# In Situ Simulation in Continuing Education for the Health Care Professions: A Systematic Review

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***Introduction:*** *Education in the health sciences increasingly relies on simulation-based training strategies to provide safe, structured, engaging, and effective practice opportunities. While this frequently occurs within a simulation center, in situ simulations occur within an actual clinical environment. This blending of learning and work environments may provide a powerful method for continuing education. However, as this is a relatively new strategy, best practices for the design and delivery of in situ learning experiences have yet to be established. This article provides a systematic review of the in situ simulation literature and compares the state of the science and practice against principles of effective education and training design, delivery, and evaluation.*

***Methods:*** *A total of 3190 articles were identified using academic databases and screened for descriptive accounts or studies of in situ simulation programs. Of these, 29 full articles were retrieved and coded using a standard data extraction protocol (kappa = 0.90).*

***Results:*** *In situ simulations have been applied to foster individual, team, unit, and organizational learning across several clinical and nonclinical areas. Approaches to design, delivery, and evaluation of the simulations were highly variable across studies. The overall quality of in situ simulation studies is low. A positive impact of in situ simulation on learning and organizational performance has been demonstrated in a small number of studies.*

***Discussion:*** *The evidence surrounding in situ simulation efficacy is still emerging, but the existing research is promising. Practical program planning strategies are evolving to meet the complexity of a novel learning activity that engages providers in their actual work environment.*

***Key Words:*** *simulation, simulation-based training, in situ simulation, medical continuing education, health professions*

## Introduction

Simulation is a powerful tool for learning. As an education and training strategy, the use of simulation has proven to be effective[1,2] and superior to other training delivery modalities for a broad range of skills including teamwork[3–5] and technical skills.[6,7] Within the context of continuing education in the health professions, simulation has been defined by the Institute of Medicine[8] as:

> The act of imitating a situation or a process through something analogous. Examples include using an actor to play a patient, a computerized mannequin to imitate the behavior of a patient, a computer program to imitate a case scenario, and an animation to mimic the spread of an infectious disease in a population. (IOM, 2010, p. 34)

In addition, conceptual distinctions have been made between the *simulator* (a specific technology used to represent

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some aspect of the real work domain), the *simulation* (the use of a simulator as described in the IOM definition above), and *simulation-based training* (a strategy incorporating information, demonstration, and practice-based learning activities into a systematically designed and delivered program of instruction).[9–11]

This article discusses methods and frameworks for maximizing the value of a specific type of simulation within health care—in situ simulation—which is a blended approach most commonly involving patient simulators embedded within an actual clinical environments. In situ simulations have the potential to drive individual, team, unit, and organizational learning. They may also provide robust empirical data on multiple layers of health care system performance, giving them unique potential as tools for delivering and evaluating learning opportunities for continuing education in the health professions. In situ simulation is a relatively new approach. As a result, far less research exists on in situ simulation than on more traditional approaches involving dedicated simulation centers. It is unclear what the best practices, standards, or methods of design, development, and evaluation are or should be.

To address this gap in our knowledge, this review describes the state of the science and practice of in situ simulation use. First, an overview of in situ simulation and its potential role in continuing education is provided. Second, the results of a systematic literature review are presented with the purpose of identifying themes in current approaches to the design, delivery, and evaluation of in situ simulation as well as the performance measurement, feedback, and evaluation strategies in use. Third, implications of this review for continuing education in the health professions are discussed.

### Background

*What Needs Are Addressed by Simulation?* Simulation has the potential to address a broad array of needs in health care, such as: (1) *training and education* to develop, elaborate upon, and reinforce technical and teamwork competencies; (2) *performance support* to facilitate the application of previously acquired competencies, as in preprocedure warm-ups[12]; (3) *assessment* for high-stakes testing and certification[2,13–15]; (4) *innovation and exploration* to discover potential problems in the health care delivery system or test new methods of work as in prospective risk analysis and hazard identification[16] or process engineering and discrete event simulations[17]; (5) *predictive and real-time modeling* to support the situational awareness and decision making of clinicians[18]; and (6) *research* where simulation is used as a test bed to further the scientific understanding of performance shaping factors in health care tasks.[19,20]

From a training and education perspective, simulation in health care has been framed as both an ethical imperative in that the early stages of learner development need to be separated from patient care for safety reasons[21] and a viable method for improving learning outcomes through providing standardized and structured exposure to patient conditions and procedures and improved delivery methods.[2] The majority of published literature to date deals with simulation use in the traditional dedicated simulation center—a facility that stands apart from the settings in which clinical care is delivered. However, in situ simulation involves blending simulated and real working environments to provide training where people actually work. This is done for several reasons including addressing logistical challenges involved in scheduling training times as well as realizing the potential for improved transfer of training due to increased fidelity—the correspondence between the simulated and the real.[22] Fidelity is a complex issue; however, research indicates at least 2 critical types of fidelity: *physical* (the degree to which a simulation looks and feels like the real thing) and *functional* (the degree to which learners are required to use the same performance strategies and competencies in the simulation and in the transfer environment—clinical practice).[23] Functional fidelity has been established as the most critical for learning; however, in situ simulations may be able to increase levels of both aspects of fidelity.

*A Multilevel Framework for In Situ Simulation.* Researchers in quality and safety and more broadly health services typically characterize the health care delivery system using a sociotechnical systems approach wherein the ultimate effectiveness of the system and quality of care are determined not solely by the competency of a single provider, but rather by a constellation of factors, including: (1) interactions of a provider with patients, other providers, and the tools and technologies used while providing care, and (2) higher-level organizational work processes, policies, and cultural factors.[24,25] In a dedicated simulation center, there are two main types of learning to target: the individual and the team. All other factors are controlled and considered part of the simulated environment. With in situ simulation, however, other components of the health care delivery system are potentially subject to evaluation, reflection, and improvement and, thus, sites for learning. This section provides a brief description of four main types of learning that can be targeted with in situ simulation.

## Individual Learning

There is a broad array of relevant theories and methods for improving performance at the individual level, including expertise, mastery learning, and automation of procedural tasks and routine decision making.[26–28] These models have been applied to simulation in health care in many ways, including


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the use of task and part-task trainers to develop procedural skills,[29] case-based learning systems to develop diagnostic and critical thinking skills,[30,31] and standardized and virtual patient encounters to build interpersonal and basic clinical skills.[32,33] Individual learning is not typically discussed in the context of in situ simulation, but several industries rely heavily on "just-in-time" training strategies for delivering content to professionals in complex domains. In situ simulation can serve as a way to provide learning opportunities to individual health care professionals on new procedural or technical skills or to reinforce competencies acquired in more traditional learning environments.

## Team Learning

Team learning can be facilitated with a broad range of established techniques, including guided team self-correction, cross-training, and crisis or crew resource management (CRM) training.[34–36] For example, guided team self-correction is a strategy for using facilitated debriefing sessions based in a clearly defined model of teamwork that can be used to help teams evaluate their communication, cooperation, and coordination processes during a given scenario.[37] The critical elements of this strategy are: (1) that the debriefing is structured around a conceptual model of teamwork, rather than a linear discussion of events; (2) discussions are specifically designed to review positive and negative teamwork processes; and (3) the discussion is framed specifically with a learning (ie, what did we do) rather than a performance (ie, how did we do) orientation. Cross-training, meanwhile, is a strategy designed to allow team members to experience the roles and responsibilities of fellow team members and to gain new perspectives.[38] CRM focuses on training team members how to recognize cues and red flags, as well as strategies for adapting their coordination strategies and resource allocation patterns based on such cues.[39]

These strategies can help individual team members develop teamwork competencies that can be generalized across the various teams of which they are or will be a part.[40] These strategies can also foster team-specific learning through shared experimentation, reflection, and codification of both shared and unique knowledge.[41,42] Most important, underlying all of these methods are general teamwork competency models rooted in input-process-output (IPO) frameworks of team performance.[35] These strategies readily lend themselves to in situ simulations, providing opportunities to practice teamwork skills and processes within the actual care environment. Additionally, in situ simulations provide a venue to develop interteam coordination skills and processes, as well as opportunities to diagnose potential breakdowns in the continuum of care across multiple care teams.

## Unit-Level Learning

Numerous work system models are available for categorizing potential performance issues at the unit level. One commonly used in health care is the Systems Engineering Initiative for Patient Safety (SEIPS) model,[43] which details high-level categories of system structures, processes, and outcomes in health care by integrating Donabedian's structure-process-outcome (SPO) framework[25] and a more general engineering work system.[44] The SEIPS model emphasizes how work systems affect work processes and the quality and safety of care, as well as staff and organizational outcomes. Five elements of the work system are emphasized in the SEIPS model: (1) the person, (2) tools/technology, (3) the task, (4) the physical environment, and (5) organizational characteristics. From the perspective of in situ simulation, potential deficiencies or defects can be explored and corrected in all of these system components as well is in the interaction between components in a way that cannot be investigated in the simulation center (eg, a set of team members may be competent in communication skills, but in certain environments with high ambient noise levels, communication will be degraded anyway).

## Organizational Learning

Many of the hazards or latent errors uncovered at the unit level may be rooted in larger organizational issues such as interdependencies between departments, policies, enterprise-wide information systems, or organizational culture and leadership. These issues may have dramatic effects locally, in the unit. Unlike traditional self-contained simulation activities where feedback and remediation are aimed at correcting the deficient performance of learners, in situ simulations can uncover systems-related issues and stimulate efforts to address them.

One model for addressing systems issues at either the unit or organizational level is the Comprehensive Unit-based Safety Program (CUSP),[45,46] which emphasizes vertical connections with executive and administrative leaders who are capable of addressing these needs. CUSP is a multifaceted approach that activates and empowers frontline staff to identify and address potential threats to patient safety. It does this by focusing not only on recovering from mistakes but also learning from them, developing dedicated partnerships with executive leaders, and providing tools to support the reliable use of evidence-based care algorithms, all with the goal of promoting teamwork and a culture of safety. By engaging both frontline providers and executives in partnership, CUSP can help to align local processes with system-level structures (eg, reward and incentive structures)—key processes for building and sustaining a culture of safety.

Because it can address learning at multiple levels, in situ simulation offers a potential mechanism for both individual


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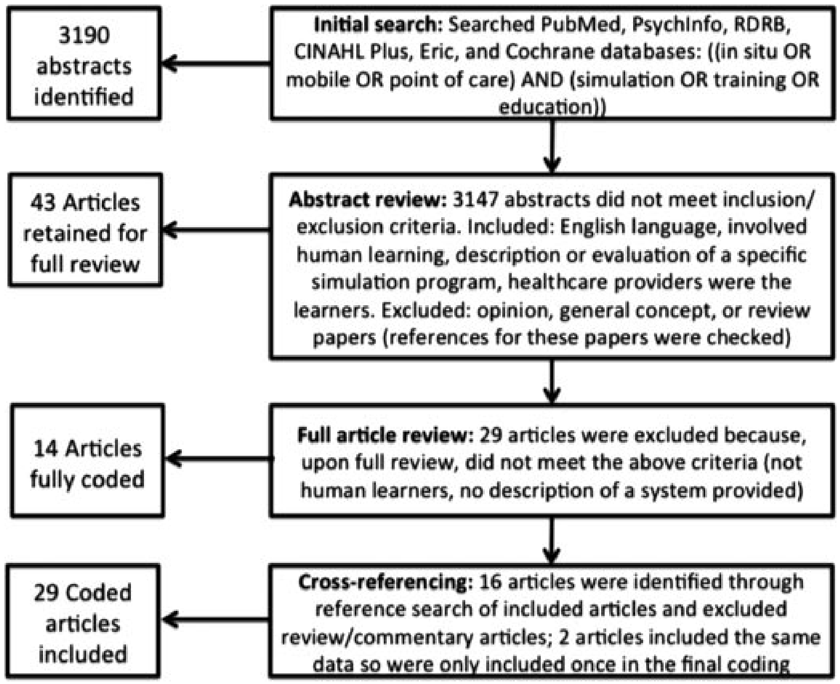


FIGURE 1. Overview of Literature Search Process

and team skill acquisition and maintenance in the context of continuing education. However, to date, no review of the literature has been dedicated specifically to this form of simulation. In the remainder of this article, we present a descriptive review of the current state of practice for in situ simulation in an effort to synthesize current practice and advance the science. Because this is a new area of research and practice, it was not anticipated that the literature would support a quantitative synthesis. Instead, we sought to evaluate current practice as it relates to best practices in the design and delivery of education, training, and development programs of all types. Specifically, we sought to understand how people are adapting practices of training design, delivery, and evaluation to this novel type of learning opportunity.

## Methods

### *Literature Search, Coding and Content Analysis*

As depicted in FIGURE 1, a total of 3190 unique abstracts were initially identified by searching the PubMed, PsychInfo, ERIC, CINHAL Plus, the Research and Development Resource Base (RDRB), and Cochrane databases using the following search term: ((in situ OR mobile OR point of care) AND (simulation OR training OR education)). Inclusion dates ranged from inception through December 31, 2011. A manual review of abstracts eliminated articles that did not pertain to human learning or education (eg, computer modeling of systems or biological processes), did not focus on care provider training (eg, patient or population focused intervention papers), or did not involve simulation (eg, articles on point of care information systems that did not include practice-based learning strategies). Two raters (M.A.R., M.A.F.) concurrently screened 20% of the abstracts with 95% agreement in inclusion and exclusion of articles. Disagreements were reconciled through discussion and consensus. This process yielded 43 articles, which were screened in full. Twenty-six of these were eliminated because they did not provide a description of an actual in situ program or system (eg, general commentaries or opinion papers) or upon complete review did not meet previously stated criteria. Three articles were eliminated due to issues of known academic fraud. Review or general commentary articles were not retained for full coding, but references were checked to ensure our search did not exclude relevant articles. Sixteen additional articles were identified through a cross-referencing search. The resulting 30 articles[47–76] were coded concurrently by 2 reviewers (M.A.R, S.J.W). Twenty percent of these articles were coded by 2 reviewers. Interrater reliability for the coding was calculated using chance corrected percent agreement, and met established criteria (kappa = 0.90). Disagreements were reconciled through discussion and consensus, and the remaining articles were coded. Two of these publications reported the same data and description of in situ system,[64,65] so were only included once in the analysis, resulting in a total of 29 distinct papers.


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## Results

The results of the coding and content analysis process are presented as answers to key questions regarding the design and delivery of in situ simulations, as well as performance measurement, feedback, and evaluation strategies currently documented in the literature. Descriptive trends are shown in TABLE 1. As anticipated, the current state of the literature did not permit quantitative synthesis of findings. Few articles presented quantitative data of any type, and those that did used widely ranging measures with small sample sizes and weak study designs. The few exceptions to this trend are discussed in the section on evaluation below. An overview of these findings is provided in TABLE 2.

### *The Design and Delivery of In Situ Simulations*

*What Needs Analysis Methods Are Being Used?* Because in situ simulation can be used for a variety of learning and improvement applications, it is unclear if traditional educational needs analysis methods are appropriate in all cases. For example, if the purpose of the simulation is to conduct prospective hazard identification (eg, to conduct a Failure Mode and Effects Analysis [FMEA]), specification of required competencies of learners is not sufficient on its own.

Approximately one quarter of the articles (7; 24%) did not report any details on formal needs analysis processes. The majority of the remaining articles (17; 48%) described some form of a traditional training or education needs analysis process; however, these needs assessments varied in quality greatly (eg, from using scenarios based on problematic events that actually happened in a unit to formal learner needs assessment processes). A small number of studies (2; 7%) described the use of system-level needs specifications such as FMEA or Premortem (ie, a prospective method for generating potential problems) exercises used to generate potential system breakdowns to explore in scenarios. Additionally, 3 articles (10%) used a combination of formal traditional training needs analysis and system-level techniques.

*What Level of the System Is Targeted for Improvement?* As described in the introduction, in situ simulations can target individual technical performance, teamwork, or unit-level performance issues (eg, equipment and tools, work processes). There was a great deal of variety in level of analyses and improvements targeted by the different programs, but there were 5 main categories; those that targeted team competencies of staff members (8; 28%), unit- or system-level latent errors (8; 28%), a combination of individual and teamwork competencies (5; 17%), a combination of teamwork competencies and unit or system issues (4; 14%), and those that attempted to train or asses individual and team competencies in addition to addressing unit- or system-level latent errors (4; 14%).

*Who Participates in In Situ Simulations?* Traditionally, simulation has found its home in the basic education of health care providers. However, in situ simulation provides the opportunity for a broader inclusion of professionals at different points in their career development. All in situ programs that reported information on their learners (90%) included multidisciplinary teams, frequently from across multiple units or departments. In addition to a wide range of physician and nursing specialties, learners included pharmacists, respiratory therapists, technicians (surgical, laboratory, radiological), and clerks and other administrators. These learners were most frequently fully credentialed and practicing providers, but several studies explicitly included residents (11; 42%) or medical students (3; 12%) as well as allied health students (1; 4%). Unlike simulation centers, the primary audience of in situ simulation appears to be practicing providers instead of trainees.

*Who Are the Instructors?* As in situ simulation frequently targets multiple types of providers and multiple levels of performance, running, analyzing, and debriefing these events may take a unique skill set or more likely, a multidisciplinary team of trainers. The majority of articles (16; 55%) did not include details on the personnel running these simulations, their backgrounds, or any training they received to prepare them for the events. Those reporting details on in situ simulation personnel suggest that the majority are clinicians (10; 34%) with some mixed groups of trainers employing simulation or Human Factors experts (3; 10%). Additionally, relatively few articles (6; 21%) reported details on specialized development or preparation the instructors received prior to conducting these in situ learning events. When instructor development was described, it ranged from tutorials on effective debrief facilitation to more intensive train-the-trainer programs.

*What Are the Learning or Assessment Objectives?* Given the unique capabilities of in situ simulation, it is not surprising that there were combinations of individual, team, and unit- or system-level objectives. In general, these fall in line with the level of analysis targeted by the in situ system. However, there was variability in the degree to which objectives were specified across these levels. Programs targeting team level improvement frequently used an established teamwork training program or competency model such as Crisis Resource Management (CRM) training or Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS); however, several programs at this level simply described vague objectives related to improving teamwork (6; 24%). Programs targeting individual level improvements


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TABLE 1. Descriptive Trends From Article Codings

| Key Questions for In Situ Simulation | Findings from article coding |
| --- | --- |
| *What needs analysis methods are being used?* | • No formal needs analysis (24%) |
| | • Traditional training or educational needs analysis methods (48%) |
| | • Work system needs analysis (7%) |
| | • Combination of educational and work system methods (10%) |
| *What level of the system is targeted for improvement?* | • Team competencies (28%) |
| | • Unit- or system-level latent errors (28%) |
| | • Individual and team competencies (28%) |
| | • Team competencies and unit-level errors (14%) |
| | • Individual, team, and unit levels (14%) |
| *Who participates in in situ simulations?* | • Multidisciplinary teams of practicing providers (100%) |
| | • Residents (42%) |
| | • Medical students (12%) |
| | • Allied health students (4%) |
| *Who are the instructors?* | • Clinicians (34%) |
| | • Clinician and nonclinician teams (10%) |
| | • Faculty development focused primarily on debrief facilitation (21%) |
| *What are the learning or assessment objectives?* | • Team objectives were rooted in established teamwork competency models (76%) or general objectives to improve teamwork (24%) |
| | • Individual objectives focused on procedural skills (64%), decision making (9%), and orientation (9%) |
| | • System-level objectives were general statements to identify hazards (87%) or specific identification of system issues to evaluate (13%) |
| *Where is in situ simulation being used?* | • Operating room (30%) |
| | • Labor and delivery (15%) |
| | • Emergency department (15%) |
| | • Intensive care unit (13%) |
| | • Postanesthesia care unit (7%) |
| | • Triage areas (4%) |
| | • Cardiac catheterization lab (2%) |
| | • Dental clinic (2%) |
| | • Palliative care (2%) |
| | • Pediatric ward (2%) |
| | • Psychatric ward (2%) |
| | • Endoscopy suite (2%) |
| | • Loading dock (2%) |

(*Continued*)


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TABLE 1. Continued

| Key Questions for In Situ Simulation | Findings from article coding |
|---|---|
| *How is performance being measured?* | • Self-report (41%) |
| | • Observation (41%) |
| | • Latent conditions identified in the debrief (21%) |
| | • Objective task outcomes (14%) |
| *How is feedback being provided?* | • Facilitated debrief (55%) with video review (31%) |
| | • Follow up for system related errors (21%) |
| *How is in situ simulation being evaluated?* | • Learner reactions (31%) |
| | • Learning (3%) |
| | • Behavior change (21%) |
| | • Outcomes (17%) |
| *Has in situ simulation proven to be effective?* | • Impact has been shown on clinical processes, task performance, and mortality and morbidity. |

(n = 11) focused predominantly on procedural clinical skills (7; 64%), with objectives for decision making in high-stress situations (1; 9%) and environment familiarization or orientation (1; 9%) specified as well. Programs focusing on system-level improvements (n = 15) most frequently left stated objectives vaguely defined (eg, "error trapping," minimize patient risk, identify latent conditions and active failures that may lead to patient harm) (13; 87%). However, a small number of programs (2; 13%) detailed specific types of system failures being tested (eg, developing a process map with failure modes).

*Where Is In Situ Simulation Being Used?* In situ simulations have been developed and implemented for a relatively broad set of clinical contexts. Several of the articles described simulations in very distinct clinical care areas (ie, care providers from different care areas were *not* involved in the same scenarios), while others presented scenarios that spanned multiple work areas (eg, perioperative services; admission through triage, to labor and delivery, to the operating room, to recovery areas). Specifically, these in situ events took place throughout clinical and nonclinical areas such as the operating room (14; 30%), labor and delivery (7; 15%), emergency department (7; 15%), intensive care unit (6; 13%), postanesthesia care unit (3; 7%), triage areas (2; 4%), cardiac catheterization lab (1; 2%), dental clinic (1; 2%), palliative care (1; 2%), pediatric ward (1; 2%), psychatric ward (1; 2%), endoscopy suite (1; 2%), and the loading dock (1; 2%).

### *Performance Measurement and Feedback*

*How Is Performance Being Measured?* Performance measurement practices varied widely. The most common methods for capturing performance were self-report data from the learners (12; 41%) and observational data recorded by trainers (12; 41%). Self-report data included typical reactions to training (eg, perceptions of learning, utility, and intent to transfer) as well as workload and self-efficacy. Observational data focused on teamwork behaviors, procedural task performance, and errors. Objective task outcomes (eg, task completion times) were included in a small number of the programs (4; 14%). Additionally, other methods such as recording errors and latent conditions discussed in the debrief (6; 21%) or tools based in FMEA (eg, a Hazard Matrix that captures the severity and frequency of latent errors encountered during the in situ simulation) were used (2; 7%).

*How Is Feedback Being Provided?* The majority of articles discussed some type of feedback system (26; 90%). The most frequently used methods for providing feedback after simulations were the facilitated debrief (16; 55%) and facilitated debriefs using video review (9; 31%). Additionally, several of the simulations that targeted unit- and system-level issues included mechanisms for follow-up to help with developing and implementing a solution to latent errors identified during the simulation that could not be corrected immediately (6; 21%).

### *Evaluation*

*How Has the Impact of In Situ Simulation Been Evaluated?* Our review found that there have been few rigorous evaluations of in situ simulation; 5 of the reports included in our review (17%) provided no evaluation at all. The most common types of evaluation data provided were learner reactions to the experience (9; 31%) and lists of latent conditions generated


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TABLE 2. Summary of Key Findings

| Key findings | What learners, trainers, and educators can do |
|---|---|
| Formal and rigorous needs analysis methods are rarely used for developing in situ simulations. | • *Learners* can seek in situ learning opportunities with clearly articulated learning objectives that match their developmental goals.<br>• *Trainers and educators* can apply formal educational needs analysis methods to individual and team level competencies, and work system models and tools (eg, FMEA frameworks) to unit-level objectives. |
| In situ simulation trainers are rarely given training to develop specialized assessment or feedback skills. | • *Trainers and educators* can develop or participate in faculty development exercises for understanding work system "lenses" to better understand the relationships between individual and team performance and the broader work system functioning. |
| In situ simulations typically address multiple levels of performance simultaneously (eg, individual, team, unit-level work systems). | • *Learners* can select in situ opportunities that explicitly build their skills, and become engaged in the improvement of local unit practices.<br>• *Trainers and educators* can ensure that learners leave the session with effective feedback and remediation for individual and teamwork competency issues, and that unit- and system-level issues are relayed to appropriate organizational entities for follow up (eg, safety and quality personnel). |
| Performance measurement practices for in situ simulation are rarely formal or rigorous. | • *Trainers and educators* can develop measurement tools for each level of the system targeted for improvement (e.g., adapt performance checklists developed for individual and team performance in center-based simulations and augment them with observational tools designed for hazard identification in work systems). |
| Evaluation practices for in situ simulation are currently poor. | • *Trainers and educators* can adopt continuing education evaluation frameworks such as Moore and colleagues'[77] and focus on transfer of training (eg, transitioning from improved competence [level 4] to improved performance [level 5] in Moore's framework of outcomes). |

in a debrief (9; 31%). Assessments at the levels of learning (1; 3%), behavior change (6; 21%) and organizational outcomes (5; 17%) were also reported. Two articles presented cost and usage data (7%), but no return on investment or similar evaluative economic analyses were found.

*Has In Situ Simulation Proven to Be Effective?* While the majority of evaluations focused on learner reactions and change in attitudes, several studies demonstrated the impact of in situ simulation on organizational performance. Steinmann and colleagues[71] examined the impact of in situ simulations on actual trauma resuscitations and found a 76% improvement in task completion and 16% reduction in resuscitation times. Riley and colleagues[69] compared the use of in situ simulations for teamwork training to a didactic training only group and a no-training control group. The results suggested that in situ simulation was effective at reducing mortality rates in labor and delivery over the course of the 4-year study. Additionally, in a series of large-scale in situ simulation evaluations[58] and training interventions in emergency departments in North Carolina, Hunt and colleagues[57] demonstrated significant improvements in trauma resuscitation task performance and that improvements were sustained for at least 6 months. These studies provide some preliminary evidence of the potential power of in situ simulation.

## Discussion

The state of the science and practice of in situ simulation is relatively underdeveloped due to its recent emergence as a method for delivering continuing education to health care professionals. However, this review of the current


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peer-reviewed literature does provide insight regarding how in situ simulation is being used, implemented, and evaluated. In line with best practice frameworks for continuing education, the majority of programs conducted some form of training needs analysis to guide program development and over 90% of programs explicitly integrated semistructured feedback systems to facilitate learner reflection. However, few programs reported meaningful evaluations of program effectiveness.

In situ simulation programs covered a limited range of clinical topics, with the majority addressing surgical care areas such as the operating room and labor and delivery. Future work examining the use of in situ simulation in less procedure-driven areas would further our understanding of how to most effectively design, implement, and evaluate in situ simulation experiences. The present study suggests several gaps in standard instructional design practices for trainers and educators. These are discussed in a broader context below.

### *Implications for Continuing Education*

As described by Moore and colleagues,[77] learners progress through phases of learning from recognizing a need, searching for learning opportunities, engaging in learning, experimenting or trying out what was learned, and integrating learning into practice. In situ simulations provide opportunities to try out what was learned in a safe environment, but they also provide means to merge what was learned with the local environment. There are numerous local system barriers to transferring what was learned into practice (eg, do new procedural skills require specialized equipment?), and in situ simulation can be a means of identifying and addressing these issues. While in situ simulation has received much attention from practitioners, there has been little rigorous research, development of standard methodologies, or systematic evaluation of effectiveness. The feasibility of in situ simulation has been well documented, at least in anecdotal terms, but little attention has been given to its cost effectiveness or comparative effectiveness relative to other learning and development activities. Numerous in situ simulation systems have been developed and fielded. Additionally, some initial methods have been developed to scaffold the needs analysis, scenario design, and performance measurement components of in situ simulations that deal with topics outside of the traditional individual or team competency building.

Some specific implications for adoption of in situ to continuing education involve the general lack of formal needs analysis in current systems, lack of rigorous evaluation approaches, and blending of levels of analysis. For example, in situ simulations may target individual, team, and system-level issues. If this is the case, how are learning objectives matched to ensure that participants are receiving a learning opportunity that fits their needs? The findings of this review indicate that these issues have not been adequately addressed. Developing multilevel training design, evaluation, and feedback systems is a priority area for future in situ simulation research and development. These systems will be critical for generating the research to indicate when in situ simulation can be used to greatest effect and how to couple it with traditional center-based simulation and other learning and development activities.

As with any intervention, educational or otherwise, the cost effectiveness of in situ simulation will be a key factor affecting its widespread adoption. One of the arguments for using in situ simulation is that it saves staff time (e.g., no travel time to a physically separate training environment) and reduces the overhead and physical footprint of a simulation center. However, there is a need for comparative cost data, sustainment cost data, and return on investment information in the published literature.

### *Limitations of This Review*

This review was descriptive in nature, due to the limitations of the primary research studies available. The majority of publications on in situ simulation have focused on describing rather than evaluating current practice. Those studies with empirical findings included a broad array of individual, team, and system-level outcomes variables, making effect size calculation impossible. Additionally, the studies available may not reflect the full range of in situ simulation practice. Many organizations may be developing and implementing in situ systems without publishing. Consequently, as a descriptive review of practice, our findings may be biased to those occurring in organizations with academic orientations. This may be a case were practice leads research due to the relatively small amount of funding available for in situ simulation and the inherent difficulty of conducting rigorous research on educational interventions of this type. For example, as the unit of analysis changes from individual to team to unit and system, obtaining appropriate sample sizes becomes increasingly difficult. Additionally, this review included only English language articles dealing with health care workers as learners.

### *The Road Ahead for In Situ Simulation in Health Care*

In situ simulations are most commonly used as a method for delivering training, as well as for conducting forms of prospective risk analysis. These simulations capture provider behavior, teamwork, and latent system errors. Even in isolation, they provide valuable learning opportunities, but when used as part of a program that integrates these learning experiences over time or across multiple facilities, in situ simulations can serve as an ongoing training evaluation system,


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## Lessons for Practice

- Emerging evidence suggests that in situ simulation can address individual and team development, as well as opportunities to diagnose and improve organizational and system-level processes.
- In situ simulation shows promise as a method for providing rich opportunities for skill diagnosis, helping learners to more clearly identify continuing education needs.
- Given the range of applications, the available research suggests that in situ simulations designed for continuing education should include structured needs analysis, and clearly defined assessment and feedback strategies in order to clarify learning objectives and support training transfer to daily practice.
- Facilitation of in situ simulation sessions requires different resources, planning, and data capture methods than traditional simulation settings; therefore, faculty development specific to in situ simulation may be required.

feeding back information about provider competency, retention, and skill decay. Specifically, in situ simulations could provide a distributed network for diagnostic data collection to drive multiple levels of system improvement and research. For example, with rigorously collected data, in situ simulations could provide insight into the degree to which other learning activities are transferring to improved competence or improved performance in actual practice.[77] This information can be used to reinforce individual and team learning, but also to adapt other learning activities not occurring in the workplace (eg, what skills do providers need more focused time to develop?). While at the present time these applications may seem far-fetched, efforts to integrate medical technologies and systems[78] could provide the backbone of a technical infrastructure necessary to transform the work environment into a true learning and performance assessment platform.

## Conclusion

While in situ simulation is a new practice in the health care field, it has the potential to be a powerful learning strategy in the continuing education toolbox alongside classroom-based didactics, audit and feedback, opinion leaders, reminders, and other interventions.[79] The science evaluating the effectiveness of in situ simulation is emerging, but recent studies are promising. Practical strategies such as needs analysis, measurement, and feedback are still evolving to meet the complexity of a novel learning activity that engages providers in their actual work environment.

## Supporting Information

Additional supporting information may be found in the online version of this article:

TABLE S1: Summary of articles included in the study

As a service to our authors and readers, this journal provides supporting information supplied by the authors. Such materials are peer reviewed and may be reorganized for online delivery, but are not copy edited or typeset. Technical support issues arising from supporting information (other than missing files) should be addressed to the authors.

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