Society for Simulation in Healthcare Guidelines for Simulation Training

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Background: Simulation has become a staple in the training of healthcare professionals with accumulating evidence on its effectiveness. However, guidelines for optimal methods of simulation training do not currently exist.
Methods: Systematic reviews of the literature on 16 identified key questions were conducted and expert panel consensus recommendations determined using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) methodology.
Objective: These evidence-based guidelines from the Society for Simulation in Healthcare intend to support healthcare professionals in decisions on the most effective methods for simulation training in healthcare
Results: Twenty recommendations on 16 questions were determined using GRADE. Four expert recommendations were also provided.
Conclusions: The first evidence-based guidelines for simulation training are provided to guide instructors and learners on the most effective use of simulation in healthcare.
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EXECUTIVE SUMMARY

Simulation is being used for the training of healthcare workers in many settings and to address a variety of clinical issues. Available evidence suggests that performance improvements as a result of simulation training result in improvements in the clinical care of patients. However, current practices vary widely in simulation training, and there are no existing guidelines based on systematic synthesis of best available evidence to guide practices. In this manuscript, we present the first evidence-based guidelines relevant to simulation training that were developed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) methodology.

How to Use These Guidelines

These guidelines are primarily intended to help trainers using simulation to make decisions about the optimal training of healthcare professionals. Other purposes are to educate, to inform policy and advocacy, and to define future research needs. Guidelines are applicable to all facing simulation training uncertainties addressed herein without regard to specialty, training, or interests. Because of the complexity of the healthcare environment, these guidelines are intended to indicate the preferred, but not necessarily the only, acceptable approach to simulation training. Guidelines are intended to be flexible depending on individual circumstances. Given the wide range of practices in healthcare, educators must always choose the course best suited to the individual learner and the variables in existence at the moment of decision.

Interpretation of Strong and Conditional Recommendations

The strength of these evidence-based recommendations is either "strong" or "conditional" as per the GRADE approach and as previously described.[1,2] The words "the guideline panel recommends" are used for strong recommendations and "the guideline panel suggests" for conditional recommendations, according to the GRADE approach as previously described.[1] Strong recommendations can be adopted as a policy in most situations. Conditional recommendations require shared decision-making between trainers and learners. When insufficient evidence existed to inform recommendations, expert consensus opinion was documented.

Key questions (KQ) addressed by these guidelines and recommendations:

KQ 1: *Should in situ simulation vs the education accrued during typical organizational practice be used for training healthcare professionals to improve clinician behaviors during patient care and/or patient outcome?*

- **For healthcare provider training, we suggest that participation in in situ simulations should be considered to improve healthcare professionals' performance, patient outcomes, and healthcare system quality and safety compared with the education accrued during typical organizational practice (conditional recommendation, moderate evidence).**

KQ 2: *Should a higher frequency of short in situ simulation events with structured debriefing vs a lower frequency of short in situ simulation events with structured debriefing be used for training healthcare professionals to improve clinician behaviors during patient care and/or patient outcomes?*

- **For healthcare provider training, we suggest more frequent participation in short skill-oriented in situ simulations to benefit patient outcomes (conditional recommendation, moderate evidence).**

KQ 3: *Should in situ simulation vs another non–in situ simulation modality be used for training healthcare professionals to improve perceptions, knowledge, skills, clinician behaviors, and patient care outcomes?*

- **For healthcare provider training, we suggest the use of in situ simulation to uncover or mitigate latent safety threats in the healthcare environment and to enhance the environmental authenticity and fidelity of the experience (conditional recommendation, moderate evidence).**

KQ 4: *Should just-in-time training (JIT) vs no JIT be used for simulation training of healthcare professionals (trainees or practitioners)?*

- **The panel suggests that 5 to 30 minutes of just-in-time simulation training (within 24 hours of performance) should be implemented with healthcare professionals (trainees or practitioners) engaged in high-stakes medical or surgical procedures particularly when there has been a prolonged period of no training (>1–2 weeks) (conditional recommendation, very low certainty evidence).**

KQ 5: *Among healthcare professionals (trainees or practitioners) engaged in simulation, does spaced training (separation of training*

into several discrete sessions over a prolonged period with measurable intervals between training sessions) compared with massed training (all training occurs during the same session) improve skill acquisition?

- **The panel suggests either spaced or massed simulation training for procedural skill acquisition using simulation (conditional recommendation, very low level of evidence).**

KQ 6: *Should higher physical realism simulators/task trainers vs lower physical realism simulators/task trainers be used for healthcare simulation training of individuals in lower and middle resource settings?*

- **The panel suggests the use of lower physical realism as opposed to higher physical realism simulators and task trainers for healthcare professionals and/or healthcare trainees/students in low- and middle-income (LMIC) settings (conditional recommendation, very low certainty of evidence).**

KQ 7: *Should high-fidelity simulation vs low-fidelity simulation be used for team training for healthcare professionals and/or healthcare trainees/students?*

- **The panel suggests the use of either higher- or lower-fidelity simulation for team training by healthcare professionals and/or healthcare trainees/students (conditional recommendation, very low certainty of evidence).**

KQ 8: *Should distance simulation vs in-person simulation vs mixed distance simulation (ie, in-person and distance) be used for the training of healthcare professionals?*

- **The panel suggests the use of either distant, in-person, or mixed distant simulation be used for the training by healthcare professionals (conditional recommendation, very low certainty of evidence).**
- **The panel also suggests that distance simulation may be preferable for specific purposes (eg, geographic limitations) and motivations (eg, convenience) (expert consensus recommendation).**

KQ 9: *For the team-based training of healthcare professionals, do any specific conditions in the clinical environment before or after training (eg, leadership support, positive work culture, staff huddles) compared with other conditions or no such conditions lead to improved learning outcomes and patient outcomes?*

- **When implementing team-based training with healthcare professionals to improve patient safety, we suggest implementing facilitated discussions, coaching, wider communication of learning objectives to staff members, or other leadership initiatives to facilitate transfer of skill to the clinical environment (conditional recommendation, very low certainty evidence).**

KQ 10: *Does a specific method or content of team training improve learning outcomes of healthcare professionals participating in simulation-based training of teamwork competencies?*

- **We suggest that debriefing after simulation training of teamwork competencies may be conducted as traditional instructor-led debriefing or by use of alternate methods such as rapid-cycle deliberate practice (RCDP), peer-led debriefing, or video-assisted debriefing (conditional recommendation, very low certainty evidence).**
- **We suggest the use of either low- or high-fidelity simulators when training teamwork competencies (conditional recommendation, very low certainty evidence).**
- **We suggest that combining the training of teamwork competencies using simulation with other learning modalities such as classroom activities or e-learning modalities may be of added benefit (conditional recommendation, very low certainty evidence).**

KQ 11: *For healthcare professionals training teamwork competencies, does interprofessional team training compared with single-professional team training lead to improved learning outcomes and patient outcomes?*

- **We suggest conducting training of teamwork competencies with interprofessional teams in situations where professionals are expected to work together across specialties or disciplines in clinical practice (conditional recommendation, very low certainty evidence).**

KQ 12: Is competency-based simulation procedural training superior to non–competency-based approaches in improving skill acquisition and patient outcomes?

- **The panel suggests that competency-based simulation training methods be used for procedural skill training of healthcare professionals (conditional recommendation, moderate level of evidence).**

KQ 13: *Does the use of virtual reality (VR), augmented reality (AR), or extended reality (XR) simulation improve healthcare professional learning and patient outcomes compared with traditional simulation methods?*

- **Both XR or traditional simulation can be used for the training of healthcare professionals as both have comparable learning outcomes (conditional recommendation, very low certainty of evidence).**
- **The panel suggest that VR experiences should be proctored, include debriefing, and have a backup plan when learner cybersickness or myopia are encountered and to document time and costs (expert consensus recommendation).**

KQ 14: *Does the use of XR simulation improve surgical/procedural learning and patient outcomes compared with standard training methods?*

- **The panel suggests that XR simulation modalities may be an effective training modality for surgical and procedural training (expert consensus recommendation).**

KQ 15: *In healthcare professionals, does the use of 1 debriefing or feedback intervention, compared with a different debriefing or feedback intervention, improve educational and clinical outcomes in simulation-based education?*

- **For healthcare provider training using simulation, we suggest that structured debriefing and feedback should be included (conditional recommendation, very low certainty of evidence).**

KQ 16: *Among healthcare professionals, does the use of simulated participants (SPs) methodology related to communication skills have an effect on improving learner knowledge, skills, attitudes, or patient outcomes compared with other simulation methodologies?*

- **The panel suggests an integrated approach to teaching communication knowledge, skills, and attitudes in healthcare education. This approach should prioritize the use of SPs for hands-on skill development, incorporate role-play scenarios for practical application, and include reflective exercises to nurture the growth of empathetic and patient-centered attitudes among healthcare professionals (expert consensus recommendation).**

Introduction

Aim of These Guidelines and Specific Objectives

These evidence-based guidelines from the Society for Simulation in Healthcare (SSH) aim to support healthcare professionals in decisions on the most effective methods for simulation training in healthcare. The key target audiences include clinician and nonclinician educators and their learners. Other stakeholders involved in delivering simulation training but also patient care delivery that may be impacted by such training may also consider these recommendations in their deliberations.

Description of the Training Problem

Over the past 30 years, there has been increasing use of simulation training modalities for the training of healthcare workers.[3] Compared with traditional training, simulation enables experiential training that augments learning and knowledge and skill retention[4] that has been shown to positively impact patient outcomes and the delivery of care.[5] However, there is variability in teaching practices that affect training quality and impact training outcomes and therefore module the potential benefit patients may derive from simulation training. Guidelines can assist educators and learners in choosing the most appropriate training methods based on systematic synthesis of best available evidence.

METHODS

The development of these guidelines was conceived by the research committee of the SSH and was conducted in conjunction with the Society's 2023 research summit. After committee and SSH board approval, a steering group was formed to oversee this project (see Table, Supplemental Digital Content 1, http://links.lww.com/SIH/B26, which lists all the contributors to this project). After numerous deliberations, the steering group defined 12 topics of relevance to simulation training: (1) mastery learning/deliberate practice/technical skills; (2) feedback/debriefing; (3) spaced learning/booster training/warm up/JIT; (4) self-guided learning/regulated learning/peer to peer learning; (5) team training/nontechnical skills training; (6) in situ training (for training vs process improvement); (7) VR/AR/hybrid; (8) remote simulation/telesimulation (consider training and assessment); (9) standardized patients; (10) simulation/simulator fidelity (task resemblance of reality); (11) faculty development; and (12) low/high stakes assessment/formative/summative. The steering committee chose 2 coleads for each of these topics based on their background and expertise in the area (see Table, Supplemental Digital Content 1, http://links.lww.com/SIH/B26, which lists all the contributors to this project). The leads of each group in collaboration with the steering group determined and invited the expert panel members for guideline development. The expert panels deliberated and prioritized topic specific guideline questions and formed corresponding systematic review working groups. Reviewers included either members with prior methodological experience and expertise or members who underwent methods pretraining. Findings of the systematic reviews were summarized in GRADE evidence profiles and summary of findings tables. Guideline recommendations were developed with the GRADE Evidence to Decisions (EtD) approach.[6,7] When evidence was lacking, expert panels provided consensus opinion. The Essential Reporting Items for Practice Guidelines in Healthcare (RIGHT) checklist was used to draft this guideline.[8]

Guideline Panel Organization

The guideline panel (expert panel) was composed of the topic coleads and volunteers with subject matter expertise. The guideline panel also included steering committee members. A nonvoting guideline development methodologist (M.T.A.) and learners (A.C., S.-M.K.-M.) also participated in panel meetings. All guidelines contributors and their roles are listed in Supplemental Digital Content 1, http://links.lww.com/SIH/B26.

Guideline Funding and Declaration and Management of Competing Interests

All committee members and voting members of the guideline panel were volunteers. Funding for the methodologists, the librarian, and partial salary support for the research fellow was provided by SSH. There was no monetary or other support from industry. All guideline panel members were required to declare conflicts of interest. The guideline leads and steering committee chair evaluated these declarations for any pertinent conflicts. All disclosed potential conflicts of interest are listed in Supplemental Digital Content 2 (see document, Supplemental Digital Content 2, http://links.lww.com/SIH/B27, conflicts of interest).

Selection of Questions and Outcomes of Interest

Under the guidance of the steering committee, topic coleads, and guideline methodologist, the expert panel created a list of KQs relevant to each topic using the PICO format (population-intervention-comparator outcome). The outcomes were clearly defined by the expert panel using the Kirkpatrick levels of educational outcomes,[9] and those deemed "critical" or "important" to decision-making for each KQ were included. The importance of these outcomes was revisited by panel members after they had reviewed the systematic review evidence. Outcomes included learner satisfaction with training, knowledge, and skills improvement and behavior/performance improvement in a clinical environment as a result of training, and a variety of patient and process outcomes that changed as a result of training. Cost to the patient was included as an additional consideration when data were available.

Evidence Synthesis and Grading the Certainty of Evidence

Standard systematic review approach using 2 independent reviewers (with third-party arbitration) was adopted to synthesize the best available evidence for each KQ. A librarian with expertise in the area searched multiple databases, including PubMed, Cochrane Library, and Embase, in May 2021. Systematic reviews and the bibliography of select included studies were hand searched for additional studies missed in the literature search. Given the potential paucity of data, both randomized controlled trials (RCTs) and observational studies addressing the KQs of interest were eligible for inclusion. Only peer-reviewed English language studies were included during study selection, which formed the bulk of the existing literature. Retrieved records were screened for eligibility and to remove duplicates at 2 levels (title and abstract, and full-text review) against the aforementioned eligibility criteria.

Study data were extracted using Covidence digital software for general study characteristics and outcomes.[10] The Cochrane *Risk of Bias Tool* for RCTs and the *Newcastle Ottawa Scale* for non-RCTs were used to assess study risk of bias as appropriate.[11,12] Meta-analysis was conducted in *Revman* using the Mantel-Haenszel random-effects model.[13] Heterogeneity between studies was

measured by I^2 and chi-square and was explored against the risk of bias and clinical covariates across the studies. Publication bias could not be assessed because of the general inadequacy of the evidence. When direct comparative evidence was lacking, evidence from noncomparative studies was used to make indirect comparisons (albeit with lower certainty). For each outcome, the certainty of evidence was graded as per the GRADE approach based on the overall risk of bias, inconsistency, indirectness, imprecision, and other considerations and summarized in Evidence Tables in the online *GRADEPro* tool.[14,15] Randomized controlled trial evidence was preferred over non-RCT evidence with the intent of generating higher certainty.

Development of Clinical Recommendations

The panel took an individual perspective, using learner-based values to formulate recommendations for a target audience composed of clinician educators and learners. We used the GRADE EtD framework in the GRADEPro tool.[14,15] The EtD framework requires panel members to make deliberated judgments about the magnitude of desirable and undesirable effects across the important and critical outcomes and the values (and associated variability in values) learners and patients place on those outcomes as they make subsequent judgments about the balance of desirable and undesirable effects, the overall certainty of evidence across the critical outcomes, the potential for inequities in health, and acceptability and feasibility of the intervention. These EtD judgments inform the final recommendation. As no literature was known to investigate the relative values and preferences patients and or learners assign to the various outcomes of interest, the panelists used their trainer and clinical experience as proxies for learner and patient values and preferences. Dissenting judgments and views were documented. Final recommendation and its wording required a majority of the panel to agree (>80%). All EtD tables relevant to the presented guidelines are included as Supplemental Digital Content and referenced hereafter under each separate KQ.

Limitations of These Guidelines

The limitations of these guidelines are inherent to the very low certainty of the evidence we identified for the majority of our KQs. Multiple identified research priorities aim to improve the certainty and quality of the evidence for which recommendations were made, so future recommendations on these KQs can be based on more robust evidence.

Guideline Monitoring and Updating

The impact of these guidelines and their use will be studied in 5 years through a literature review and surveys; the guidelines will be updated in 5 years as well.

Guideline Document Review

After composition of these guidelines, this manuscript was reviewed and appropriately revised, including steering group members, topic coleads, panelists, and methodologist before submission for publication. The AGREE-II tool[16] was used to assess the quality of these guidelines by 2 independent reviewers (S.-M.K.-M. and A.C.) and revealed a score of 6.1 of 7.

KQs and Recommendations

Topic: In Situ Simulation

KQ 1: *Should in situ simulation vs the education accrued during typical organizational practice be used for training healthcare professionals to improve clinician behaviors during patient care and/or patient outcome?*

- **For healthcare provider training, we suggest that participation in in situ simulations should be considered to improve healthcare professionals' performance, patient outcomes, and healthcare system quality and safety compared with the education accrued during typical organizational practice (conditional recommendation, moderate evidence).**

Problem statement: In situ simulation (ie, simulation at the point of care) is increasingly being used to impact provider skills and behavior. The overall benefit of this on provider behaviors in the environment of care and/or patient outcomes, however, has not been firmly established.

Summary of the evidence: Nineteen studies[17–36] addressed a range of in situ simulation outcomes, including mortality, clinical metrics of patient care delivery, nontechnical skill levels as measured during actual patient care, latent safety threat mitigation, and diagnostic decision-making. Clinical areas addressed included neonatal resuscitation, pediatric and adult resuscitation, obstetric care, outpatient care, stroke care, and trauma.

Benefits: Meta-analysis of included study data revealed that use of in situ simulation reduced risk of death [odds ratio, 0.66; 95% confidence interval (CI), 0.55–0.78], improved metrics of care delivery (standardized mean difference [SMD] = −0.34; 95% CI, −0.45 to −0.21), and improved nontechnical skills (SMD = −0.52; 95% CI, −0.99 to −0.05). Although meta-analysis was not feasible for diagnostic decision-making or latent safety threats, all presented outcomes were in favor of in situ simulation.

Harms and burden: Harms remained largely unaddressed by the identified studies, and only 2 reported on the cost of the intervention.

Certainty in the evidence of effects: Overall level of certainty was low and varied by outcome (high for the measurement of diagnostic decision-making; low for clinical metrics of care; and very low for mortality, nontechnical skill measurements, and effect on latent safety threats).

Decision criteria and additional considerations: The panel considered the desirable impact of in situ simulation on patient outcome and provider behavior in relation to the lack of data regarding potential deleterious effects at the patient, provider, or institutional level; the panel judged that undesirable effects were likely trivial. Consideration was also given to issues of accessibility, equity, and inclusion, which was of particular importance given that several included studies addressed low-cost in situ methods deployed in LMIC settings. Despite the limitations of the literature, the panel's opinion was influenced by the consistent benefit of in situ simulation in the reviewed studies. The panel considered providing a strong recommendation but decided not to because of the lack of evidence on undesirable effects and low level of certainty.

Conclusions: The panel suggests that in situ simulation be implemented in addition to current educational methods with the goal of improving patient care and mortality. The most robust findings were seen in postpartum hemorrhage, postpartum sepsis recognition, and in neonatal resuscitation skills. Accessibility to this type of training in LMIC settings is enhanced by low-cost, low-fidelity simulators promoting health equity.

Institutions implementing this guideline should consider associated costs to ensure sustainability.

Research Priorities: The panel recommends the following research priorities be pursued:

1. High-quality studies focused on the impact of in situ simulation on simulation program resource use, the financial costs to the institution, and return on investment considering the potential cost savings due to avoided harmful events.
2. Studies that measure the effect of in situ simulation (especially unannounced in situ simulation) on the emotions of participating professionals and on the care provided to other patients in nearby areas that may be disrupted.

Please also refer to the relevant tables in Supplemental Digital Contents 3 and 4 (see tables, Supplemental Digital Content 3, http://links.lww.com/SIH/B28, KQ GRADE evidence table; and Supplemental Digital Content 4, http://links.lww.com/SIH/B29, EtD table).

KQ 2: *Should a higher frequency of short in situ simulation events with structured debriefing vs a lower frequency of short in situ simulation events with structured debriefing be used for training healthcare professionals to improve clinician behaviors during patient care and/or patient outcomes?*

- For healthcare provider training, we suggest more frequent participation in short skill–oriented in situ simulations to benefit patient outcomes (conditional recommendation, moderate evidence).

Problem statement: Given the time and resources required to implement in situ simulations, it is important to determine whether a dose-response relationship exists between frequency of exposure and beneficial effects and what the ideal exposure frequency is.

Summary of the evidence: One study was found[37] that addressed this question: a comparative, nonrandomized study conducted with 572 teams across 26 hospitals that examined differences in survival after cardiac arrest in hospitals with low exposure to in situ simulation (3.2 in situ simulations per 100 beds) compared with those with high exposure (177 in situ simulations per 100 beds).

Benefits: Improved survival was noted in those hospitals with higher levels of in situ simulation (odds ratio, 0.62; n = 572 teams).

Harms and burden: No data were found that addressed harms and burden.

Certainty in the evidence of effects: Level of certainty was deemed to be moderate for this study.

Decision criteria and additional considerations: Given the reliance on 1 study with a relatively narrow focus (the study examined only short, skills-based in situ simulations focused on cardiac arrest care), the panel's recommendation specifically applies to skills-based in situ simulations. It was also felt that the survival benefits likely outweigh simulation costs especially given the use of low-cost low-tech mannequins and the short length (5 minutes) of the proposed simulations. The panel further opined that the findings of this study likely apply to other types of in situ simulation as well; issues of accessibility and equity were also considered.

Conclusions: The panel suggests that hospitals should engage in higher frequencies of short, skills-based in situ simulations to improve cardiac arrest outcomes. Given that the differences in simulation frequency between the 2 groups in this study were large, no recommendation can be provided on the optimal frequency of in situ simulation exposure.

Research Priorities: The panel recommends the following research priorities be pursued:

1. High-quality studies examining the level of exposure to in situ simulation needed to enhance patient outcomes that is balanced against measures of cost, resource use, and workflow (ie, the level of diminishing returns).
2. High-quality studies addressing the impact of frequent in situ simulations on participants' psychological responses.

Please also refer to the relevant tables in Supplemental Digital Contents 5 and 6, respectively (see tables, Supplemental Digital Content 5, http://links.lww.com/SIH/B30, KQ GRADE evidence table; and Supplemental Digital Content 6, http://links.lww.com/SIH/B31, EtD table).

KQ 3: *Should in situ simulation vs another non–in situ simulation modality be used for training healthcare professionals to improve perceptions, knowledge, skills, clinician behaviors, and patient care outcomes?*

- **For healthcare provider training, we suggest the use of in situ simulation to uncover or mitigate latent safety threats in the healthcare environment and to enhance the environmental authenticity and fidelity of the experience (conditional recommendation, moderate evidence).**

Problem statement: It is currently unknown whether in situ simulation offers any benefit over traditional, simulation center-based approaches. The answer to this question will inform the educator the choice of preferred training modality.

Summary of the evidence: Four relevant studies were included.[38–42] Outcomes measured included participant preference and satisfaction, participant knowledge, participant stress, participant skill as evaluated in the simulated environment, and latent safety threat mitigation. Clinical areas addressed included infection prevention, airway management, perinatal resuscitation, and general resuscitation.

Benefits: The heterogeneity of the studies did not allow meta-analysis; instead, standardized mean differences were reported. Regarding participant performance, 1 study favored in situ simulation (SMD = −0.06, N = 57 providers), whereas another favored traditional simulation (SMD = 0.67, N = 120 providers). Regarding participant preference and satisfaction, some favored in situ simulation (SMD = −0.08, N = 1415 providers) and some favored traditional simulation with varying effect sizes (SMD = 4.26, N = 120 providers; SMD = 0.068, N = 97 providers). Participant knowledge acquisition was largely equivalent between in situ and traditional simulation (SMD = 0.07, N = 97 providers). In situ simulation was perceived as having higher authenticity (SMD = −0.49, N = 97 providers), and higher levels of salivary cortisol (a measure of stress) were found in the in situ group (SMD = −0.42, N = 97 providers). More latent safety threats (51 vs 40) were detected by in situ simulation.

Harms and burden: No measures of harm or burden were assessed in the identified studies.

Certainty in the evidence of effects: The level of certainty was deemed to be high for technical skill, knowledge, and latent safety threat measurements because of low risk of bias.

Decision criteria and additional considerations: The panel was not surprised by the equivalency of both modalities in terms of preference or knowledge, given that similar content can be taught using both. However, the panel considered the evidence that in situ simulation enables higher levels of environmental fidelity and uncovers more latent safety threats as adequate to offer a recommendation. The limited number of available comparative studies, presence of confounders, and lack of evidence on potential undesirable effects such as cost, effect on personnel, and effect on institutional efficiency made the panel offer a conditional recommendation.

Conclusions: Although in situ simulation has similar impact on provider preferences, knowledge, and skill compared with traditional simulation, its use may enhance training authenticity and improve latent safety threat detection.

Research Priorities: The panel recommends the following research priorities be pursued:

1. High-quality comparative studies addressing the effectiveness of in situ simulation vs other traditional simulation and non–simulation-based educational approaches that also evaluate potential undesirable effects such as cost, resource use, and workflow disruption.
2. Systematic reviews focused on in situ simulation as a means of detecting latent safety threats.

Please also refer to the relevant tables in Supplemental Digital Contents 7 and 8, respectively (see tables, Supplemental Digital Content 7, http://links.lww.com/SIH/B32, KQ GRADE evidence table; and Supplemental Digital Content 8, http://links.lww.com/SIH/B33, EtD table).

Topic: JIT

KQ 4: *Should JIT vs no JIT be used for simulation training of healthcare professionals (trainees or practitioners)?*

- **The panel suggests that 5–30 minutes of just-in-time simulation training (within 24 hours of performance) should be implemented with healthcare professionals (trainees or practitioners) engaged in high-stakes medical or surgical procedures particularly when there has been a prolonged period of no training (>1–2 weeks) (conditional recommendation, very low certainty evidence).**

Problem statement: Just-in-time simulation training, defined as training that is conducted in temporal or spatial proximity to performance, may be an effective method to improve performance and patient outcomes. Such training, however, is resource intensive and its benefits should be weighed against its risks.

Summary of the evidence: Sixteen studies were eligible for inclusion.[43–59] Just-in-time training simulation training has been evaluated for a variety of medical, resuscitation, and surgical procedures. Most JIT simulation training occurred immediately before procedures and lasted between 5 and 30 minutes. The panel assigned relative values and preferences to outcomes. Specifically, time (ie, efficiency) was an outcome that was applicable across various training contexts and therefore the panel assigned a greater value to this outcome.

Benefits: All examined outcomes were in favor of JIT. The effect sizes ranged from small to large and the panel decided that the overall effect was moderate.

Harms and burden: Research examining the undesirable effects of JIT is lacking. Panel members noted that some of the undesirable effects of this intervention might be the time, resource intensiveness, and disruption of regular care processes related to implementing JIT before performance.

Certainty in the evidence of effects: All evidence for each outcome was deemed to be of very low certainty.

Decision criteria and additional considerations: The panel weighed the desirable effects of JIT simulation training against any potential undesirable effects. The panel felt that even if there was evidence of high cost or resource use related to JIT simulation training, most relevant stakeholders and decision-makers would still favor its use given the anticipated improvements in patient outcomes. The panel also opined that implementation of JIT simulation training is likely to initially target university hospitals and tertiary care centers potentially giving rise to disparities in patient outcomes between these centers and other healthcare-providing facilities. Although the disparities in patient outcomes may provide empiric evidence of the effectiveness of the implementation of these guidelines in the real-world settings, it is hoped that subsequent implementation interventions would be adopted to minimize such disparities.

Conclusions: The panel judged that given the moderate desirable benefits and unknown but likely trivial undesirable effects, use of JIT simulation training should be suggested.

Research Priorities: The panel recommended additional research to address the following areas:

- Studies examining the effectiveness of JIT simulation training in nonphysicians and physicians in practice.
- Studies examining the impact of JIT simulation training on patient outcomes such as patient morbidity and mortality.
- Studies using interrupted time series analysis (where the effectiveness of JIT simulation training on patient outcomes is evaluated before and after JIT simulation training implementation).
- Studies examining the undesirable effects of JIT simulation training (costs, resources, and time) to better understand the overall balance of desirable and undesirable effects.

Please also refer to the relevant tables in Supplemental Digital Content 9 (see tables, Supplemental Digital Content 9, http://links.lww.com/SIH/B34, KQ GRADE evidence table and EtD table).

Topic: Spaced Training

KQ 5: *Among healthcare professionals (trainees or practitioners) engaged in simulation, does spaced training (separation of training into several discrete sessions over a prolonged period with measurable intervals between training sessions) compared with massed training (all training occurs during the same session) improve skill acquisition?*

- **The panel suggests either spaced or massed simulation training for procedural skill acquisition using simulation (conditional recommendation, very low level of evidence).**

Problem statement: Spaced training, defined as the separation of training into several discrete sessions over a prolonged period with measurable intervals between training sessions, has been proposed to be a more effective method than massed training for skill acquisition. However, it is unclear if this is true for spaced training using simulation across settings and skills, and if the potential benefits of spaced training outweigh the potential drawbacks.

Summary of the evidence: Fifteen RCTs were included, comparing simulation-based spaced vs massed training.[60–73] Most of

the studies involved physician trainees doing procedures or operations. Outcomes measured were heterogeneous but primarily at the T1 level (based on the translational outcomes framework), in the simulated setting. In the highest prioritized outcomes (time to complete a procedure and final product assessment scores) measured after a retention interval, there was a signal that spaced training may be advantageous over massed training. However, findings were quite heterogeneous across outcomes and settings, especially for lower weighted outcomes (such as global rating scales assessment of performance and procedure-specific measures) measured immediately post-training.

Benefits: Although there was significant heterogeneity in the reported outcomes of the included studies, there were moderate potential desirable effects from spaced training to improve the acquisition of competence. For the outcomes of time to complete a procedure (efficiency) and global rating scales of performance after a retention interval, there was a moderate potential benefit found for spaced training. For the outcome of final product assessment scores immediately after training, there were trivial to large potential benefits. For the outcomes of global rating scales of performance immediately after training and objective procedure-specific metrics at immediate and at retention assessment, the findings were inconclusive with some studies demonstrating outcomes favoring massed training.

Harms and burden: There were no reported harms related to spaced training

Certainty in the evidence of effects: There was very low certainty of evidence. All research evidence had high risk of bias, with inconsistency across studies and significant imprecision.

Decision criteria and additional considerations: The panel weighed the reported benefits of spaced training against the very low certainty of the evidence, the heterogeneity of reported outcomes, and that some studies revealed no difference or favored massed training. It further considered the absence of any evidence on harms and burden; thus, the panel decided to offer a recommendation for either spaced or massed training.

Conclusions: Given the very low certainty of evidence in favor of spaced training, and that some studies revealed no difference or favored massed training, the panel decided to offer a recommendation for either spaced or massed training.

Research Priorities: The panel recommended additional research to address the following areas:

- Quality studies that explore for which settings, which procedure, which trainees, and which outcomes spaced training may be superior to massed training.
- Studies that assess the impact of spaced training on the acquisition of competence for healthcare professionals other than physician trainees.
- Larger quality studies of spaced-training measuring outcomes in the patient care setting (ie, impact of spaced training on patient morbidity, mortality, cost, and resource use).

Please also refer to the relevant tables in Supplemental Digital Content 10 (see tables, Supplemental Digital Content 10, http://links.lww.com/SIH/B35, KQ GRADE evidence table and EtD table).

Topic: Simulation Fidelity

KQ 6: *Should higher physical realism simulators/task trainers vs lower physical realism simulators/task trainers be used for healthcare simulation training of individuals in lower and middle resource countries?*

- **The panel suggests the use of lower physical realism as opposed to higher physical realism simulators and task trainers for healthcare professionals and/or healthcare trainees/students in LMIC countries (conditional recommendation, very low certainty of evidence).**

Problem statement: Although simulation in LMICs can be an effective teaching methodology, it is unclear if higher-fidelity simulation should be used in these countries because of the human resources required and financial costs involved. It is unclear whether the level of physical realism of simulators impacts clinical, educational, and procedural outcomes in LMIC countries.

Summary of the evidence: Of 2311 initially identified and screened articles, 8 randomized studies relevant to this KQ were included.[74–81] Studies frequently considered animal models or VR simulators as being of high fidelity and realism and bench top simulators as low fidelity and realism.

Benefits: The majority of reviewed studies demonstrated no statistically significant difference in skill acquisition or clinical performance of medical students and residents when trained using higher-fidelity vs lower-fidelity simulators.[74–80] Only 1 study found that the higher-fidelity models were better than the lower-fidelity models for skill acquisition of intramuscular injections by midwifery students.[81]

Harms and burden: No evidence was found for any undesirable effects of higher-fidelity simulation. The panel opined, however, that the associated resources and costs might prohibit high-fidelity simulation training in some LMIC healthcare settings or come at the expense of other healthcare educational interventions.

Certainty in the evidence of effects: The certainty of evidence was judged to be very low for all outcomes, downgraded for very serious risk of bias and inconsistency.

Decision criteria and additional considerations: The panel considered the limited to absent evidence in favor of higher physical realism simulation in the context of its use in LMICs with their associated significant cost and resource limitations. The panel also discussed sustainability considerations (eg, repair of equipment) and scalability of simulation use across LMIC practice settings.

Conclusions: Given the lack of strong evidence for high-fidelity simulation and resource limitations of LMICs, the panel concluded that low-cost physical realism simulator equipment would be preferable for the training of healthcare professionals and/or healthcare trainees/students in LMICs.

Research Priorities: The panel recommended additional research to address the following areas:

- Quality studies that consider the balance between physical realism and cost, equity, impact of resources, sustainability, and scalability.
- Studies in LMICs that focus on appropriate study populations and interventions and are adequately powered to address relevant learning and patient outcomes.
- Comparative studies that use consistent and standardized definitions of "high" and "low" physical realism to better address this research question.

Please also refer to the relevant tables in Supplemental Digital Content 11 (see tables, Supplemental Digital Content 11, http://links.lww.com/SIH/B36, KQ GRADE evidence table and EtD table).

KQ 7: *Should high-fidelity simulation vs low-fidelity simulation be used for team training for healthcare professionals and/or healthcare trainees/students?*

- **The panel suggests the use of either higher- or lower-fidelity simulation for team training by healthcare professionals and/or healthcare trainees/students (conditional recommendation, very low certainty of evidence).**

Problem statement: Simulation-based team training has been demonstrated to be effective in facilitating interprofessional education and collaboration. Whether the level of simulation fidelity affects training outcomes is, however, unclear.

Summary of the evidence: Of 1390 identified and reviewed articles, 14 randomized studies were chosen for inclusion in this guideline[40,82–95]; these addressed the acquisition of nontechnical skills, teamwork performance, knowledge acquisition, and learner satisfaction between high- and low-fidelity conditions. Seven randomized studies with 766 participants addressed the acquisition of nontechnical skills in high-fidelity vs low-fidelity simulations.

Benefits: Two studies (n = 436) of surgical residents engaged in operative training and medical students undergoing communication skills training showed increased nontechnical skills for higher fidelity.[85,86] The remainder of the studies (n = 330) were conducted across a spectrum of study participants (neonatal trainees, anesthesia, and radiology, residents, medical and nursing students, anesthesiologists, internal medicine, emergency medicine, palliative care, and intensive care physicians, interprofessional PALS instructors, nurses, and midwives), types of skills assessed (task management, situation awareness, and decision making), and assessment tools used [OSCE, Anesthesia nontechnical skills (ANTS), NOTECHS, and other novel behaviorally anchored rating scales, Clinical Performance Tool, Teamwork Behavioral Rater score, Team Emergency Assessment Measure, Behavioral Measures Check-Off Tool, Teamwork Attitudes Questionnaire, and TeamSTEPPS score]; no differences in nontechnical skills, teamwork, and knowledge acquisition were identified between groups trained using high vs low-fidelity simulation. In contrast, 8 studies revealed increased learner satisfaction with higher-fidelity training, whereas 4 studies showed mixed results or no difference.

Harms and burden: No evidence was found for any undesirable effects of either high or low-fidelity simulation for team training.

Certainty in the evidence of effects: The certainty of evidence was judged to be very low for all outcomes, downgraded for very serious risk of bias and inconsistency.

Decision criteria and additional considerations: The panel weighed the evidence that overwhelmingly does not suggest any training outcome differences between low- and high-fidelity simulations in terms of knowledge, or teamwork, with limited evidence for improved attitudinal/affective (eg, nontechnical) skills vs the preference of learners for high-fidelity simulations. The panel opined that given the cost, and the personnel, equipment, and space needed to operate high-fidelity simulators, they can be cost prohibitive and unfeasible to use in some settings (eg, rural and remote health centers, low numbers of health personnel to train, LMICs, etc). Use of low-fidelity simulators and in situ simulation in such instances may offer greater access to simulation-based education and training, reduce travel costs and time away, and reduce skill deterioration and decay because of lack of simulation-based learning opportunities.

Conclusions: The panel suggests the use of either higher- or lower-fidelity simulation for team training of healthcare professionals and/or healthcare trainees/students and recognizes the benefits of low-fidelity simulation in resource constraint settings.

Research Priorities: The panel recommended additional research to address the following areas:

- Additional high-quality comparative studies of high- vs low-fidelity simulators and simulations.
- Studies that provide cost comparisons and the feasibility of high- vs low-fidelity simulations across various environments and skills.
- Development of an evaluation framework that provides a standardized format for defining and measuring desirable outcomes in simulation-based interprofessional education.

Please also refer to the relevant tables in Supplemental Digital Content 12 (see tables, Supplemental Digital Content 12, http://links.lww.com/SIH/B37, KQ GRADE evidence table and EtD table).

Topic: Distance Simulation

KQ 8: *Should distance simulation vs in-person simulation vs mixed distance simulation (ie, in-person and distance) be used for the training of healthcare professionals?*

- **The panel suggests the use of either distant, in-person, or mixed distant simulation be used for the training by healthcare professionals (conditional recommendation, very low certainty of evidence).**
- **The panel also suggests that distance simulation may be preferable for specific purposes (eg, geographic limitations) and motivations (eg, convenience) (expert recommendation).**

Problem statement: Distance simulation has rapidly grown in the past years because of physical distance requirements during the COVID-19 pandemic. However, the comparative effectiveness of in-person simulation, distance simulation, or a combination of distance and in-person simulation to ensure high-quality education is unclear.

Summary of the evidence: Three separate systematic reviews including an umbrella review were performed; 132 articles on in-person simulation, 55 articles on distance simulation where all participants were separate, and 34 articles where participants were both in person and at a distance were included in this analysis.[96–100]

Benefits: Distance simulation, mixed distance simulation, and in-person simulation led to similar learning outcomes of participants across the examined studies. Results on learner satisfaction were mixed, with most studies showing higher satisfaction in distance simulation, whereas other studies showed higher satisfaction in-person simulation. Distance simulation was superior in geographic accessibility, convenience, and novelty.

Harms and burden: Research examining the undesirable effects of distance simulation is lacking. Panel members noted that some of the undesirable effects of this intervention might be lack of equipment, expertise, resource intensiveness in design and creation, economic equity for accessibility, human factors considerations, security and psychological safety breaches, and the need for researching technologies, software, and faculty development.

Certainty in the evidence of effects: All evidence for each outcome was deemed to be of very low certainty.

Decision criteria and additional considerations: The panel weighed the benefits of distance simulation described previously

against the lack of information about any undesirable effects. The panel decided to offer 2 recommendations recognizing not only the training outcome equivalency of the compared modalities but also the advantages that distance simulation offers in select settings. The panel also speculated that the costs of quality distance simulation are likely comparable (and not cost-efficient) to quality in-person simulation based on different software, technology, and expert human resources.

Conclusions: Based on the available evidence with very low certainty, the expert panel judged that the benefits of distance simulation, although different, are comparable to in-person simulation.

Research Priorities: The panel recommended additional research to address the following areas:

- Quality studies that assess the return on investment and return on expectations of distance simulation and its cost-effectiveness compared with in-person simulation.
- Quality studies that explore the impact of regional differences in attitudes, perception, and behaviors of faculty and learners on distance simulation-based education.
- Studies that determine the scalability of distance simulation as it relates to various environments.
- Studies that assess any undesirable effects of distance simulation.

Topic: Team Training/Nontechnical Skills Training

KQ 9: *For the team-based training of healthcare professionals, do any specific conditions in the clinical environment before or after training (eg, leadership support, positive work culture, staff huddles) compared with other conditions or no such conditions lead to improved learning outcomes and patient outcomes?*

- **When implementing team-based training with healthcare professionals to improve patient safety, we suggest implementing facilitated discussions, coaching, wider communication of learning objectives to staff members, or other leadership initiatives to facilitate transfer of skill to the clinical environment (conditional recommendation, very low certainty evidence).**

Problem statement: Training teamwork competencies is crucial to improve the performance of healthcare professionals and patient safety. The degree of skill transfer from this training to the clinical environment, however, varies. In addition, how the clinical environment conditions before or after training affect learning outcomes is unknown.

Summary of the evidence: Six nonrandomized studies that lacked a control group for the conditions present before or after training of teamwork competencies were included.[15–20] Interventions included coaching after training[15,18] as well as complex strategies combining targeted communication, meetings, staff huddles, guideline development, and leadership incentives.[16,17,19,20]

Benefits: All reviewed studies reported improved outcomes after implementation of a variety of peri-training conditions such as facilitated discussions, coaching, wider communication of learning objectives to staff members, and others. Improved outcomes included improved patient safety culture scores, reduced rates of severe complications, lower-than-expected mortality, improved attitude and teamwork climate, and higher risk-adjusted survival.

Harms and burden: No harm or negative impacts were reported after the implementation of conditions, and no studies reported on financial impacts.

Certainty in the evidence of effects: The overall certainty of evidence was very low for all outcomes assessed. The certainty of evidence was downgraded for risk of bias, indirectness, and imprecision.

Decision criteria and additional considerations: The panel considered the very low certainty evidence from observational studies. All studies suggested positive impacts on patient safety culture and/or patient outcomes, which are supported by the general belief that strategies to implement learning from training will translate to better use of the acquired skills. Although the studies carried a critical risk of bias, the panel deemed that the desirable effects were substantial and consistent. Moreover, the panel judged the conditions used to be of low cost with no likely harm.

Conclusions: Based on the large desirable effects and the negligible harms, the panels suggest the implementation of peri-intervention conditions such as facilitated discussions, coaching, wider communication of learning objectives to staff members, etc when conducting team training.

Research Priorities: The panel recommended additional research to address the following areas:

- Quality studies that compare whether team training with conditions results in improved skill transfer when compared with training without conditions.
- Studies that assess whether specific conditions are superior to other conditions and for what specific groups of learners and what specific skills.

Please also refer to the relevant tables in Supplemental Digital Content 13 (see tables, Supplemental Digital Content 13, http://links.lww.com/SIH/B38, KQ GRADE evidence table and EtD table).

KQ 10: *Does a specific method or content of team training improve learning outcomes of healthcare professionals participating in simulation-based training of teamwork competencies?*

- **We suggest that debriefing after simulation training of teamwork competencies may be conducted as traditional instructor-led debriefing or by use of alternate methods such as RCDP, peer-led debriefing, or video-assisted debriefing (conditional recommendation, very low certainty evidence).**
- **We suggest the use of either low- or high-fidelity simulators when training teamwork competencies (conditional recommendation, very low certainty evidence).**
- **We suggest that combining the training of teamwork competencies using simulation with other learning modalities such as classroom activities or e-learning modalities may be of added benefit (conditional recommendation, very low certainty evidence).**

Problem statement: The best method of training to promote teamwork competencies has yet to be determined. Given that simulation-based team training requires a large amount of time, resources, and coordination of participants, knowing the most effective methods and modalities to use is necessary to optimize learning teamwork competencies and minimize disruption of clinical responsibilities.

Summary of the evidence: Of the 54 randomized and 10 observational studies reviewed, 19 studies focused on standard debriefing compared with other debriefing methods,[101–119] 6 studies compared low-fidelity to high-fidelity simulation-based training,[120–125] and 7 studies compared simulation to other learning modalities.[126–132]

Studies included healthcare professionals and students, residents and fellows, or mixed teams. Study endpoints included team performance, teamwork attitudes, debriefing satisfaction, debriefing assessment, technical skill evaluation, skill retention,

and self-reported assessments. Comparisons examined included debriefing vs no debriefing, peer-led debriefing vs instructor-led debriefing, scripted vs nonscripted debriefing, individual vs collective debriefing, RCDP vs traditional debriefing, and video-assisted debriefing vs traditional debriefing. In addition, simulation-based training was compared with e-learning, blended learning, VR, classroom training, or case review.

Benefits: Debriefing was found to be superior to no debriefing,[101–119] but it was unclear whether 1 method of debriefing was superior over another. Improved retention of skills was reported with video-reviewed debriefing vs without.[117] High-fidelity team training did not show any benefit over low-fidelity training regarding debriefing quality, technical and nontechnical performance, and stress levels in the majority of reviewed studies.[120,121,124,125] Single studies demonstrated improved teamwork, communication, and team-based performance scores when high-fidelity simulation was used for team training.[122,123] Participants often favored high-fidelity simulation over low fidelity. Simulation-based training was superior to classroom-only training[126] but similar to e-learning and VR training.[131,132]

Harms and burden: None of the manuscripts reported harms or negative findings for any of the 3 categories of methods examined.

Certainty in the evidence of effects: The overall level of certainty was very low. Certainty of evidence was downgraded for risk of bias, indirectness, and imprecision.

Decision criteria and additional considerations: The panel opined that the beneficial effects of debriefing outweighed any concerns related to cost of implementation, which was deemed low. In the absence of conclusive evidence, the panel judged that the optimal method of debriefing may depend on the skills being trained and the group of learners.

Regarding the importance of fidelity, the panel weighed the similarity of learning outcomes between high and low-fidelity team simulations against learner preference for high-fidelity training, its higher cost, and the absence of any reported risks of harm. The panel judged that the benefit for high-fidelity *vs* low-fidelity training may depend on the skills being trained and the group of learners. For preferred learning modality, the panel considered the superiority of simulation-based training vs classroom training and the benefits of e-learning and VR and their associated potential costs and harms. The panel opined that the combination of these methods depending on the setting would likely be more beneficial.

Conclusions: The panel recommended that debriefing should be part of training in team competencies given its beneficial impact and low cost of implementation, but no particular debriefing method was found to be superior. The panel deemed that the form of fidelity (high vs low) was similar in effectiveness but recognized that high-fidelity simulation had the higher cost and higher participant preference. Finally, the panel considered the benefits of simulation-based training over classroom training alone, and the benefits of e-learning and VR on team performance, and deemed that combining simulation-based training with other learning modalities has the potential to enhance the effectiveness of the training.

Research Priorities: The panel recommended additional research to address the following areas:

- Studies that focus on determining which modalities are most beneficial in training team competencies for a particular learner team.
- Studies that examine which debriefing method, simulator fidelity, and combined learning modality aligns best with a particular team-based skill or competency and helps optimize and accelerate training and learning.

Please also refer to the relevant tables in Supplemental Digital Content 14 (see tables, Supplemental Digital Content 14, http://links.lww.com/SIH/B39, KQ GRADE evidence table and EtD table).

KQ 11: *For healthcare professionals training in teamwork competencies, does interprofessional team composition compared with a single-professional team lead to improved learning and patient outcomes?*

- **We suggest conducting training of teamwork competencies with interprofessional teams in situations where professionals are expected to work together across specialties or disciplines in clinical practice (conditional recommendation, very low certainty evidence).**

Problem statement: The impact of team composition (single-professional teams vs interprofessional teams) on learning outcomes from training in teamwork competencies remains unknown.

Summary of the evidence: Six studies comparing interprofessional vs single-professional team training of healthcare students[133–138] were included.

Benefits: Interprofessional training led to improved knowledge acquisition and performance of learners compared with single-professional training.[133,135–137] Learners also reported higher self-efficacy and satisfaction with interprofessional training.[133,134,138] These results were not ubiquitous as some studies did not reveal any differences in learning outcomes.[134,138]

Harms and burden: No harm or negative impacts were reported following the implementation of interprofessional training, and no studies reported on financial impacts.

Certainty in the evidence of effects: The overall certainty of the evidence was rated as very low for all outcomes and was downgraded for risk of bias, indirectness, and inconsistency.

Decision criteria and additional considerations: The panel weighed the positive effects of interprofessional team training in a majority of studies, the absence of studies in favor of single-professional team training, and the likely improved skill transfer to clinical practice when training approximates clinical interprofessional practice against the lack of differences between these training paradigms in some studies. It also considered the general preference of participants for interprofessional team training and the absence of any reported harms, which were however judged to be negligible.

Conclusions: Based on the general benefits of conducting contextualized training and participant preferences for interprofessional training, the panel decided to recommend interprofessional training when teams are expected to work interprofessionally in clinical contexts.

Research Priorities: The panel recommended additional research to address the following areas:

- Studies investigating the effect of interprofessional training on healthcare professionals (as current evidence is based on healthcare students).
- Studies that assess skill retention as well as patient safety culture, performance in clinical practice, and patient outcomes.

- Studies that determine the effect of team composition modification (eg, type of learners or skills being taught) on the outcomes of team training.

Please also refer to the relevant tables in Supplemental Digital Content 15 (see tables, Supplemental Digital Content 15, http://links.lww.com/SIH/B40, KQ GRADE evidence table and EtD table).

Topic: Competency-Based Training

KQ 12: *Is competency-based simulation procedural training superior to non–competency-based approaches in improving skill acquisition and patient outcomes?*

- **The panel suggests that competency-based simulation training methods be used for procedural skill training of healthcare professionals (conditional recommendation, moderate level of evidence).**

Problem statement: Competency-based simulation training[139] for procedural training is generally considered to be superior to other pedagogical approaches; however, very limited head-to-head comparisons exist. In addition to optimize training experiences, it would be helpful to understand the impact each component of competency-based training (such as competency threshold determination, simulator features, time spent on task, instructor experience, and the mode and timing of feedback) has on learning outcomes.

Summary of the evidence: Of 46,483 studies identified, 48 comparative studies (44 randomized trials) were included in our systematic review and 21 in meta-analysis.[140–142] Eleven articles directly compared competency-based simulation training vs an alternative simulation-based training approach (noncompetency) for procedural skills. Within the included competency-based studies, 7 studies compared automated feedback to nonautomated feedback, and 7 studies compared the presence of an instructor to self-regulated learning.

Benefits: Meta-analysis of the pooled skill outcomes revealed improved performance among participants trained in a competency-based simulation framework when compared with a non–competency-based simulation framework (pooled SMD = 0.67; 95% CI, 0.20–1.07; $P = 0.0009$).

Harms and burden: No harms have been reported because of competency-based training. On the other hand, competency-based training puts increased burden on both learner and faculty time that must be considered when implementing such curricula.

Certainty in the evidence of effects: Level of certainty for the effect was moderate for the comparison of competency-based simulation to non–competency-based simulation on procedural skill outcomes. All but 1 study had a high MERSQI assessment of ≥12 with a median MERSQI of 15.5 (interquartile range, 13.9–15.9, of possible 18).

Decision criteria and additional considerations: The panel considered the effect of competency-based training on learner skills and behaviors and clinical outcomes to be substantial. There was discussion over how organizations might manage to prioritize competency-based curricula for a wide spectrum of both simple and complex procedural skills. It was recognized that the time and resources needed to ensure adequate opportunities for deliberate practice, standard setting, faculty development, robust assessments, consequences of training, and need for integration over the training continuum are expected to be substantial and require coordination from multiple stakeholders. The panel considered that there may be a potential trade-off between competency-based training effectiveness and resources available. The panel also noted the glaring lack of evidence exploring the contribution of individual modifiable components of competency-based training on learning outcomes. Few studies were identified that compared methods of training, feedback, or setting, but the available evidence was inadequate to base any further recommendations about the effectiveness/contribution of such factors.

Conclusions: Despite the concerns expressed about feasibility of competency-based training in all environments, the panel considered its substantial benefits for learning and recommended in favor of competency-based simulation training curricula for procedural skills in healthcare professions education.

Research Priorities: The panel recommended additional research to address the following areas:

- Comparative efficacy studies exploring optimal dose, frequency, and interval of training sessions for competency-based training.
- Research comparing variables such as feedback mode and method, faculty role and presence, and standard setting and assessment methods used in competency-based curricula.
- Studies that explore system level outcomes such as improved safety and effectiveness of procedures as a result of competency-based training.
- Studies that explore differences between mastery learning, proficiency-based training, and other competency-based training paradigms.

Topic: VR/AR/Hybrid Simulation

Virtual, augmented, and mixed reality are forms of technology that are now used in simulation-based education and often are referenced using the umbrella term XR or extended reality. Virtual reality is a fully immersive, digital environment that is artificially created using software and requires a head-mounted display or similar by the user. Augmented reality overlays digital content into the user's real world; the user is still present in the real world yet can visualize virtual or digital objects.[143]

KQ 13: *Does the use of VR, AR, or XR simulation improve healthcare professional learning and patient outcomes compared with traditional simulation methods?*

- **The panel suggests that both XR or traditional simulation can be used for the training of healthcare professionals as both have comparable learning outcomes (conditional recommendation, very low certainty of evidence).**
- **The panel suggests that VR experiences should be proctored, include debriefing, and have a backup plan when learner cybersickness or myopia are encountered and to document time and costs (expert recommendation).**

Problem statement: To date, no clear evidence of effectiveness exists for XR technologies, and their comparative effectiveness to traditional simulation remains unexplored. Understanding the benefits and drawbacks of XR technologies would allow educators to better incorporate them into training curricula.

Summary of the evidence: Of 2615 studies screened, 15 studies (11 randomized controlled trials) were included. The studies covered a large range of XR modalities, learner groups, and healthcare topics. The evidence identified reported only Kirkpatrick level 1 and 2 outcomes, and the majority of VR studies only implemented the intervention in 1 session. The levels of evidence according to Melnyk's hierarchy of evidence were II or III for the majority of

studies. Approximately one-third of the studies lacked randomization, and the majority lacked blinding of participants to the intervention, blinded investigators, and included team members who analyzed the outcomes. In just over half of the studies, the reviewers were unable to determine if the effect size of the intervention was measured or reported.

Benefits: Virtual reality was found to have comparable learning outcomes with traditional simulation and potentially lower cost. One study showed improved recognition of pediatric abnormal physical signs when in AR *vs* not. Most other studies showed no difference in knowledge and simulated performance. No outcomes for provider behavior change in real settings nor patient outcomes were reported.

Harms and burden: Cybersickness is an infrequent but real problem for some learners using VR, and individuals with myopia may also have difficulty with the headset fit and visibility. Using the Simulation Sickness Questionnaire, cybersickness elements were rarely reported ($Z = -0.95$ to 1.80, $P > 0.07$) except for fatigue ($Z = -3.20$, $P = 0.001$)

Certainty in the evidence of effects: The overall certainty of the evidence was rated as very low for all outcomes and was downgraded for risk of bias, indirectness, and inconsistency. Risk of bias was not trivial, with 3 of 11 RCTs with high risk of bias and an additional 3 with moderate risk.

Decision criteria and additional considerations: The panel weighed the limited available comparative evidence between XR and traditional simulation against the undesirable effects of cybersickness with VR and the potential cost savings. It further recognized the heterogeneity of "XR modalities" and their rapid development that has outpaced the available validity evidence and was therefore hesitant to provide a blanket recommendation on all technologies and use cases.

Conclusions: Based on the available evidence, the effectiveness of XR was found to be comparable to that of high-fidelity simulation with similar learning outcomes.

Research Priorities: The panel recommended the following research priorities:

- An active consensus definition for XR in healthcare simulation, including hybrid versions in which digital and analog simulations are combined.
- Studies that explore the best application of XR to maximize training effectiveness and efficiency.
- Comparative effectiveness studies of XR with other training technologies.
- Studies that explore mitigation strategies for learner cybersickness with VR use.
- Studies that measure provider behavior in real clinical settings.

KQ 14: *Does the use of XR simulation improve surgical/procedural learning and patient outcomes compared with standard training methods?*

- **The panel suggests that XR simulation modalities may be an effective training modality for surgical and procedural training (expert consensus recommendation).**

Problem statement: The use of XR technologies for enhancing procedural/surgical training has increased significantly in recent years; however, no clear comparative evidence of XR vs other training methods for surgical or procedural training exists.

Summary of the evidence: Of 136 studies reviewed, 32 studies (17 RCTs) were included in these guidelines. Study participants included students, residents, and surgical attendings from general surgery, urology, neurosurgery, orthopedics, and ophthalmology. A variety of commercial and experimental XR devices were evaluated. Systematic reviews and 2 meta-analyses were also reviewed with a variety of XR modalities and headset hardware.

Benefits: Extended reality training focused on surgical simulation, and procedural skills were found to improve simulated surgical performance, whereas knowledge acquisition was similar to traditional training. Importantly, although AR led to improved technical performance, VR did not.

Harms and burden: No reported undesirable effects were found in the literature, including elements of cybersickness.

Certainty in the evidence of effects: The overall certainty of the evidence was rated as very low. Certainty was downgraded for risk of bias, indirectness, and inconsistency. Several studies were funded by the technology company manufacturing the hardware or software of the XR interventions.

Decision criteria and additional considerations: The panel deliberated the available limited evidence on the use of XR for the training of healthcare professionals and the substantial heterogeneity in study design, subjects, and devices. It opined that the high number of novices and students included in the studies may not be representative of the target populations. It also considered the very little cost information available and recognized the quickly accumulating literature in the area, which is likely to change any provided recommendations.

Conclusions: Extended reality seems useful for the training of procedural and surgical skills compared with traditional training

Research Priorities: The panel recommended additional research to address the following areas:

- Studies that standardized grading methods for assessments for surgical performance using objective or blinded observers.
- Studies that evaluate cost-effectiveness of XR implementation.

Topic: Debriefing and Feedback

KQ 15: *In healthcare professionals, does the use of 1 debriefing or feedback intervention, compared with a different debriefing or feedback intervention, improve educational and clinical outcomes in simulation-based education?*

For healthcare provider training using simulation, we suggest that structured debriefing and feedback should be included (conditional recommendation, very low certainty of evidence).

Problem statement: Debriefing is a critical component in most simulation experiences. With the growing number of debriefing concepts, approaches, and tools, we need to understand how to debrief most effectively to maximize the benefit to our learners.

Summary of the evidence: Of 1572 articles identified in our search, 70 studies were included (80% were RCTs). Most of the studies were single-center studies (n = 64, 91.4%); 75.7% used objective assessments and 84.3% studies focused on knowledge or skills measurement (Kirkpatrick level I and II outcomes). Questions addressed included (a) who should debrief/provide feedback (self, peer, facilitator), or (b) when to debrief/provide feedback (during or after a simulated case), or (c) with what device (video, script), or (d) based on what approach (eg, PEARLS).

Benefits: One study demonstrated that debriefing (vs no debriefing) led to improvement in teamwork skills in learners.[144] Instructor-led debrief was generally favored by learners over self-debriefing, but their comparative effectiveness on learning outcomes was variable. Providing a structure to the self-debrief (such as specific goals,[145] a debriefing framework,[146] or a video[147,148]) generally improved outcomes compared with self-debriefs without a guide. The use of video to help learners reflect was associated with mixed results.[144,149–153] Rapid-cycle deliberate practice[154–157] showed a benefit on early skill acquisition.[158,159] However, no consistent evidence for the superiority of 1 method of debriefing over another was seen.

Harms and burden: Harms and burden were not addressed by the identified studies.

Certainty in the evidence of effects: The level of certainty was low/very low. Most studies had a high risk of bias, were not theory driven or testing debriefing models, used low-level outcomes (Kirkpatrick levels 1 and 2), and did not control for team/dyad membership when studying team debriefings. In addition, there were large gaps in the reporting of study methods and outcomes.

Decision criteria and additional considerations: The panel considered the important role and desirable impact of debriefing on healthcare professionals' learning and patient care in relation to the poor reporting and lack of data factoring in the complexity and dynamics of the debriefing and feedback process. Consideration was also given to issues of accessibility, equity, and inclusion of debriefing and feedback research in simulation with most studies coming from the global north. The panel also discussed that most included studies lacked interdisciplinarity in their design considerations; for example, theory and methodology from team science and meeting science, with very few exceptions, were not included.

Conclusions: The panel suggested that debriefing and feedback should be incorporated in simulation-based education. Given the lack of robust empirical evidence on its effectiveness, the panel recommends intentional simulation debriefing research to ensure the best possible learning experiences.

Research Priorities: The panel recommends the following research priorities be pursued:

- High-quality, theory-driven studies looking beyond simple interventions and main effects, including moderating and mediating variables and testing interaction effects and using meaningful outcomes.
- Studies factoring in team and meeting science theory and methodology when examining debriefing and feedback with individuals nested in dyads and teams (eg, multilevel analysis).
- Improved reporting of debriefing interventions, including details such as content, debriefer characteristics, duration, and frameworks used.
- Studies that investigate potential undesirable effects of current debriefing methods.
- High-quality studies that evaluate comparative effectiveness of the various available debriefing techniques.

Topic: SP

KQ 16: *Among healthcare professionals, does the use of SP methodology related to communication skills have an effect on improving learner knowledge, skills, attitudes, or patient outcomes compared with other simulation methodologies?*

- **The panel suggests an integrated approach to teaching communication knowledge, skills, and attitudes in healthcare education. This approach should prioritize the use of SPs for hands-on skill development, incorporate role-play scenarios for practical application, and include reflective exercises to nurture the growth of empathetic and patient-centered attitudes among healthcare professionals (expert consensus opinion).**

Problem statement: Simulated participants are commonly used in healthcare education to simulate real patients and teach communication skills. However, the comparative effectiveness of SPs for teaching communication skills compared with other modalities, such as role-play, manikins, or virtual SPs, is unclear.

Summary of the evidence: Of 8058 screened studies published over the last decade (2011–2021), 18 relevant studies[160–177] that compared SP methodology to other simulation modalities, such as role-play, manikins, and virtual SPs, were included. The outcomes reported by the included studies were heterogeneous and did not allow the conduct of a meta-analysis.

Benefits: Simulated participants have been found to offer advantages in teaching communication knowledge and skills over other simulation modalities, particularly role-play and manikins. Specifically, SP methodology was found to be superior in 75% of studies assessing knowledge, 67% of studies evaluating communication skills, and 25% of studies evaluating attitude.

Harms and burden: No specific harms or negative outcomes were identified associated with the use of SPs or other simulation modalities.

Certainty in the evidence of effects: The overall certainty of the evidence was very low because of the limited number of studies, variations in study designs, and the absence of research on patient outcomes.

Decision criteria and additional considerations: The panel considered the very low quality of the available evidence, the variation in reported outcomes, the lack of patient outcome reporting, the absence of skill retention data after SP training, and the limited evidence on cost, feasibility, and training requirements for SP. Because of these limitations, the panel decided to not offer an expert consensus recommendation rather than a GRADE recommendation.

Conclusions: Simulated participants methodology has advantages in teaching knowledge and skills, but further high-quality comparative effectiveness research is needed.

Research Priorities: The panel recommends additional research in the following areas:

1. Studies that investigate the long-term retention of communication skills taught using SP vs other simulation modalities.
2. Studies that compare the cost-effectiveness of SPs, role-play, manikins, and virtual SPs.
3. Studies that explore the impact of SP training on patient outcomes.

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Authorship

D.S. was the steering committee chair and oversaw the guideline development process of all groups, wrote the first draft of the manuscript, and revised the manuscript based on all author's suggestions; D.K., J.V., J.D., M.K., C.P., A.H., K.G.L., J.P., Y.L., A.C., J.P., I.T.G., T.R.-H.,

A.D., and A.L. were the panel cochairs, contributed to drafting and critical revisions of the manuscript and contributed to further drafts, moderated the panel sessions, and checked the manuscript accuracy; D.C., S.-M. K.-M., and M.T.A. provided methodological support; and S.M.-W. and S.D. provided supervision and guidance through the development process and critically revised this guideline. Guideline panel members (see table, Supplemental Digital Content 1, which lists all their names) participated in the creation of the EtD tables (see tables in Supplemental Digital Content 3–12, which list the evidence tables and EtD tables for relevant recommendations), critically reviewed the manuscript, and provided suggestions for improvement. All authors approved the content.

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