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Priorities in surgical simulation research: What do the experts say?

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ABSTRACT

Introduction: Progressing the field of surgical simulation research cohesively requires organization. The purpose of this study was to establish contemporary research priorities utilizing Delphi methodology.
Methods: Surgical researchers with expertise in simulation-based research were invited to submit important questions for the field according to an organized framework. Thematic analysis was used to collapse questions into unique questions. In a second round, experts rated the importance of questions. In a third round, experts re-rated the importance of questions. A prioritized agenda was then created.
Results: Eighteen experts submitted 80 questions in round one, which were collapsed into 43. In the final round, experts rated the following question as the most important priority: "Does demonstrated competency in the simulation lab translate to clinical competency (OR etc.)?"
Conclusions: Our systematic approach identified multiple important questions to advance the field that may guide researchers and funding agencies alike.

Background

In response to the changing landscape of surgical education over the past few decades, surgical simulation training has been implemented in residency to offer trainees opportunities for deliberate practice of technical and nontechnical skills.[1–4] A recent review of surgical simulation training in surgical education reported that simulation is a cost-effective method of enhancing surgeons' exposure, confidence, and performance of technical and nontechnical skills throughout the continuum of surgeons' careers.[5] The authors also contend that as surgical techniques evolve and greater emphasis is placed on proficiency-based training, simulation will play an ever-increasing role in surgical education. As simulation has become increasingly incorporated in surgical education, research efforts to study optimal simulation methodology has been burgeoning. However, in order to organize surgical simulation research efforts systematically, it is necessary to define research priorities.

Stefanidis et al. (2012) sought to systematically create a research agenda for surgical simulation following a modified Delphi process.[6] Delphi methodology is a systematic process of soliciting expert opinion on a given topic, and deriving a group consensus.[7] The benefit of using this approach is that expert opinions can be sampled without being dominated by the opinions of particular influential individuals in the field, and consensus can be achieved through the provision of appropriate feedback. Through an iterative process, Stefanidis et al. (2012) solicited initial questions from participating experts, had the experts rate the questions on their importance to the field, and then redistributed questions to the experts to come to a consensus agreement on their importance to the field.[6] The researchers identified several important research questions to the field of surgical simulation, which included the following top three questions (i.e., in descending order of importance): "Does simulator training lead to improved patient outcomes, safety, and quality of case?", "Does training on simulators transfer to improved clinical performance?", and "Does documented simulator competence equal clinical competence?".

Four years after the aforementioned work by Stefanidis et al. (2012), a systematic review of the literature was conducted by Johnston et al. (2016) to determine the progress that has been made to research the priorities identified in the original Delphi project since 2000.[8] The authors reviewed relevant literature according to the top ten priorities previously identified for surgical simulation research. Based on their review, Johnston et al. (2016) found that since 2000, there had been numerous efforts made to research the use of surgical simulation in curricula development, skills

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assessment, decision making, and debriefing. Comparatively, little work had been done to study performance criteria needed to achieve competency using surgical simulation, and the role of simulation for certifying residents and practicing surgeons. These findings suggest that the research priorities in simulation have likely changed since they were first established.

It is also possible that technological advances and changes in surgical education paradigms in recent years may have shifted priorities for the field. For example the wide spread use of the da Vinci robotic system (Intuitive Surgical, Sunnyvale, CA)[9] has created the need for new skills curricula, and the shift towards competency-based education has generated new questions about its best implementation.

Given the changes in surgical technology and training paradigms, and the gaps in research addressing the previously-identified priorities for surgical simulation, it is necessary, to establish what experts consider to be the most important research priorities for surgical simulation today. The purpose of the present study was to identify contemporary research priorities in surgical simulation utilizing the Delphi methodology. We hypothesized that current research priorities would differ from the priorities established in the previous work by Stefanidis et al. (2012).

Methods

Initial delphi survey round

Following Institutional Review Board approval, the study team conferred and identified potential participants with documented expertise in surgical simulation research. Inclusion criteria included reputation in the surgical simulation field, and leadership positions in simulation either at their institutions or nationally. These individuals were contacted via electronic mail to submit important research questions for the field of surgical simulation through an electronic survey distributed through REDCap electronic data capture tools at Indiana University School of Medicine.[10,11] Using an organized and systematic framework (Population, Intervention, Comparison, Outcome; PICO), participating experts submitted up to five important research questions for the field. The PICO framework was originally developed in the field of clinical medicine to generate well-built clinical questions.[12] The purpose of this framework is to ensure clinical questions 1) are directly related to the patient or problem at hand, 2) define the intervention being considered, 3) consider the comparison intervention, and 4) define the clinical outcome of interest. For the current study, the PICO framework was modified slightly and the following instructions for question submission were provided to participants:

1. Topic: Develop questions whose answer would be most useful to educators and researchers in the area of surgical simulation. In some cases, a problem might be important because it is frequent and severe. In other cases, it is possible that an intervention has been well studied, but conclusions about its effectiveness are not available because of conflicting information. Think of questions and topics with the greatest opportunity for meaningful change/contribution to our education methods as they relate to improved patient outcomes.
2. Problem: Briefly and precisely describe the process.
3. Intervention: Specifically state what main intervention you are considering.
4. Comparison Intervention (if necessary): Specifically state the main alternative to compare with the intervention.
5. Outcome(s): Specifically state what the key outcome measure is. (e.g., performance, patient safety, team function, etc.)

The Research Question: Combine all five components to generate a research question in sentence form.

Our research team, consisting of researchers with experience in Delphi survey methodology, then performed a thematic analysis on submitted questions to categorize them. The categorized questions were then reviewed, and similar questions were collapsed into unique questions, while questions that did not align with the PICO framework or were unanswerable as submitted were modified accordingly or deleted.

Second delphi survey round

In the second Delphi survey round, unique questions solicited in the first survey round were combined randomly into a single survey. Participating experts from the first survey round were contacted via electronic mail to rate the importance of the questions using a 5-point Likert scale ranging from “1-Not at all important” to “5-Extremely Important”.

Third delphi survey round

Following the second Delphi survey round, responses were aggregated to determine average and standard deviation of the perceived importance. Then, questions were randomized and combined into a new survey that displayed the average and standard deviation of the previous survey round. Again, participants from the first and second survey rounds were contacted via electronic mail to rate the importance of questions using the same 5-point Likert scale.

Statistical analysis

Descriptive statistics (means and standard deviations) were calculated for each question at each survey round, which were used to rank the importance of questions for rounds 2 and 3. To assess the agreement between rankings in rounds 2 and 3, ratings were compared using an unpaired *t*-test. A p-value of 0.05 was considered significant.

Results

Eighteen surgical simulation experts with 18.3 ± 10.3 years of experience in surgical simulation participated in the study (67% response rate) (Tables 1a and 1b). Experts initially submitted a total of 80 questions, which were reduced by the study team to 43 unique, answerable questions. Thematic analysis identified 9 common themes of submitted questions: curriculum development ($n = 12$ questions), technology ($n = 8$), team training ($n = 6$), simulation for assessment ($n = 5$), patient outcomes ($n = 4$), expanding the use of simulation ($n = 2$), operating room performance ($n = 2$), simulation for selection ($n = 2$), and simulation center management ($n = 2$).

Round 2 ratings of the 43 unique questions were 3.41 ± 1.04 (range 2.39–4.3) and round 3 ratings were 3.25 ± 1.04 (range 2–4.65). From round 2 to 3, there was only one question with significantly different ratings: “Does demonstrated competency in the sim lab translate to clinical competency (OR etc.)?” (Round 2: 4.06 ± 0.94 vs. Round 3: 4.65 ± 0.61, $p = 0.03$). Based on the highest mean Round 3 ratings (and lowest standard deviations), the top 10 research questions are listed in Table 2.

Discussion

In the present study, we asked individuals with documented expertise in surgical simulation to submit important research

Table 1a
Participating expert characteristics.

Participant*	Age	Gender	Specialty	Years in Practice	Surgical Simulation Publications as first/senior author
1	34	Male	General Surgery	1	10
2	46	Male	Minimally Invasive Surgery	16	5
3	44	Male	Urology	10	20
4	62	Male	General and laparoscopic surgery	28	5
5	46	Male	General Surgery/Minimally Invasive Surgery	15	40
6	48	Male	General Surgery	16	10
7	70	Male	Thoracic Surgery	35	6
8	47	Male	Urology	14	65
9	30	Female	PhD Psychology	4	50
10	53	Male	General Surgery	21	10
11	52	Male	Minimally Invasive Surgery	22	30
12	50	Male	General Surgery	23	7
13		Male	General Surgery	15	60
14	41	Female	Minimally Invasive Surgery/Bariatric	10	3
15	75	Male	General Surgery	43	50
16	54	Female	Vascular Surgery	11	6
17	57	Male	General Surgery	23	15
Avg ± SD	**52.6 ± 11**	**17.6% Female**		**18.1 ± 10.8**	**23.1 ± 28.6**

*Participant 18 did not submit demographic data.

questions for the field using an organized, systematic framework. The surgical simulation experts who participated in our study represented multiple disciplines in surgery, had significant experience (18.3 ± 10.3 years of experience in surgical simulation), and made significant contributions to the field through publications as first or senior author (23.1 ± 28.6 publications) (Tables 1a and 1b). We found that the highest ranked questions were related to surgical skill transfer to the clinical environment, return on investment of simulation, surgical skill development, and utilizing simulation for credentialing and assessing competency.

Seven years ago, a similar study was conducted to determine the priorities for surgical simulation research utilizing Delphi methodology.[6] In that study, the authors also identified the top ten research questions for the field. When comparing the top 10 priorities between our study and the previous study, the following questions remain top priorities for the field:

1. “Does demonstrated competency in the sim lab translate to clinical competence?”
2. “Does training using simulation improve patient outcomes?”

Table 1b
Participating expert characteristics.

Participant*	Role(s) at Institution	Specialized Simulation Training	Grant funding in surgical simulation
1	Education Scientist	Yes, PhD Surgical Simulation	Yes, Institutional Grant
2	Simulation Center Director, Associate/Assistant Program Director	Yes, Center for simulation instructor course	Yes, Institutional Grant
3	Program Director	No	Yes, Federal Grant
4	Associate/Assistant Program Director	No	Yes, Institutional Grant
5	Program Director, Education Scientist, Vice Chair of Education	Yes, MHPE Simulation Course	Yes, Federal Grant, Grant funded through professional organization, Institutional Grant
6	Simulation Center Director	Yes, Lapco TT, ACS Surgical Educators Course, ATLS Instructors Course	Yes, Federal Grant, Grant funded through professional organization, Institutional Grant
7	Associate/Assistant Program Director, Research simulator development and set up/proctor simulation exercises	No	Yes, Federal Grant, Institutional Grant
8	Simulation Center Director, Education Scientist	Yes, Aura Scholar- 2 years at Univetsity of Washington	Yes, Federal Grant, Grant funded through professional organization, Institutional Grant, Other: Industry
9	Education Scientist, Assistant/Associate Dean	Yes, CMS Comprehensive Simulation Instructor Course, Fellowship in Medical Simulation	Yes, Grant funded through professional organization, Institutional Grant, Other: Industry
10	Simulation Center Director, Education Scientist	No	Yes, Grant funded through professional organization, Institutional Grant
11	Simulation Center Director, Program Director, Associate/Assistant Dean	No	Yes, Federal Grant, Grant funded through professional organization
12	Simulation Center Director, Program Director, Vice Chair of Education	Yes, TeamSTEPPS, LapcoTT	No
13	Simulation Center Director	Yes, LapcoTT	Yes, Federal Grant, Grant funded through professional organization, Institutional Grant
14	Simulation Center Director, Associate/Assistant Program Director	Yes, Team training course	Yes, Grant funded through professional organization, Institutional Grant
15	Other: Surgical Simulation Education Consultant	No	Yes, Federal Grant, Grant funded through professional organization, Institutional Grant
16	Simulation Center Director, Program Director, Vice Chair for Quality	Yes, Masters Education, Surgical Education	Yes, Institutional Grant
17	Simulation Center Director	No	Yes, Institutional Grant

*Participant 18 did not submit demographic data.

Table 2
Top 10 research questions in surgical simulation.

	Round 2 Rating	Final Rating
Does demonstrated competency in the sim lab translate to clinical competency (OR etc)?	4.06 ± 0.94	4.65 ± 0.61
Does training using simulation improve patient outcomes (vs no training)?	4.20 ± 0.94	4.41 ± 1.00
Does having a simulation center for training result in improved patient outcomes, resource utilization, and staff engagement compared to not having a simulation center and what is the return on investment?	3.94 ± 1.26	4.29 ± 0.92
Can simulation-based error identification training lead to more effective and efficient (cost and time) development of psychomotor skill compared to traditional training?	4.17 ± 0.51	4.24 ± 0.56
Does the incorporation of simulation based assessment for ACGME competency/milestones improve the objectivity of current assessment tools? (ability to discriminate trainee performance levels)?	4.30 ± 0.69	4.24 ± 0.90
Does the use of simulation for surgeon assessment for (re) certification and/or (re) credentialing purposes lead to improved patient care quality and outcomes? (compared to current practice)	4.20 ± 0.94	4.18 ± 0.95
Does the development of an open simulation curriculum lead to enhanced trainee open surgical performance (compared to current training)?	3.78 ± 1.17	3.88 ± 0.60
Does the use of simulation improve the effectiveness and efficiency of remediation programs/efforts compared to current practices?	4.06 ± 0.73	3.88 ± 0.93
Does mastery/proficiency based training lead to improved skill acquisition and transfer compared to traditional time based training?	3.39 ± 1.42	3.77 ± 1.30
Does simulation before an upcoming clinical experience lead to better learning outcomes compared to simulation training after a clinical experience?	3.83 ± 0.79	3.71 ± 0.69

3. “Does the incorporation of simulation based assessment for ACGME competency/milestones improve the objectivity of current assessment tools? (ability to discriminate trainee performance levels)?”
4. “Does the use of simulation for surgeon assessment for (re) certification and/or (re) credentialing purposes lead to improved patient care quality and outcomes? (compared to current practice)”

This finding begs the question of why these stated priorities have not yet been addressed yet. It is the author’s opinion that this lack of progress is due to the lack of adequate funding to support research efforts in these areas. Addressing these research questions will likely require significant time and resources to be studied effectively, and in the absence of grant funding, they remain top research priorities for the field. Given their ongoing importance, it is our hope that grant funding agencies will utilize the priorities identified in this study to fund relevant proposals to advance the field in a meaningful way.

There are also several novel priorities identified in the present study such as: identifying the systems-level return on investment of simulation centers, ascertaining the benefit of an open surgical skills simulation curriculum, utilizing simulation for trainee remediation, assessing the benefit of mastery/proficiency-based simulation training vs. traditional time-based training, and the benefit of utilizing simulation immediately prior to a clinical experience. Accordingly, these identified priorities should also be emphasized in future surgical simulation research efforts. The other significant difference between this study and the previous work done in this area is the participants who participated in the Delphi survey process. Unlike the previous study which was open to any member of the Association for Surgical Education, this study solicited the opinions of hand-picked experts, which likely yielded more relevant results.

Defining the current priorities for surgical simulation research can be extremely valuable for researchers, funding agencies, and industry alike. Researchers can focus their efforts to address the most important research questions, and utilizing collaborations with researchers at multiple institutions, can leverage resources across multiple sites to ensure that this research is conducted effectively and efficiently. Funding agencies and industry organizations could benefit from this work as well, as outlining the most important research priorities for the field may guide their decisions in funding relevant, timely and innovative research proposals.

There were limitations in the present study. Individuals with expertise (i.e., as defined by the research team) were approached to participate in this study. While we felt the metrics used to select participants (i.e., reputation in the surgical simulation field, and leadership positions in simulation either at their institutions or nationally) were appropriate, it is possible that the group we selected were not representative of the population. However, given the lack of available guidelines defining expertise in surgical simulation research, we are confident that our approach captured a strong representation of surgical simulation experts. In addition, while our sample size of 18 experts may be perceived as small by some, the literature suggests that an appropriate sample size for similar Delphi studies of expert opinion typically use 15–20 respondents.[13] Furthermore, we accrued a total of 80 research questions, which was very comprehensive as evidenced through our thematic analysis. Furthermore, our response rate was high (67%) and only one participant dropped out in the third survey round, which indicates that the experts who did participate in our study were invested in this work. We are therefore confident that the data obtained in this study led to the development of a robust research agenda for the field.

Conclusion

In conclusion, utilizing a systematic methodological approach, a research agenda for the field of surgical simulation was developed. The identified questions can serve as priorities to the field of surgical simulation research that may guide researchers and funding agencies alike in their pursuit of relevant and innovative research.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2019.10.017.

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