being taught regularly during simulation instructor development courses and discussed in meetings or discussion groups.<sup>18</sup> Research should focus on selecting the optimal approach to achieve desired and defined learning outcomes. In addition, research efforts should be directed toward providing guidance to users regarding which debriefing mode works best and under what conditions.

### Research Questions—Debriefing

- What are the relevant characteristics of debriefing that lead to effective learning?
  - What is the optimal use of video recordings of scenarios during the debriefing (eg, replay of the full video versus parts only and selection of relevant episodes to be replayed)?
  - What are the differences in outcomes between faculty-led debriefings and peer-led or self-guided debriefings?
- Which debriefing characteristics are most relevant to a particular clinical domain (acute versus elective care) and learner level (eg, novice versus experienced)?

### Learner Characteristics

Most simulation-based research studies include some description of the learner population. These usually include their profession, level of training, previous experience, current knowledge and skill level, and gender. However, very little is known about how motivation affects learning and too often many of the existing studies either include volunteer subjects or subjects who understand there will be little to no consequences to their overall grade, promotion, or licensure status based on their performance. In addition to carrying out research that includes participants that represent the target group for which acquisition of the task is important for their clinical work, observational studies that evaluate highest and lowest achievers in a particular domain to identify common elements of these “outliers” can provide guidance on setting conditions that are appropriate for all learners.

### Research Questions—Learner Characteristics

- How does learner motivation affect the acquisition and retention of skills in simulation-based activities?
- What are characteristics (eg, cognitive, emotional, social) that distinguish high achievers from low achievers,

**Table 2.** Research Questions Grouped According to Three Main Themes of Utstein Style Meeting on Simulation

Theme (Subtheme)	Research Questions
Instructional design (learning acquisition, Retention of skills, and cognitive load)	How do theories of learning and teaching inform the design of simulation interventions (eg, frequency, timing, and deliberate practice)?
	How do theories of cognitive load inform the design and structure of simulation programs, courses, and concrete scenarios based on the complexity of tasks required for learners to acquire and maintain?
	How do different simulation modalities and their contextualized use affect skill development and retention?
Instructional design (debriefing)	What are the relevant characteristics of debriefing that lead to effective learning? What is the optimal use of video recordings of scenarios during the debriefing (eg, replay of the full video vs. parts only and selection of relevant episodes to be replayed). What are the differences in outcomes between faculty-led debriefings and peer-led or self-guided debriefings?
	Which debriefing characteristics are most relevant to a particular clinical domain (acute vs. elective care) and learner level (eg, novice vs. experienced)?
	How does learner motivation affect the acquisition and retention of skills in simulation-based activities?
Instructional design (learner characteristics)	What are characteristics (eg, cognitive, emotional, and social) that distinguish high achievers from low achievers, and are these domain specific or generalizable to all disciplines and tasks?
	How can simulation activities be used to validate learning theories in the context of healthcare?
Instructional design (impact on learning theory)	How do theoretical concepts and empirical findings about learning in nonmedical domains such as cognitive psychology and sociology apply in healthcare education settings?
	Can “automaticity” in a specific task (eg, suturing) be achieved without subjects being simultaneously challenged with secondary tasks (eg, managing cardiac arrhythmia and question from staff on unrelated topic)?
Instructional design (resource requirements and challenges—role of instructor)	What are the faculty/instructor/facilitator characteristics and behaviors that optimize trainee learning and experience?
	What are the effects of faculty incentives (eg, financial reward, promotion, and peer recognition) on student learning?
Instructional design (resource requirements and challenges—system requirements/challenges)	How do resources (physical/financial/models) influence optimal simulation learning?
	How can institutions address operational scale issues to ensure their educational outcomes are being achieved and sustained? [eg, can small portable systems (eg, in situ) operated by a small cadre of full-time, well-trained simulation experts lead to effective outcomes?]
	How do institutions maximize the value of large-scale simulation centers with large requirements of staffing and instructors?
Instruction design (simulation program implementation)	What kind of learner preparation is necessary or required to optimize simulation-based learning? How should nonsimulation learning be balanced with simulation learning?
	How do characteristics of the environment (eg, student/context) affect learning in simulation (eg, onsite, offsite, individual vs. group, peers vs. multidisciplinary, timing frequency, and procedure embedded vs. isolated)?
Outcomes measurement (Kirkpatrick level—reaction)	What are the short- and long-term, intended and unintended reactions to simulation-based learning beyond mere satisfaction—amongst learners, instructors, and institutions? To which elements in the simulation setting do participants and instructors react at all?
	How do these reactions relate to or impact the three dimensions of learning (eg, cognitive, emotional, and social) in simulation settings and on future behavior and performance in healthcare settings?
	What kind of data and measurement instruments can be identified or should be developed to measure broad aspects of reactions to simulation-based learning?
	How do results from measuring these reactions inform the design, conduction, and evaluation of simulation-based learning and assessment programs?
Outcomes measurement (Kirkpatrick level—learning)	What kind of learning needs assessment is required regarding simulation-based learning, and what instruments need to be developed to better estimate learning needs accordingly?
	What is the effect of simulation-based learning on learning outcomes when implemented on a broad scale in formal educational programs?
	Which personal, neurobiological, and contextual factors influence test-enhanced skills learning and in what way?
	How can process goals related to simulation-based learning be identified, defined, and measured in simulation settings and clinical settings?
Outcomes measurement (Kirkpatrick level—behavior)	What is the effect of simulation-based learning on “preparation for future learning” and how can this construct be defined and measured?
	What are the enabling and hindering factors, beyond learning decay, to application of simulation-based learning outcomes in healthcare practice?
	What outcome measures are most relevant to encompass the application of behaviors to healthcare settings, including the ability to adapt to different contextual factors?
Outcomes measurement (Kirkpatrick level—organization)	How do we measure the complexity of behavior at the individual, team, and organizational level and the interconnections between those levels in their influence on behavior?
	What are the needs for simulation-based learning and how can these be identified, analyzed, and described?
	What is the impact of simulation-based learning on healthcare organizations regarding clinical practice, work organization, and quality of care and patient outcomes?
	What kind of data and databases regarding work organizations, quality of care, and patient outcome can be identified or should be developed to monitor and associate educational variables with healthcare organizational outcomes?
	What kind of databases regarding learners’ educational needs, experience, and performance can be identified or should be developed to monitor and associate educational variables and organizational outcomes?

*(Continued)*

**Table 2.** (Continued)

Theme (Subtheme)	Research Questions
Translational research	How can simulation be used to analyze the interplay between patients, healthcare professions, technology, and organization?
	How can simulation settings contribute to revealing learning needs and inform the design, implementation, and evaluation of initiatives to enhance organizational performance?
	How do principles of learning and instruction derived from simulation-based learning in standardized settings (“the bench”) translate into learning in simulations centers or local training practice?
	How can users be identified who will benefit from a specific educational method—can simulation be used to identify and fulfill learning needs of specific target populations?
	How do principles of learning and instruction derived from simulation-based learning translate into clinical learning practice and educational organization?
	How can principles of learning and instruction derived from simulation-based learning be implemented in curricula for individuals and for teams in clinical practice?
	What characterizes areas (eg, individuals, tasks, and context dependent features) in which simulation-based learning will be a clear advantage over clinical learning regarding learning efficiency and cost-effectiveness?

and are these domain specific or generalizable to all disciplines and tasks?

### Impact on Learning Theory

It is recognized that simulation-based research should be grounded in a theoretical or conceptual framework. This process of theory identification is important to link individual studies together in a meaningful way. Several learning theories have been helpful to guide researchers working on simulation in providing a framework on which to build a complex series of activities and processes which are important to carrying out simulation-based learning. These include Kolb’s theory of experiential learning,<sup>19</sup> Vygotsky’s zone of proximal development,<sup>20</sup> Ericsson’s deliberate practice theory for the development of expertise,<sup>21</sup> and Fitz and Posner’s model on skills learning.<sup>22</sup> Simulation has thus provided an opportune environment to apply these established theories in new conditions and contexts. However, simulation can also provide a controlled environmental setting to develop and test new theories or challenge old assumptions about how people learn.

### Research Questions—Impact on Learning Theory

- How can simulation activities be used to validate learning theories in the context of healthcare?
- How do theoretical concepts and empirical findings about learning in nonmedical domains such as cognitive psychology and sociology apply in healthcare education settings?
- Can “automaticity” in a specific task (eg, suturing) be achieved without subjects being simultaneously challenged with secondary tasks (eg, managing cardiac arrhythmia, question from staff on unrelated topic)?

### Resource Requirements and Challenges

**Role of Instructor.** A growing body of evidence in the simulation literature demonstrates when simulation is used under the right conditions, learners can build competencies and capabilities which are applicable in the clinical setting and can have a positive impact on patient care and/or outcomes.<sup>23–26</sup> However, it is difficult to identify in the literature the role of the instructor and her/his contributions that were important and often essential to the success of the learning programs. In many communications on simulation, the technology or innovative curricula are highlighted. However, the contributions of the

instructors, technical and operational staff are often minimized and/or unclear. Members of the Utstein Style Meeting implicitly understood and explicitly emphasized the importance of an instructor who has some training in adult learning theory and principles of debriefing, engaging the learners in activities, individualizing the experience for the individual or team, and making the session relevant to their clinical care responsibilities. This is a “black box” of simulation-based education, but one that is critical to the sustained success of simulation learning. Institutions that make large investments in space, simulation systems, and supporting equipment, but do not invest in the human capital and provide opportunities for these individuals to develop necessary skills and reward them for their efforts, will have a difficult time realizing the potential of their simulation learning program and will never see an optimal return on their investment.

### Research Questions—Role of Instructor

- What are the instructor characteristics and behaviors that optimize trainee learning and experience?
- What are the effects of faculty incentives (eg, financial reward, promotion, peer recognition) on student learning?

**System Requirements/Challenges.** Now that simulation has become widely adopted within the mainstream of health sciences education throughout the professions (eg, nursing, medicine, education), disciplines (eg, internal medicine, pediatrics, surgery, anesthesiology), and continuum of learning, institutions are challenged to identify sources of funding to support and sustain these activities. Research is needed in systems design to identify critical elements for healthcare learning environments. Health sciences education can explore the work carried out in industrial systems design and the conceptual frameworks that have been created to guide consumer product development.<sup>27</sup> These findings will help guide institutions on those resources that have the greatest impact on learning.

### Research Questions—System Requirements/Challenges

- How do resources (eg, physical, financial) influence optimal simulation learning?
- How can institutions address operational scale issues to ensure that their educational outcomes are being

achieved and sustained? [eg, Can portable systems (eg, in situ) operated by a cadre of full-time, well-trained simulation experts lead to effective outcomes? How do institutions maximize the value of permanent simulation centers with large requirements of staffing and instructors?]

### **Simulation Program Implementation**

Many simulation programs are now challenged with capacity issues as an increasing number of departments, disciplines, and professions are adopting and integrating simulation into their overall curricula. As a result, curriculum leaders must identify ways to optimize the time spent at the simulation center on those activities that take most advantage of interactive, hands-on, resource-intensive training.

Another important issue is related to those disciplines and/or countries in which the opportunities for experiential learning in actual clinical settings are diminishing (eg, due to more healthcare professionals entering the field without a concomitant increase in clinical sites, financial disincentives for clinical care professionals to spend time teaching students). Stakeholders representing academic institutions, medical and nursing licensing (organizations that grant licenses for individuals to practice), and accrediting bodies (organizations that grant accreditations to institutions of higher learning) are interested in the quantity and quality of learning in the clinical environment that can be substituted/complemented with the simulation learning environment. Some nursing licensing organizations in the United States have now already allowed for up to 25% of clinical learning occur in a simulated environment.<sup>28</sup> As programs have already or will soon face these same challenges, research should be prioritized to study different models, in different contexts, to provide guidance to stakeholders at all levels.

### **Research Questions—Simulation Program Implementation**

- What kind of learner preparation is necessary to optimize simulation-based learning? How should nonsimulation learning be balanced with simulation learning?
- How do characteristics of the environment (eg, student/context) affect learning in simulation (eg, on-site, offsite, individual versus group, peers versus multidisciplinary, timing frequency, procedure embedded versus isolated)?

### **Summary on the Research Agenda for Instructional Design**

Research related to instructional design needs to move beyond descriptions of how a local institution uses its simulation systems and curricula to train its learners. Furthermore, studies that compare simulation training to traditional training or no training (as is often the case in control groups), in which the goal is to justify its use or prove it can work, do little to advance the field of human learning and training. As Eva suggests, “meaningfully contributing to discussions of ‘Why did it work?’ or ‘Why didn’t it work?’ can go a long way towards ... prompting previously unthought ways of dealing with inherently difficult issues.” Eva challenges the research community to “move away from research that is intended to prove the effectiveness of our educational endeavors and to-

wards research that aims to understand the complexity inherent in those activities.”<sup>29</sup>

### **Outcomes Measurement**

This research agenda on outcomes measurement focuses on issues that are poorly addressed in prior research and therefore need further investigation. The important issue of psychometric properties pertaining to any measurement has been thoroughly dealt with elsewhere<sup>30</sup> and will not be addressed in detail in this paper. However, we anticipate aspects of validity, reliability, and standard setting to be implicit regarding any future studies on measurement instruments.

The structure for dealing with the topic of outcomes measurement in this article relates to Kirkpatrick’s four levels of evaluating the effect of training: (1) Reaction; (2) Learning; (3) Behavior; and (4) Results in the organization.<sup>31</sup> We consider these four aspects as inter-related rather than hierarchically ordered levels. Yet, for the convenience of formulating a research agenda, we deal with the four aspects one at a time in the subsections below.

#### **Kirkpatrick Level—Reaction**

Measuring learner reaction regarding satisfaction with a course or a learning session is trivial and common to apply immediately after any course. It can serve a purpose to convince stakeholder groups to support simulation endeavors but does not hold great promise for scientific advances in the field. Little is known about reactions on a long-term basis. Moreover, recent studies indicate that simulation-based learning might evoke a number of other reactions beyond mere satisfaction. How these reactions affect the cognitive,<sup>32,33</sup> emotional,<sup>34</sup> and social dimensions<sup>14</sup> of learning<sup>35</sup> is poorly researched in the domain of simulation-based learning. Finally, little is known about how simulation training affects instructors and how the clinical context reacts to receiving learners after simulation-based learning.

#### **Research Questions—Kirkpatrick Level—Reaction**

- What are the short- and long-term, intended and unintended reactions to simulation-based learning beyond mere satisfaction—among learners, instructors, and institutions? To which elements in the simulation setting do learners and instructors react at all?
- How do these reactions relate to or impact the three dimensions of learning (eg, cognitive, emotional, and social) in simulation settings and on future behavior and performance in healthcare settings?
- What kind of data and measurement instruments can be identified or should be developed to measure broad aspects of reactions to simulation-based learning?
- How do results from measuring these reactions inform the design, conduct, and evaluation of simulation-based learning and assessment programs?

#### **Kirkpatrick Level—Learning**

An increasing number of studies report on measuring learning from simulation-based learning. However, many are controlled experimental studies on small numbers of subjects including groups that are not the intended target groups (eg, studies on students rather than trained health professionals). Hence, large-scale studies on appropriate target groups are one area for future research. Related to this area are the ques-

tions of how subjects' prior knowledge, skills, and professional cultures impact their learning. Three additional issues are important to address:

- The problem of measurement points (eg, when and in what situations learning outcome is measured).
- The effect of testing on learning.
- The concept of learning outcome.

Regarding measurement points, there is an increasing awareness among researchers—inspired from theories on motor skills learning—that “true learning” has to be measured by retention and/or transfer.<sup>35</sup> Studies from skills learning have demonstrated that immediate learning outcome can be misleading regarding “true learning” and in some cases immediate learning outcome shows the opposite direction of learning outcome measured as retention or transfer.<sup>36</sup> That has implications for reviews compiling quantitative studies on the effect of simulation-based learning, and conclusions might be distorted if attention to measurement points is lacking.

Regarding the effect of testing on learning, recent studies have demonstrated that test-enhanced learning, which has been firmly documented in knowledge learning,<sup>37</sup> also applies to clinical skills learning.<sup>38,39</sup> Although this topic needs far more research into the mechanisms explaining the phenomenon of test-enhanced skills learning, it draws attention to being cautious with applying pretests and immediate post-tests. Furthermore, the topic of how outcome measurement can be used for learning needs further investigation. To that end, we know very little about how personal and contextual conditions influence the testing effect. Preliminary studies indicate a complex relation between test, stress, gender, and learning.<sup>39</sup>

The concept of outcome is related to questions about the basic perception of learning. Frequently, simulation-based learning seeks to train learners to achieve a certain standard of performance. However, as Schwartz indicates, any education and training should be seen as a preparation for future practice, in part because the skills are to be applied in unstandardized clinical settings and hence need some adaptation to the situation.<sup>40</sup> This perspective emphasizes the innovative dimension of performance and not only the efficiency dimension. Outcome studies related to simulation have until now primarily focused on predefined standards of performance, and little is known about how simulation training contributes to preparation for future learning. Closely linked to this concept is the notion of deliberate practice, which has received quite some attention in research on simulation-based learning.<sup>23,41</sup> However, prior focus has primarily been on the efficiency dimension, ie, mastery of specific competencies, whereas the innovative dimension, ie, ability to adapt to situational challenges, and reflection in and on practice remain under-researched. Recent studies draw attention to how setting the focus on process goals rather than outcome goals might lead to better learning.<sup>42</sup> Other studies question whether structured step-by-step learning approaches are an advantage over directed self-guided learning.<sup>43</sup> Far more studies into this topic are needed.<sup>44</sup>

### **Research Questions—Kirkpatrick Level—Learning**

- What kind of learning needs assessment is required regarding simulation-based learning, and what instruments need to be developed to better estimate learning needs accordingly?
- What is the effect of simulation-based learning on learning outcomes when implemented on a broad scale in educational programs?
- Which personal (eg, motivation, self-efficacy), neurobiological (eg, gender, stress hormones), and contextual (eg, simulation versus clinical setting, formative versus summative formats) factors influence test-enhanced skills learning and in what way?
- How can process goals related to simulation-based learning be identified, defined, and measured in simulation settings and clinical settings?
- What is the effect of simulation-based learning on “preparation for future learning” and how can this construct be defined and measured?

### **Kirkpatrick Level—Behavior**

Quite a few studies have addressed the effect of simulation-based learning on behavior. Frequently, simulation training seeks to induce a standard set of behaviors according to guidelines for practice or teamwork/communication.<sup>45</sup> However, several studies indicate that compliance with the standards in practice is not optimal. In part, this is explained by poor retention of the learning. Yet, other factors such as fear of failure and organizational responsiveness might contribute to low application of learned behavior from the learning setting into behavior in the operational healthcare setting. Hence, more research is needed on enabling and hindering factors in the individual and organizations and on how the simulation learning can accommodate these.

### **Research Questions—Kirkpatrick Level—Behavior**

- What are the enabling and hindering factors, beyond learning decay, to application of simulation-based learning outcomes in healthcare practice?
- What outcome measures are most relevant to encompass the application of behaviors to healthcare settings, including the ability to adapt to different contextual factors?
- How do we measure the complexity of behavior at the individual, team, and organizational level and the interconnections between those levels in their influence on behavior?

### **Kirkpatrick Level—Organization**

There are many intuitive beliefs and assumptions about the advantages of simulation-based learning. However, there is a paucity of studies on learning needs analyses and the cost-effectiveness of applying simulation-based approaches.<sup>46</sup> Yet, it is possible to use simulation settings to reveal learning needs at the individual, team, and organizational level. Only a few studies demonstrate the effect of simulation-based learning on quality of patient care and safety,<sup>45</sup> and this is an area that requires more research. In this regard, there is a need for identifying and establishing databases of quality issues that can be used to study the effect on healthcare organizational level. Moreover, regarding impact on organizations, it is likely that a wide array of indicators

related to healthcare organizations (eg, quality indicators that organizations use to measure success are often beyond the scope of most simulation research) will have to be identified. Finally, the issue of how simulation learning impacts teaching and learning strategies in clinical settings is another area for future scientific inquiry.

**Research Questions—Kirkpatrick Level—Organization**

- What are the needs for simulation-based learning within the organization and how can these be identified, analyzed, and described?
- What is the impact of simulation-based learning on healthcare organizations regarding clinical practice, work organization, quality of care, and patient outcomes?
- What kind of data and databases regarding work organizations, quality of care, and patient outcome can be identified or should be developed to monitor and associate educational variables with healthcare organizational outcomes?
- What kind of databases regarding learners’ educational needs, experience, and performance can be identified or should be developed to monitor and associate educational variables and organizational outcomes?

**Summary of the Research Agenda for Outcomes Measurement**

In summary, there is need for much more research related to all four Kirkpatrick levels. This includes for a large part identifying or developing new outcome measures. Irrespective of the outcome measure level, a broad array of research approaches is needed, often in combination. Moreover, a broad search for conceptual and theoretical frameworks is required for these studies drawing upon several disciplines within biomedical science, epidemiology, and the behavioral and social sciences. However, it is possible that existing theories fall short and probably new models and theories relating to the simulation context need to be developed.

**Translational Research**

Translational research has been described as the process that leads from evidence-based medicine to sustainable solutions for public health problems. The National Institutes of

Health has made translational research a priority for forming centers.<sup>47</sup> The purpose of translational research is to bring novel therapeutic strategies and/or equipment developed in the laboratory to the user. The concept derives from drug development—from the development/testing in the laboratory, moving to clinical trials with human beings, to the implementation of the new recommended treatment in organizations. It is referred to as the “bench to bedside” concept (Table 3). Two translational blocks are described: phase 1 (T1) and phase 2 (T2).<sup>48</sup> The goals, settings, and investigational designs differ considerably in the two phases. T1 takes place in the experimental setting, and the studies are typically randomized controlled trials on a selected study sample. T2 studies investigate how findings from the selected groups in T1 apply to a broader study population and investigate the acceptability and the cost effectiveness. T2 research requires different research skills and methods, such as implementation science and evaluating interventions. Cohort studies and pre-post study designs might be necessary to provide answers to T2 types of questions, and a more qualitative approach or a nonexperimental design might be necessary to demonstrate improvements.<sup>49</sup> T2 studies will need multidisciplinary teams with expertise in different fields such as biostatistics, health economics, and health care delivery.<sup>50</sup> Recently, a phase 3 (T3) has been included to convert treatments/strategies, shown to be effective and cost-effective in T2, into sustainable solutions.<sup>51</sup> Each step can generate new research questions that must be answered through a research continuum that requires different methods and a continuous bidirectional engagement with the global research community.<sup>52</sup> Observational research that may generate research questions to define health problems is also included.<sup>53</sup>

In this article, the concept of translational research is applied to healthcare education, and more specifically to simulation-based learning. In this section, simulation-based learning encompasses the pedagogical concept (the briefing, debriefing, and feedback techniques used)—the package around the tool to facilitate learning and not the tool itself.<sup>18,54,55</sup> Ideally, basic science (T1), clinical trials (T2), followed by defined community interventions (T3) and continuous improvement based on the synthesis of evidence should lead to environ-

**Table 3.** An Example of the Phases in Translational Research in Medical Education Using Simulation-Based Learning as an Example

Setting	Phase 1 (T1) Bench	Phase 2 (T2) Bedside/Simulation Centre	Phase 3 (T3) Community Setting
Educational research	Experimental studies in the laboratory and randomized control trials	Studies addressing: Acceptability Trainee’s Facilitators Economics Cost-effectiveness Logistics	Guidelines for when and how to use the educational method Implementation in other communities (where relevant)
Examples of study questions	How to use it? Pedagogical concept Briefing Debriefing and feedback Effectiveness How to train the trainers?	How to adjust to? Local context Other type of users How to address barriers? How to implement in curriculum?	How to implement in larger scale? How to implement in primary health care?

mental change (T3). The concept should lead to translation and sustainability. However, one of the challenges is the lack of information and evidence of a direct effect, making it difficult to select between different educational methods. Is simulation-based learning just a new “drug,” more expensive but equally effective as an old “drug”? Without the necessary documentation, it becomes difficult for regulatory bodies to advocate the use of simulation-based learning. Hence, in simulation research, the concept of translational science can also be perceived as demonstrating (1) the effect in the laboratory setting; (2) the effect on learners’ clinical behavior; and (3) the effect on patient outcome.<sup>56</sup> Yet, the simulation education community should also be prepared to link from bedside to bench to inform and generate further research questions back to the simulation program. Simulation might also have a role in needs assessment, as it can be used as an analysis and intervention tool in the workplace.<sup>57</sup>

#### Research Questions—Translational Research

- How can simulation be used to analyze the interplay between patients, healthcare professions, technology, and organization?
- How can simulation settings contribute to revealing learning needs and inform the design, implementation, and evaluation of initiatives to enhance organizational performance?
- How do principles of learning and instruction derived from simulation-based learning in standardized research projects (“the bench”) (T1) translate into learning in simulation centers or local training practice?
- How can users be identified who will benefit from a specific educational method—can simulation be used to identify and fulfill learning needs of specific target populations?
- How do principles of learning and instruction derived from simulation-based learning translate into learning situations in clinical practice and in the organization of educational programs?
- How can principles of learning and instruction derived from simulation-based learning be implemented in curricula for individuals and for teams in clinical practice?
- What characterizes areas (eg, individuals, tasks, context-dependent features) in which simulation-based learning will be a clear advantage over clinical learning regarding learning efficiency and cost-effectiveness?

## SUMMARY

Simulation-based research is still a relatively new field, where it can play an important role in the analysis of the interplay between humans, technology, and the healthcare organization. Simulation is a complex service intervention that operates in a complex social system<sup>58</sup> and often involves a needs analysis to identify learning objectives and test possible solutions at the bench (simulation laboratory), conduct multifaceted interventions, and implement evidence-based, sustainable solutions to problems in healthcare. We believe that this type of research should be based on different methods and is best conducted by a multiprofessional team of experts.

The Utstein Style Meeting in Copenhagen was carried out with the aim of identifying the state-of-the-art of educational simulation research and further focusing the research agenda in simulation-based learning. Another goal was to identify the future directions for educational simulation research, with central themes and research questions: instructional design, outcome measurement, and translational research. The research questions are not exhaustive and they are intended to be challenged, rebuked, modified, and will evolve over time. The participants in this meeting and the authors of this article also contributed to the development of the 10 topic groups presented at the SSH Research Summit that preceded the 2011 International Meeting on Simulation in Healthcare. These meetings and publications that result will complement each other and aim to provide further guidance to the simulation and healthcare community at large. An improved understanding of conceptual issues and evidence of their effectiveness will ultimately guide the development, use, and funding of simulation. Finally, these efforts reflect the growing awareness that research and its publication are critical to advancing the field of simulation for the benefit of healthcare educators, clinical professionals, and patients.

## APPENDIX

References suggested by participants in the Utstein Meeting, June 20–22, 2010, Copenhagen, Denmark.

This is the list of references suggested by the participants. The 15 articles that cover most of the topics related to the meeting are indicated in bold.

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