Five Topics Health Care Simulation Can Address to Improve Patient Safety: Results From a Consensus Process

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Five Topics Health Care Simulation Can Address to Improve Patient Safety: Results From a Consensus Process

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Objectives: There is little knowledge about which elements of health care simulation are most effective in improving patient safety. When empirical evidence is lacking, a consensus statement can help define priorities in, for example, education and research. A consensus process was therefore initiated to define priorities in health care simulation that contribute the most to improve patient safety.

Methods: An international group of experts took part in a 4-stage consensus process based on a modified nominal group technique. Stages 1 to 3 were based on electronic communication; stage 4 was a 2-day consensus meeting at the Utstein Abbey in Norway. The goals of stage 4 were to agree on the top 5 topics in health care simulation that contribute the most to patient safety, identify the patient safety problems they relate to, and suggest solutions with implementation strategies for these problems.

Results: The expert group agreed on the following topics: technical skills, nontechnical skills, system probing, assessment, and effectiveness. For each topic, 5 patient safety problems were suggested that each topic might contribute to solve. Solutions to these problems and implementation strategies for these solutions were identified for technical skills, nontechnical skills, and system probing. In the case of assessment and effectiveness, the expert group found it difficult to suggest solutions and implementation strategies mainly because of lacking consensus on metrics and methodology.

Conclusions: The expert group recommends that the 5 topics identified in this consensus process should be the main focus when health care simulation is implemented in patient safety curricula.

Key Words: simulation, patient safety, consensus process

(J Patient Saf 2016;6:00: 00–00)

There is growing evidence that health care simulation contributes to increased quality of care and survival through skills training and team training.1–3 The use of health care simulation does however reach beyond education and can probably impact patient safety beyond improving skills, knowledge, and attitudes in health care professionals.4–7 One example is the use of in situ simulation in risk assessment and management to detect system flaws that can be mitigated before they may combine to promote errors.8

Previous consensus meetings have proposed strategies for improving research in health care simulation by suggesting research areas and providing guidance for the conduct of such research.9,10 The 2008 Academic Emergency Medicine Consensus Conference also produced an extensive number of articles with recommendations on the use of simulation-based education and evaluation in medical education.9 Similarly, we think it is necessary to define more clearly ways in which health care simulation can contribute most effectively to improve patient safety. Some other reviews have touched on this issue, although they have not addressed it directly. For example, a recent review describes how simulation can promote the 6 core competencies of medical practitioners as described by the Accreditation Council for Graduate Medical Education in the United States and thus contribute to improved medical care.10 The Patient Safety Curriculum Guide by the World Health Organization emphasizes simulation as an integral part of any patient safety curriculum.11

Simulation in health care has however many facets, and no one has attempted to delineate the most effective use of health care simulation in improving patient safety. When a scholarly field in health care has little existing evidence available, a consensus statement by subject experts can help to define priorities in education, clinical practice, organization, planning, and research. Commonly used methods for establishing consensus are the Delphi method or the nominal group technique (NGT).12

We determined that the time is right for creating such a consensus statement about simulation and patient safety to provide guidance to patient safety and simulation communities and to suggest research activities that are most likely to enhance or demonstrate the effect of simulation on patient safety. We initiated a consensus process to accomplish this goal. This article reports the methods and results from the consensus process and discusses its findings.

METHODS

The consensus process was based on a 4-stage modified NGT13,14 similar to that performed in other studies.15 An international expert panel, selected based on their reputation and experience in simulation and patient safety, was invited to take part in the process. The experts were identified through the professional network of the project group, a search in relevant scientific databases (PubMed, CINAHL, ERIC), and through suggestions from other group members. We aimed for a group representing different countries and a mix of professions and disciplines. Some of these experts had participated in previous consensus meetings about simulation.4,5

Stage 1

In stage 1, the expert group was briefed on the process via e-mail, and each individual was asked to propose 5 topics in health care simulation that would contribute the most to improve patient...
safety. All topics were sent to the project coordinator (S.J.M.S.), who collected them in a worksheet (Microsoft Excel for Mac 2011, Microsoft Corporation; Redmond, WA) without ranking, categorizing, or editing them.

**Stage 2**

In stage 2, the expert group received the worksheet with all topics provided in stage 1. They were asked to consider all topics and propose a prioritized list of 10. By asking for 10 topics, we prevented the experts from only contemplating and nominating the same 5 topics as in stage 1. We also encouraged the experts to combine topics they considered to be similar. They were also asked to attach notes or comments to the topics suggested.

**Stage 3**

In stage 3, the prioritized topics from round 2 were combined by the project leader (S.J.M.S.) to create an overall list, using a modified version of a system described by Delbecq and Van de Ven in 1971 and recently used in a similar consensus process. In this system, the suggested topics were first awarded points depending on their rank in the individual top 10 lists from each expert. A first place ranking was awarded 10 points, a second place 9 points, and so forth. Two extra points were awarded to a topic for every time it was suggested in the top 10 lists of one of the experts, allowing for a maximum of 44 extra points if suggested by all the experts. This point awarding system allowed the ranking of the topics to be based not only on the individual ranking of each topic by the experts but also on the frequency they were suggested by all the experts, thus allowing frequently suggested topics with low scores to be considered too. The overall top 5 topics and next 5 “runner-ups” identified in this stage were then presented to the expert group 2 weeks before the consensus meeting.

**Stage 4**

Stage 4 was performed as a 2-day consensus meeting in June 2012 at the Uistean Abbey outside Stavanger, Norway. Four of the experts, who were part of the project group, acted as group leaders and facilitated the discussions. We defined the following 4 goals for the meeting:

- **Goal 1**: Agree on the final list of 5 topics in health care simulation that contribute the most to improving patient safety.
- **Goal 2**: Define the patient safety problems that are related to these topics, that is, which are underlying the topic or which might be solved by ideas within the topic.
- **Goal 3**: Describe possible solutions to the problems identified in goal 2, when considering the topics from goal 1.
- **Goal 4**: Suggest implementation strategies for the solutions identified as part of goal 3.

The goals were addressed in small groups, and the results were presented with a brief plenary discussion and final summary. Goals 1 and 2 were discussed in 2 groups on day 1 with the summary and conclusion at the beginning of day 2. Goals 3 and 4 were discussed in 4 groups on day 2 and summarized and concluded at the end of the meeting on day 2.

### RESULTS

Of the 24 invited experts, 22 accepted the invitation to take part in the consensus process (Table 1). Two experts were not able to physically attend the consensus meeting in stage 4 but contributed to the discussion via e-mail and videoconference.

A total of 108 topics were suggested in the first stage. This list was reduced to 68 topics in stage 2 (Appendix 1), and points were awarded to the topics of this list in stage 3 as previously described. A challenge in this process was that several topics were similar in theme (e.g., “use of simulation to test new equipment before introduction to clinical practice” and “using simulation for design, redesign, and testing of clinical practice protocols”), but different wording was used. Such nuances made it difficult to combine the topics. Some topics were therefore awarded points as separate topics although they could be considered thematically as 1 topic. It was then left to the expert group to discuss and decide in stage 4 if some of these topics could be combined, which then changed the relative ranking of the topics. By leaving this to the experts, we hoped to avoid bias by the project leader in combining these topics. A further rationale was that the experts would have a better understanding of any similarities in the topics that would allow for combination since they had suggested them.

The 10 topics that received the highest score in stage 3 were as follows:

1. Handover/handoff
2. Technical skills training
3. Credentialing/simulation-based high-stakes assessment of health professionals’ readiness for practice in well-selected junctions
4. Translational science/studies on cost-effectiveness and evidence of effect
5. Interprofessional training and collaboration
6. Nontechnical skills simulation
7. Team training
8. Simulation as a required assessment for health care professional in all acute care settings, with fail/pass consequences, in all levels of a career
9. Top-down simulation-based training of faculty to improve their debriefing skills
10. Use of simulation to test new equipment before introduction to clinical practice

#### Goal 1 of Stage 4

The final list of 5 topics in health care simulation that contribute the most to improving patient safety as agreed on by the expert group contained technical skills, nontechnical skills, system probing, assessment, and effectiveness. The expert group did however find it difficult to rank the 5 topics according to their importance, especially because 2 of the topics, assessment and effectiveness, can be considered to be part of the other 3. The final 5 topics are therefore presented as equally important, and Figure 1 illustrates how the expert group felt they interconnected.

#### Goal 2 of Stage 4

Based on the discussion in small groups, the experts proposed a list of up to 5 patient safety problems that each topic is addressing or may contribute to solve. Table 2 lists the patient safety problems for each of the 5 topics, unedited as proposed by the groups to the rest of the expert group.

#### Goals 3 and 4 of Stage 4

The expert group decided to combine the last 2 tasks as 1. Three groups worked with 1 of the topics technical skills, nontechnical skills and system probing, respectively, and the fourth group worked with the topics effectiveness and assessment. The fourth group quickly established that it was difficult to suggest and describe solutions and implementation strategies for the topics effectiveness and assessment. The group was able to suggest solutions for effectiveness but felt that the task could not be solved within the time frame given. In the case of assessment, the group decided that there were too many unanswered questions regarding the use...
of assessment in health care simulation to suggest solutions and implementation strategies. There is, for example, little proof available on metrics and methodology and how and when assessment should be performed. The group therefore recommended that both effectiveness and assessment be the theme of a new separate Utstein style meeting to discuss and agree on solutions for how to prove effectiveness of health care simulation on patient safety and how to implement these solutions.

The expert group discussed the results and challenges of tasks 3 and 4 in plenum and agreed on the results before the meeting was adjourned. Table 3 lists the solutions proposed by the groups to solve the patient safety problems previously identified for the topics technical skills, nontechnical skills, and system probing. Table 4 lists the implementation strategies for these solutions within the same topics. Both tables present the unedited content as presented by the groups to the rest of the expert group.

**DISCUSSION**

The expert group was able to identify and agree on 5 topics in health care simulation that contribute the most to improving patient safety. These topics are technical skills, nontechnical skills, assessment, effectiveness, and system probing. As stated earlier, the expert group agreed that the topics could not be ranked or sequenced. The expert groups recommend that these 5 topics be the focus of the use of simulation in patient safety initiatives. In the following, we will put these topics into a context, describe their connections, and discuss how they can be used to guide future patient safety initiatives.

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**TABLE 1. Expert Group**

<table>
<thead>
<tr>
<th>Name</th>
<th>Country</th>
<th>Affiliation at the time of the meeting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanja Manser</td>
<td>Switzerland</td>
<td>Université de Fribourg</td>
</tr>
<tr>
<td>Charlotte Ringsted</td>
<td>Denmark</td>
<td>University of Copenhagen and Capital Region</td>
</tr>
<tr>
<td>Ronnie Glavin</td>
<td>United Kingdom</td>
<td>Scottish Clinical Simulation Centre</td>
</tr>
<tr>
<td>Nikki Maran</td>
<td>United Kingdom</td>
<td>Scottish Clinical Simulation Centre</td>
</tr>
<tr>
<td>Marcus Rall†</td>
<td>Germany</td>
<td>Institute for Training and Patient Safety—InPASS</td>
</tr>
<tr>
<td>David Gaba*</td>
<td>United States</td>
<td>Stanford University</td>
</tr>
<tr>
<td>Vinay Nadkarni</td>
<td>United States</td>
<td>Children’s Hospital of Philadelphia</td>
</tr>
<tr>
<td>Tim Draycott</td>
<td>United Kingdom</td>
<td>Spire Bristol Hospital</td>
</tr>
<tr>
<td>Dimitrios Stefanidis</td>
<td>United States</td>
<td>Carolinas Medical Center</td>
</tr>
<tr>
<td>Amitai Ziv</td>
<td>Israel</td>
<td>Israel Center for Medical Simulation (MSR), Sheba Medical Center</td>
</tr>
<tr>
<td>Jette Led Sørensen</td>
<td>Denmark</td>
<td>Juliane Marie Centre for Children, Women and Reproduction, Rigshospitalet, University of Copenhagen</td>
</tr>
<tr>
<td>Olli Vaisanen</td>
<td>Finland</td>
<td>National Institute for Health and Welfare, Finland</td>
</tr>
<tr>
<td>Rajesh Aggarwal</td>
<td>United Kingdom</td>
<td>Imperial College Healthcare NHS Trust</td>
</tr>
<tr>
<td>Suzan Kardong-Edgren</td>
<td>United States</td>
<td>Washington State University</td>
</tr>
<tr>
<td>Filippo Bressan</td>
<td>Italy</td>
<td>Ospedale Santo Stefano—USL 4—Prato</td>
</tr>
<tr>
<td>Barry Issenberg</td>
<td>United States</td>
<td>Michael S. Gordon Center for Research in Medical Education</td>
</tr>
<tr>
<td>Mary E. Mancini</td>
<td>United States</td>
<td>University of Texas</td>
</tr>
<tr>
<td>Torben Nordahl-Amoroe</td>
<td>Sweden</td>
<td>Sahlgrenska University Hospital Simulation Center</td>
</tr>
<tr>
<td>Eldar Søreide†</td>
<td>Norway</td>
<td>Stavanger Acute Medicine Foundation for Education and Research</td>
</tr>
<tr>
<td>Karina Aase†</td>
<td>Norway</td>
<td>University of Stavanger</td>
</tr>
<tr>
<td>Doris Østergaard†</td>
<td>Denmark</td>
<td>Danish Institute for Medical Simulation</td>
</tr>
<tr>
<td>Peter Dieckmann†</td>
<td>Denmark</td>
<td>Danish Institute for Medical Simulation</td>
</tr>
</tbody>
</table>

*Did not attend stage 4.
†Members of the project group.
<table>
<thead>
<tr>
<th>Technical Skills</th>
<th>Non-Technical Skills</th>
<th>System Probing</th>
<th>Effectiveness</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician technical competence</td>
<td>Fragmentation of care</td>
<td>Unaware of existing patient safety problems</td>
<td>Lack of evidence/paucity of data that demonstrate that simulation is effective and cost-effective</td>
<td>Poor competence leads to patient harm</td>
</tr>
<tr>
<td>- Rarely assessed objectively</td>
<td>- Professional silos</td>
<td></td>
<td></td>
<td>- Poor definition of competence</td>
</tr>
<tr>
<td>- Lack of standards</td>
<td>- Hierarchies, culture, roles</td>
<td></td>
<td></td>
<td>- Lack of linkage between tests of competence and actual competence</td>
</tr>
<tr>
<td>- Limited performance metrics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Incomplete learning retention</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Optimal maintenance training unknown</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction of new technologies and procedures</td>
<td>Transitions between routine and nonroutine activities</td>
<td>Lack of probes to identify processes at individual, team, and system levels</td>
<td></td>
<td>Lack of awareness that mistakes were being made</td>
</tr>
<tr>
<td>- Multiple new technologies/procedures being introduced in suboptimal ways</td>
<td>- &quot;Mode shift,&quot; required skills, awareness</td>
<td></td>
<td></td>
<td>- Reflective skills?</td>
</tr>
<tr>
<td>- Appropriate learning not ensured</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-risk/low-frequency procedures</td>
<td>Lack of shared understanding</td>
<td>Suboptimal link between patient safety challenges (outcomes) and training interventions</td>
<td></td>
<td>Lack of accountability</td>
</tr>
<tr>
<td>- High-risk and/or infrequently encountered procedures more likely to lead to patient harm</td>
<td>- Lack of systems approach and anticipatory guidance</td>
<td></td>
<td>- Systematic measurement/accountability of system</td>
<td></td>
</tr>
<tr>
<td>Learning on patients</td>
<td>Monitoring, error detection, and recovery</td>
<td>System complexity—lack of appropriate research to deal with dynamic system</td>
<td></td>
<td>Punitive patient safety culture</td>
</tr>
<tr>
<td>- Most procedural learning still occurs on patients putting them at risk for harm</td>
<td></td>
<td></td>
<td>- Openness and ability to talk about error</td>
<td></td>
</tr>
<tr>
<td>- Optimal balance between simulator/patient learning unknown</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Learner overconfidence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implementation challenges/resistance to change</td>
<td>Context complexity, interdependence, dynamics</td>
<td>Suboptimal link between patient/public perception/experience of safety and interventions (educational, system)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Implementation of already existing best practices faces several challenges (time, cost, buy-in, logistics, resources, faculty engagement)</td>
<td>- Related to limits of human performance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Resistance to change in culture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Suboptimal curricula</td>
<td></td>
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</tr>
</tbody>
</table>

The results are presented unedited as they were presented for plenary discussion by the groups working with their assigned topic.
Technical and Nontechnical Skills

Health care providers must possess a combination of technical and nontechnical skills, as reflected in the 7 Canadian Medical Education Directions for Specialists (CanMEDS) roles: medical expert, communicator, health advocate, professional, scholar, collaborator, and academic.\textsuperscript{16} Technical skills are traditionally the core element of patient management and have always been part of health care training and the competence-as-performance discourse.\textsuperscript{17} In recent years, nontechnical skills training has received increased attention and is now an integral part of many training programs in health care. One example is the TeamSTEPPS program that aims to improve quality of patient care through team training.\textsuperscript{18} Both technical and nontechnical skills trainings are important; training one without the other is likely not effective for patient safety outcomes. Having good nontechnical skills could allow health care providers to concentrate more on the technical side of the task. By, for example, delegating subtasks to team members and reducing one’s own workload, an additional safety layer is introduced in the technical performance. Conversely, good technical performance might leave the mental resources to actually draw on the help of others. The labels of nontechnical skills are similar across systems and context and are as such generic. However, to what extent they are brought to life is very much context specific. Surgeons will, for example, do different things to maintain situational awareness than anesthesiologists; they need to understand different types of information. It therefore seems likely that certain combinations of nontechnical skills are more effective than others across contexts. This context dependency of nontechnical skills combinations to improve technical skills performance remains to be studied.

Skills training using simulation play a central part in this discourse, and testing of skills is widespread in health care education, for example, using the Objective Structured Clinical Examinations (OSCE). Thus, there seems to be a well-defined mutual understanding about what good technical performance is. The nontechnical side only recently became part of the performance discourse, and testing of skills is widespread in health care education. One example is the TeamSTEPPS program that aims to improve quality of patient care through team training.\textsuperscript{18} Both technical and nontechnical skills trainings are important; training one without the other is likely not effective for patient safety outcomes. Having good nontechnical skills could allow health care providers to concentrate more on the technical side of the task. By, for example, delegating subtasks to team members and reducing one’s own workload, an additional safety layer is introduced in the technical performance. Conversely, good technical performance might leave the mental resources to actually draw on the help of others. The labels of nontechnical skills are similar across systems and context and are as such generic. However, to what extent they are brought to life is very much context specific. Surgeons will, for example, do different things to maintain situational awareness than anesthesiologists; they need to understand different types of information. It therefore seems likely that certain combinations of nontechnical skills are more effective than others across contexts. This context dependency of nontechnical skills combinations to improve technical skills performance remains to be studied.

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The results are presented unedited as they were presented for plenary discussion by the groups working with their assigned topic.

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### Table 3. Solutions Suggested by the Expert Group to the Patient Safety Problems Previously Identified for 3 of the 5 Topics in Stage 4 of the Consensus Process

<table>
<thead>
<tr>
<th>Technical Skills</th>
<th>Nontechnical Skills</th>
<th>System Probing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of validated simulators for assessment</td>
<td>Educational delivery</td>
<td>-In situ diagnostic drills (targeted and planned)</td>
</tr>
<tr>
<td>Definition of performance norms/proficiency criteria</td>
<td>-Use of simulation to develop and rehearse nontechnical skills</td>
<td>-To a purpose</td>
</tr>
<tr>
<td>Optimizing curricula</td>
<td>-Highlight (lack of) shared understanding</td>
<td>-Realistic</td>
</tr>
<tr>
<td>Ongoing evaluation</td>
<td></td>
<td>-Multidisciplinary team</td>
</tr>
<tr>
<td>Remediation programs</td>
<td></td>
<td>-Nonspecific observation and description</td>
</tr>
<tr>
<td>Development of training programs that ensure competency on simulators prior to clinical practice</td>
<td>Faculty development</td>
<td>-Unstructured/structured data collection (interviews, self/team reflection, checklists)</td>
</tr>
<tr>
<td>Documentation of patient outcomes</td>
<td>-Skills for briefing/debriefing/reflection on performance in clinical environment</td>
<td>-Combine/develop new methods</td>
</tr>
<tr>
<td></td>
<td>-Introduction of vocabulary in controlled environment</td>
<td>-Audit cases to feedback to simulation</td>
</tr>
<tr>
<td></td>
<td>-Introducing and using the language of nontechnical skills</td>
<td>-Patient tracer through journey</td>
</tr>
<tr>
<td>Training on new/existing simulators</td>
<td>Simulation demonstrations for decision makers</td>
<td>-Establish multidisciplinary stakeholders involved in patient safety to develop and use existing structured quality improvement metrics used in clinical environment</td>
</tr>
<tr>
<td>Just-in-time training</td>
<td>-Assessors, politicians, managers</td>
<td>-Apply implementation science, e.g., simulation as a complex intervention</td>
</tr>
<tr>
<td>Post-hoc simulation</td>
<td>Multiprofessional/interprofessional education</td>
<td>-Evaluate patient/family/public perception of their safety experience</td>
</tr>
<tr>
<td>Warmup</td>
<td>-Starting early and training together helps reducing the silos</td>
<td>-Involvement in the planning of simulation experiences</td>
</tr>
<tr>
<td>Error training</td>
<td>-Used for selection of future candidates and remediation of current professionals</td>
<td></td>
</tr>
<tr>
<td>Patient-specific simulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deliberate practice on simulators</td>
<td>Research</td>
<td></td>
</tr>
<tr>
<td>Definition of learning curves and performance benchmarks</td>
<td>-Requirement for research on what to provide</td>
<td></td>
</tr>
<tr>
<td>Research to define optimal training balance</td>
<td>-Using simulation to test benefits of interventions</td>
<td></td>
</tr>
<tr>
<td>Education of all parties</td>
<td>-Do it — and collect meaningful data at same time</td>
<td></td>
</tr>
<tr>
<td>Research into barriers and facilitators</td>
<td>-Numbers needed to treat — how many do we have to train to get effective outcome</td>
<td></td>
</tr>
<tr>
<td>Develop most efficient/implementation friendly curricula</td>
<td>-What are the knots and bolts of nontechnical skills and how do they relate to technical skills, task, and context</td>
<td></td>
</tr>
</tbody>
</table>

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1. Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.
There is an increasing interest in using system probing to identify patient safety problems. This can help ensure that training and system design are aligned and that requirements are met. However, we need to decide what data points to collect and how to ensure that content expertise is used in system probing. Importantly, content expertise can allow for defining which part of the system would need technical and nontechnical skills into account.

Assessment tools can be used for formative and summative assessment. Assessment of health care providers has moved from only summative assessment in the end of an education to continuous formative assessment (feedback) to facilitate learning and improve the health professionals' reflective skills, which is needed to become lifelong learners. The assessment would be facilitated by multiple formative assessments during training and aligning the tools used in the educational (simulation) settings and clinical settings. The combination of all the formative assessments performed during training can have a summative function. Beyond using assessment strategies for individual learning, tools are needed to assess simulation training effects on patient safety. Existing educational and clinical registries or outcome databases can be used, but we need to decide what data points are relevant to extract. This decision probably depends on the nature of the intervention.

Since the early days of health care simulation-based training, evaluation was at the reaction level. Later, the studies aimed at measuring the effect of simulation on patient safety in practice. To date, the approaches to measure both technical and nontechnical skills in their mutual interdependencies. One way of doing this is to develop behavioral marker systems or checklists. Validity evidence for these tools must be collected, and content expert raters need to be trained to use such tools. Importantly, content expertise in this context means the technical medical as well as human factors nontechnical expertise. This is the way to take the interdependency of technical and nontechnical skills into account.

Assessment tools can be used for formative and summative assessment. Assessment of health care providers has moved from only summative assessment in the end of an education to continuous formative assessment (feedback) to facilitate learning and improve the health professionals' reflective skills, which is needed to become lifelong learners. The assessment would be facilitated by multiple formative assessments during training and aligning the tools used in the educational (simulation) settings and clinical settings. The combination of all the formative assessments performed during training can have a summative function. Beyond using assessment strategies for individual learning, tools are needed to assess simulation training effects on patient safety. Existing educational and clinical registries or outcome databases can be used, but we need to decide what data points are relevant to extract. This decision probably depends on the nature of the intervention.

TABLE 4. Implementation Strategies Identified by the Expert Group for 3 of the 5 Topics in Stage 4 of the Consensus Process

<table>
<thead>
<tr>
<th>Technical Skills</th>
<th>Nontechnical Skills</th>
<th>System Probing</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Buy-in from certifying bodies</td>
<td>Integrate into curricula</td>
<td>Research</td>
</tr>
<tr>
<td>-Research and development norms</td>
<td>-Specify curriculum content</td>
<td>-Individual</td>
</tr>
<tr>
<td>-Research to identify best methods</td>
<td>-Create seamless transition from technical to nontechnical skills</td>
<td>-Institutional</td>
</tr>
<tr>
<td>-Funding</td>
<td>technical to nontechnical skills</td>
<td>-Societal</td>
</tr>
<tr>
<td>-Development of guidelines/pathways</td>
<td>Faculty</td>
<td>-Use data/evidence to inform</td>
</tr>
<tr>
<td>-Ensure practicing physician time to participate</td>
<td>-Find the critical mass</td>
<td>-Ongoing evaluation</td>
</tr>
<tr>
<td>-Funding</td>
<td>-Selection criteria for faculty</td>
<td>and quality improvement</td>
</tr>
<tr>
<td>-Curriculum mapping</td>
<td>Technical Skills Nontechnical Skills System Probing</td>
<td>-Implementing and evaluating adherence to guidelines</td>
</tr>
<tr>
<td>-Maintenance training</td>
<td>-Reduced insurance premiums with simulation</td>
<td>-Powerful narratives</td>
</tr>
<tr>
<td>-Learner-specific curriculum/curriculum mapping</td>
<td>-Politicians and patient involvement</td>
<td>-Best practices from other industries, solicit expertise from implementation science</td>
</tr>
<tr>
<td>-Stakeholder buy-in</td>
<td>Root cause analysis</td>
<td>-Involve patients, education of patients to become active participants in these solutions</td>
</tr>
<tr>
<td>-In situ simulation</td>
<td>-Using critical incidents from clinical practice to run simulations (in situ)</td>
<td></td>
</tr>
<tr>
<td>-Learn from implementation science</td>
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<td></td>
</tr>
<tr>
<td>-Governing body and patient involvement and buy-in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Funding</td>
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<td></td>
</tr>
</tbody>
</table>

The results are presented unedited as they were presented for plenary discussion by the groups working with their assigned topic.

Assessment and Effectiveness

Measuring the effect of simulation on patient safety in practice demands to use approaches to measure both technical and nontechnical skills in their mutual interdependencies. One way of doing this is to develop behavioral marker systems or checklists. Validity evidence for these tools must be collected, and content expert raters need to be trained to use such tools. Importantly, content expertise in this context means the technical medical as well as human factors nontechnical expertise. This is the way to take the interdependency of technical and nontechnical skills into account.

Assessment tools can be used for formative and summative assessment. Assessment of health care providers has moved from only summative assessment in the end of an education to continuous formative assessment (feedback) to facilitate learning and improve the health professionals' reflective skills, which is needed to become lifelong learners. The assessment would be facilitated by multiple formative assessments during training and aligning the tools used in the educational (simulation) settings and clinical settings. The combination of all the formative assessments performed during training can have a summative function. Beyond using assessment strategies for individual learning, tools are needed to assess simulation training effects on patient safety. Existing educational and clinical registries or outcome databases can be used, but we need to decide what data points are relevant to extract. This decision probably depends on the nature of the intervention.

Since the early days of health care simulation-based training, evaluation was at the reaction level. Later, the studies aimed at demonstrating an effect at the other Kirkpatrick levels: learning, application, and outcome. There is an increasing interest in measuring the effect of simulation-based training on patient outcome. This is difficult if the training only addresses individuals and neglects system-based influences and context. For example, if not all members of a team are trained in using a standardized terminology, the training of some members might actually hinder a good communication flow and introduce barriers between the trained and nontrained subgroups, ultimately potentially decreasing patient safety.

To understand why some initiatives work and some do not, it is important to more closely investigate the concrete implementation on a systematic level. The Helping Babies Breathe program in Tanzania is a good example, where the overall mortality was improved by implementing simple simulation-based training. However, the improvement in mortality at the individual hospital differed greatly because the training was implemented differently. Hospitals with high-frequency low-dose in situ training had better outcome than hospitals where only initial training was conducted. A recent study on the retention of skills in cardiopulmonary resuscitation supports this and indicates a retention optimum when training is repeated every 3 months.

System Probing

Despite the fact that patient safety problems are known to exist for a long time and many initiatives, including health care simulation, were launched, patient safety still remains a problem. System probing can identify those patient safety problems that can be remedied by training or system changes. The latter might be equipment missing or an inefficient layout of the department. Such system probing can serve as a needs assessment and help define learning objectives and educational interventions. On the level of learning objectives, system probing can reveal that knowledge-oriented objectives may not lead to improvement as the real challenge is rooted in attitudes and culture. It seems reasonable to assume that bulk training of an entire organization in a single topic has a stronger impact on patient safety as compared with superficial trainings in many topics in isolated spots in an organization. One example is the study by Neily et al showing a decrease in annual mortality rates of 18% by introducing team training in an organization. The system probing also allows for defining which part of the system would need further attention.
to be looked at or investigated to evaluate the value of any inter-
vention. For example, the training of a certain target group might
lose its effect because other groups that interact with the target
group are not trained or the introduction of a safety measure might
not improve safety because it is counter-balanced by risk behavior.

To really assess how effective simulation is, it is necessary to
establish relevant assessment strategies on the individual, team,
and organizational level. By taking the system probing into ac-
tount, it will also be easier to identify and take into account the
confounding variables that can make or break the success of
simulation-based interventions. For example, where an interven-
tion is provided only to parts of the department, the degree of im-
plementation is measured and not the effect of the training itself,
as was demonstrated in the Helping Babies Breathe program.34
The full effect of simulation-based intervention is probably only
released when the entire system is integrated into the intervention.
Otherwise, the intervention might stay subthreshold of impacting
the patient safety.

In line with standard risk management models, for example, the
ISO-31000:2009 standard for risk management, simulation-
based system probing should be an integrated part in any program
aiming at improving patient safety. In this context, simulation-
based system probing will not only serve as a tool for needs as-
essment and hazards identification but also provide feedback
on the effect of the simulation program by comparing preintervention
and postintervention simulations. This notion is consistent with
recommendations made by previous consensus meetings addressing
system probing.35

Although the expert group decided not to rank the 5 topics
according to importance, we propose that they can be assigned a
sequential priority. Each topic probably contributes to improve
patient safety on its own, but together, they have the potential
for synergistic impact beyond the sum of each individual topic.
As mentioned earlier, system probing can be a good starting point
and serve as a needs assessment and identify areas that need im-
provement. Technical and nontechnical simulation programs can
then be developed to meet the needs and solve the problems
identified. Assessment should then determine to what extent the
simulation program has contributed to solve the problems
identified. Future studies should explore if this model of using
simulation to improve patient safety is effective. However, mon-
itoring challenges encountered during training can also be inter-
preted on a systemic basis and would then indicate structural
challenges in an educational system rather than individual
challenges. So, the assessment of training results, further investiga-
tions in the actual work system, and refinement of training and
assessment could be another sequence, in which the topics can
be linked.

LIMITATIONS

The limitations of using NGT to answer scientific questions, and
more specifically the modified NGT used in this study, has
been discussed by others.15 Our greatest challenge with the tech-
nique occurred when we attempted to condense the suggestions
from stages 1 and 2 and to combine suggested topics having
similar content. The suggestions were often formulated as a
complete or partially complete sentence, in some cases also
including a subpremise that made it difficult to combine with
other similar suggestions.

For future attempts at using the same technique, we suggest
being clearer in the instructions to the expert group, that sug-
gested topics must be clear and concise without subpremises.
A brief explanation along with examples might help the ex-
erts, but there would be a risk that they could cause further
confusion or even suggest additional subpremises. The poten-
tial danger for the final results is that a topic might receive
fewer votes/points because it ends up being counted as 2 differ-
tent topics (i.e., “diluting” the vote). We tried to address this
potential process error by allowing the expert group to review
and revise the topic list in the initial part of stage 4.

The members of the expert group all came from either a
North American or European country. For a more global perspective,
it would have been desirable to have representatives from other
continents too. This might have voiced potential cultural differ-
ences that could influence the top 5 list. The experts did represent
different professional groups within health care. Some of the
experts also came from non–health care backgrounds, and they
helped broaden the perspective from health care itself to the more
general issues of the methodology of simulation and of patient
safety theory.

CONCLUSIONS

An international expert group identified 5 topics in health care
simulation that contribute the most to improve patient safety:
technical and nontechnical skills training, effectiveness,
assessment, and system probing. For each topic, the expert group
identified problems that each topic addresses and discussed and
suggested strategies for implementation of solutions to these
problems. Based on the discussion in the expert group, we have
suggested a framework for implementing the 5 topics. We do
acknowledge that the consensus regarding assessment in simula-
tion is lacking and warrants further experience, research, and
consensus. Proof of effectiveness is emerging, but there is still
a need for research to support the systematic effect of health
care simulation on patient safety.

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APPENDIX 1. List of topics following stage 2 of the consensus process.

Handover/handoff
Technical skills training (mastery learning, deliberate practice)
Credentialing/simulation-based high-stakes assessment of health professionals' readiness for practice in well-selected junctions such as professional schools' graduation, residency board exams, maintenance of competence for periodic licensure recertification, etc
Translational science/studies on cost-effectiveness and evidence of effect (outcome, quality, etc)
Interprofessional training and collaboration (interprofessional education [IPE], interprofessional teamwork [IPTW], CRM, communication)
Nontechnical skills simulation
Team training
Simulation as a required assessment for health care professional in all acute care settings, with fail/pass consequences, in all levels of a career
Top-down simulation-based training of faculty to improve their debriefing skills (train the trainer workshops) in the simulation environment that will then be transferred to the real-world environment where health professionals are expected to routinely reflect on their mistakes, their suboptimal doings, etc
Use of simulation to test new equipment before introduction to clinical practice
The use of simulation as a research tool to investigate the clinical environment (organization, technology, human, and culture)
Global sim
In situ simulation
Maternity
Probabilistic risk assessment using in situ “systems probes” to identify latent and actual problems
In situ simulation process improvements with interdisciplinary experts
Full team and departmental simulation training with focus on human factors and CRM, often to be performed in situ
Optimization of transfer of simulator-acquired skill to the clinical environment
Studies with clinically relevant outcome measures
Human factors and systems engineering approach: organizational dynamics that result in blending of human, machine, and environment to improve safe clinical practice
Linking simulation more closely with other risk management activities, like incident reporting
Embedding maintenance of certification/mastery into distributed training and patient care: assessment, training, refresher update, forcing functions, and personalized titration of care for anticipated emergencies “at the point of care” to the “providers at the sharp end”
Simulation as a research laboratory, as an “animal laboratory” replacement before application to humans
Simulation-based mandatory training positioned in JIT [just-in-time] crucial professional development junctions, which focus on the enhancement of skills relevant to the new professional level of the trainees
Formal adoption of simulation as a major teaching/learning strategy in academia/health professions education, rather than an add-on
The use of interprofessional simulation activities in undergraduate health professions program
Change of culture
Simulation-based training on conflict resolution skills among health professionals, using simulated (standardized) patients. Mishandling conflicts with patients, families, and staff is often sources of patient safety failures.
The best way to educate for retention with simulation initially and with deliberate practice
Effect of context/site on training effect
Improving the systematic changes after simulation.
Serious gaming
Simulation as “laboratory bench” of patient safety research
Simulation team training with human factors and CRM as a requirement for all health care professionals at least every year, perhaps more often
Training reflection in and on action and metacognitive skills as preparation for future learning
Use of patient databases to obtain information of the effect of training
Implementation of science traceability structure to simulation-enhanced patient safety performance (themes, goals, objectives, investigations, measurements, instruments)
Investigation into the implementation of simulation
Simulation-based training with proficiency-based “hard-stops”
Study of human factors of clinician performance
Self-identification of performance gaps
Using simulation for the study of efficient training protocols in simulation and clinical settings
Engagement of patients to drive simulation-based training in medicine
Development of reflection in learners
Preparing the individual health care worker to work with others
Using simulation for the study of error learning
Sims for studying general human factors issues of individuals, systems, and organizations
Effective leadership behaviors

(Continued next page)
APPENDIX 1. (Continued)

Sense of personal security
Stress management
Attitude toward making mistakes
Awareness of limitations of the individual in complex situations
Embedding simulation into the fabric of health care
Simulation and health care innovation
Use of simulation in awareness raising and the development of nontechnical skills at all levels during application of knowledge and practical skills at all levels
Intraprofessional education and clinical practice
Disclosure of errors and delivering bad news (related to nonpunitive incident reporting)
Using simulation for study of multiprofessional performance and learning
Telemedicine/teletraining/telepresence and the concept of “instant replay” with local or remote “coaching.”
Communication skills
Identification of effective communication strategies for health care professionals managing different acute patient episodes
Testing team structure
Using simulation for design, redesign, and testing of clinical practice protocols
Leadership in clinical teams
Implementation of interventions in health care
Increase our understanding of what are the key tasks/skills required for safe patient care
Opaque theorization
Interprofessional research on simulation training and assessment, as well as new technologies development (simulations and simulators need to be developed rapidly to adapt to training needs!)